

Long term trends in gold exploration

Is the love affair over, or is it just warming up?

Richard Schodde

Managing Director, MinEx Consulting

Adjunct Professor, Centre for Exploration Targeting , UWA

Technical presentation to the Melbourne Branch of the AusIMM

7th June 2016

Overview

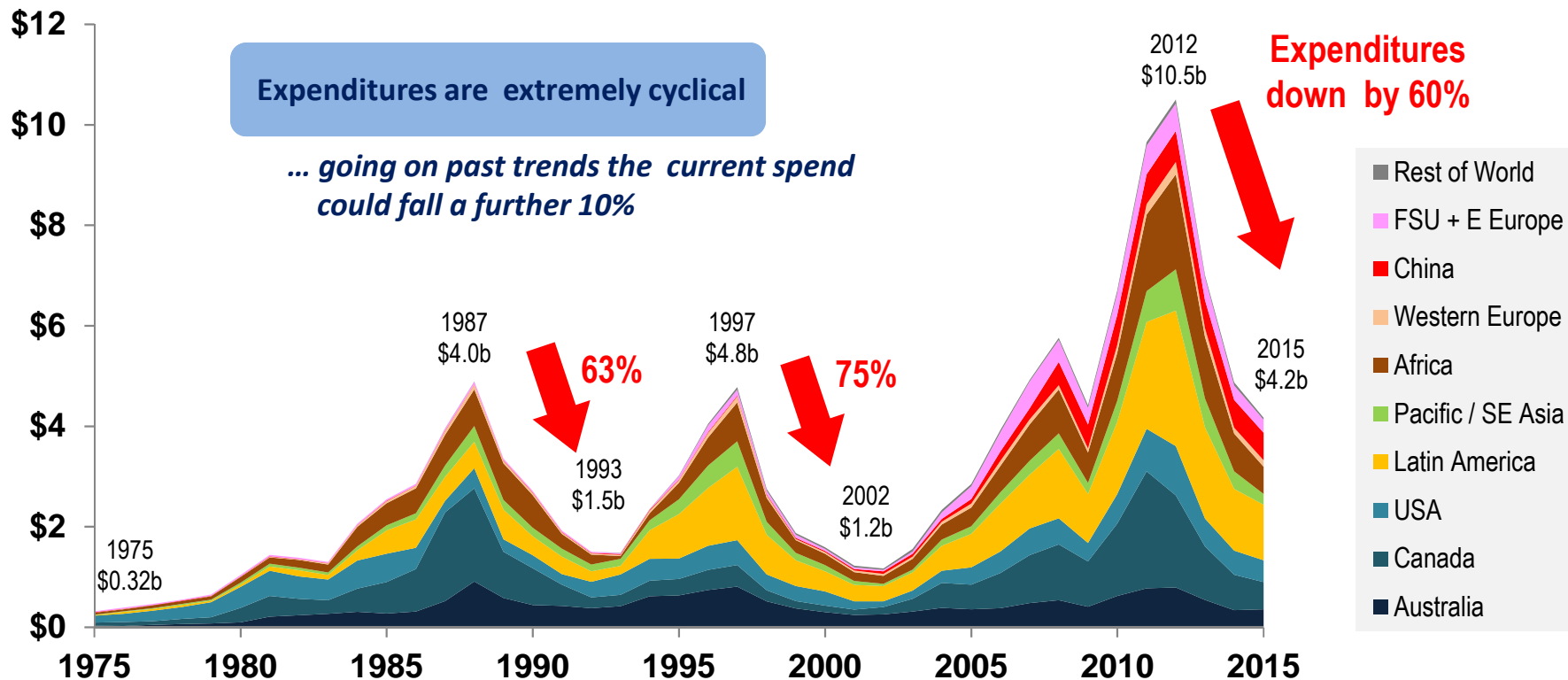
1. Trends in exploration expenditure
2. Key drivers for exploration spend
3. Trends in the number of discoveries and ounces – *How much found?*
4. Trends in the location of discoveries – *Where are the “hot spots”?*
5. Size and grade of discoveries - *Are we running out of “good” deposits?*
6. Trends in discovery methods – *Geochem versus Geophysics*
7. Depth of cover for discoveries – *What’s the average depth by Region?*
8. Who made the discoveries? – *Majors versus Juniors*
9. Quality of the discoveries – *What tonnes & grade are required for a Tier 1*
10. Trends in unit discovery costs – *\$/oz costs are rising over time*
11. Country-Risk issues – *Is it worth exploring in riskier places?*
12. Outlook for Australia – *is the love affair still on?*
13. Conclusions

Exploration expenditures reached an all-time high in 2012

1. TRENDS IN EXPLORATION SPEND

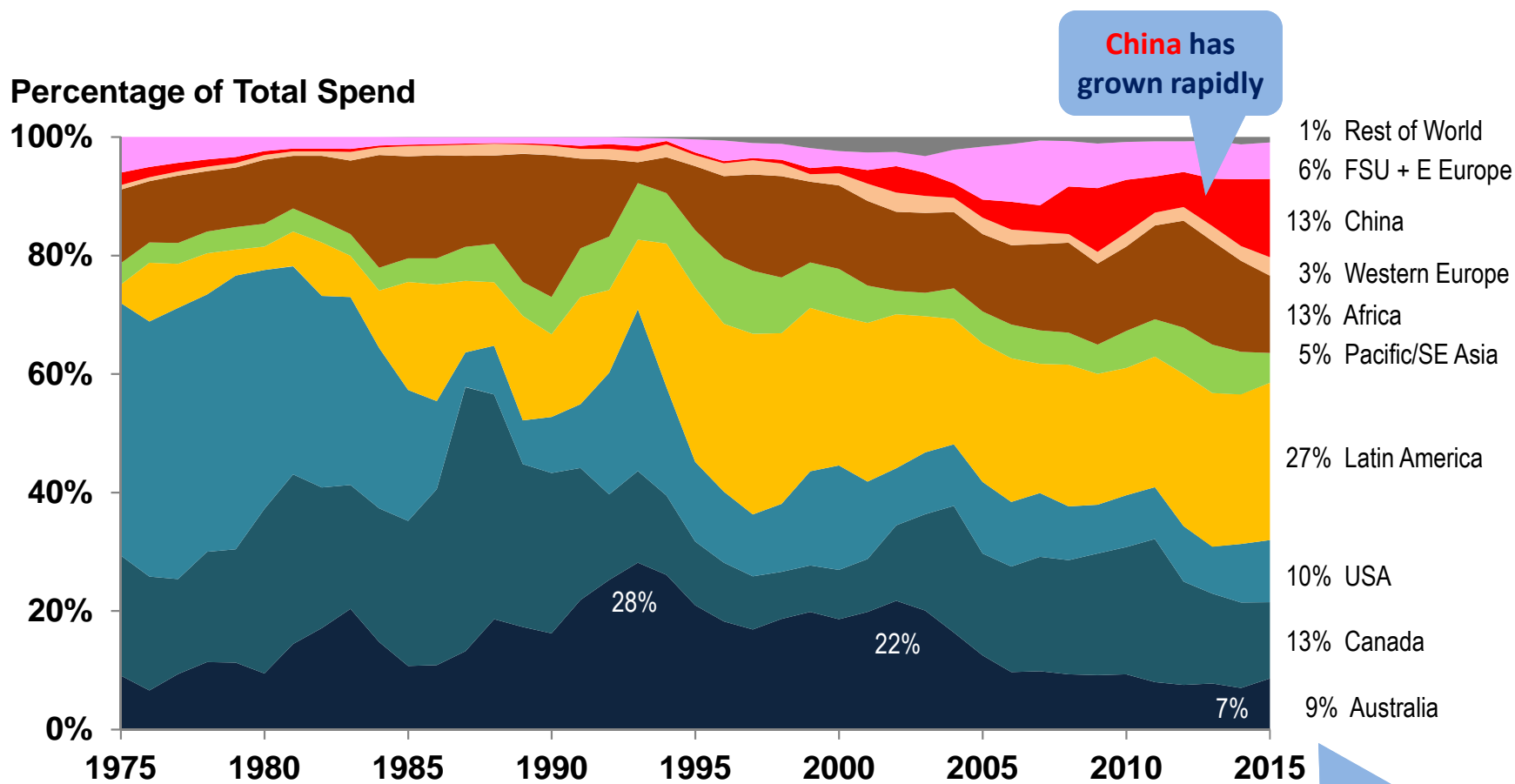
Gold Exploration Expenditures: World

June 2015 US\$ Billion



Sources: MinEx Consulting estimates, based on data from ABS, NRCAN, MOLAR (China), Tilton (1988), Wallace (1992,93) and SNL © 2015

Gold Exploration Expenditures: World



Sources: MinEx Consulting estimates, based on data from ABS, NRCAN, MOLAR (China), Tilton (1988), Wallace (1992,93) and SNL © 2015


Commodity price is the main driver

2. KEY DRIVERS FOR EXPLORATION SPEND

Key Drivers

- Growth in metal demand (and the need to replace what's been mined)
- Commodity prices
- Availability of funds (especially for Junior Companies)
- Input costs (such as geos, drilling and land access)
- Changes in Business Risk (both good & bad)
- Exploration success & major discoveries
 - Main influence is at the local level
- Technical innovations
 - Geological models
 - Exploration tools
 - Processing methods

Key Drivers

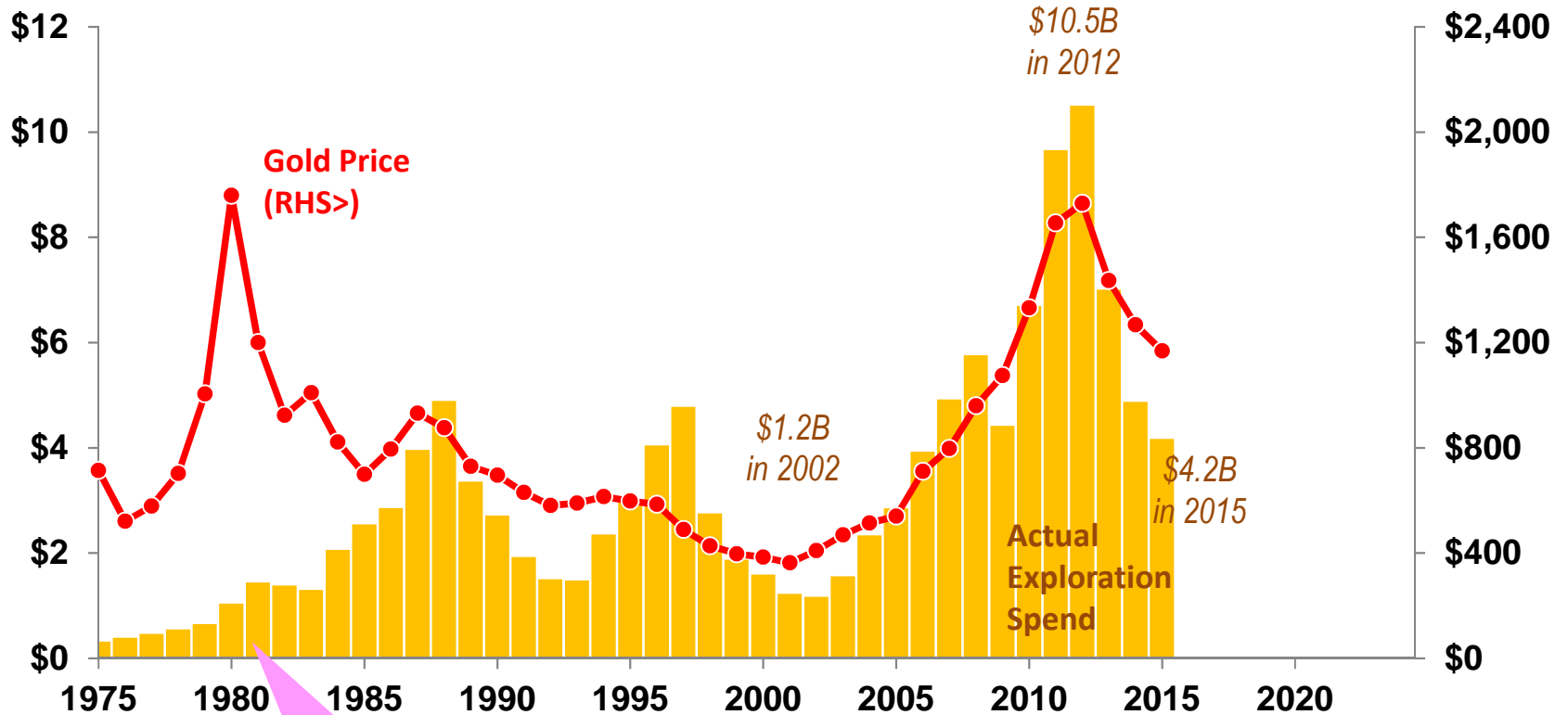
- Growth in metal demand (and the need to replace what's been mined)
- **Commodity prices**  **Main Driver**
- Availability of funds (especially for Junior Cos)
- Input costs (such as geos, drilling and land access)
- Changes in Business Risk (both good & bad)
- Exploration success & major discoveries
 - Main influence is at the local level
- Technical innovations
 - Geological models
 - Exploration tools
 - Processing methods

Exploration spend is closely linked to commodity prices

World gold exploration expenditures versus gold price

Exploration Expenditures
(June 2015 US\$ billion)

Gold Price
(June 2015 US\$/oz)



NOTE: Industry was slow to respond to the 1980 price spike

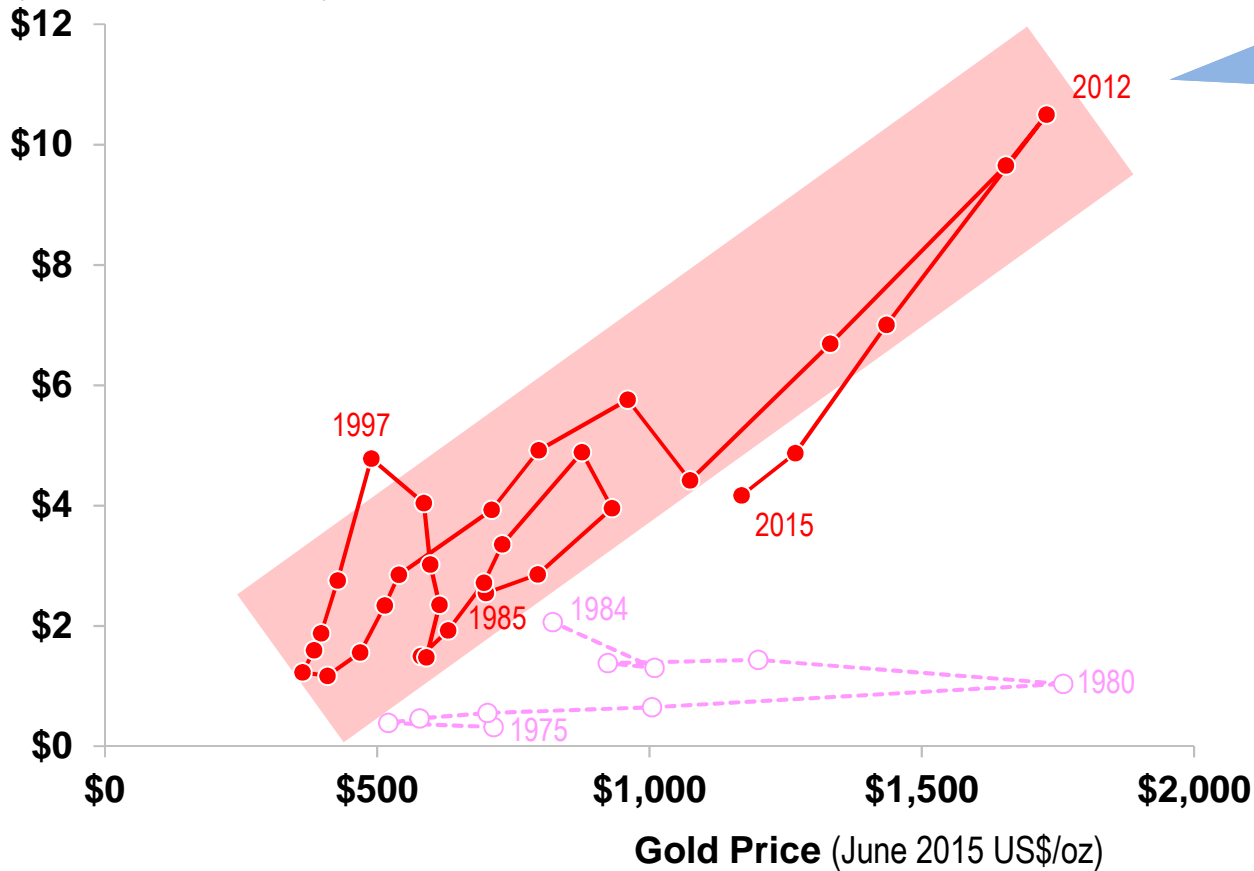
Needed more trained geologists plus innovations in exploration methods (geochem) and processing (CIP)

Sources: MinEx Consulting © June 2016, LME

Exploration spend versus gold price

World: 1975-2015

Exploration Expenditures
(June 2015 US\$ billion)



Since the mid-1980s exploration spend has moved in-line with gold prices

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

NOTE: have excluded data for 1975-1984 because industry was slow in responding to the 1980 gold price spike

Source: MinEx Consulting © June 2016

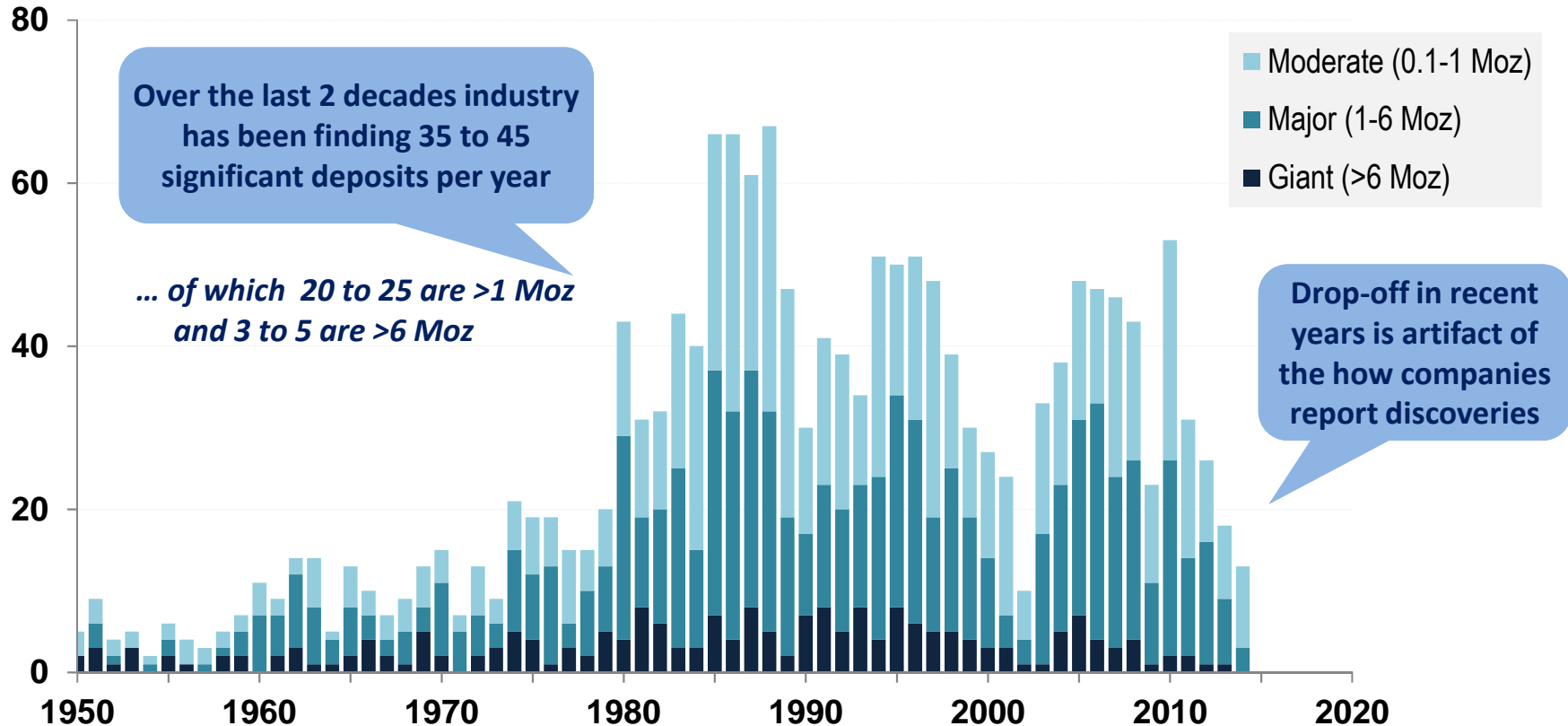
Discovery rates have plateaued (if not declining)

3. TRENDS IN THE NUMBER OF DISCOVERIES AND OUNCES FOUND

Number of Gold Discoveries: World

Primary Gold Deposits by Size : 1950-2014

Number of Deposits



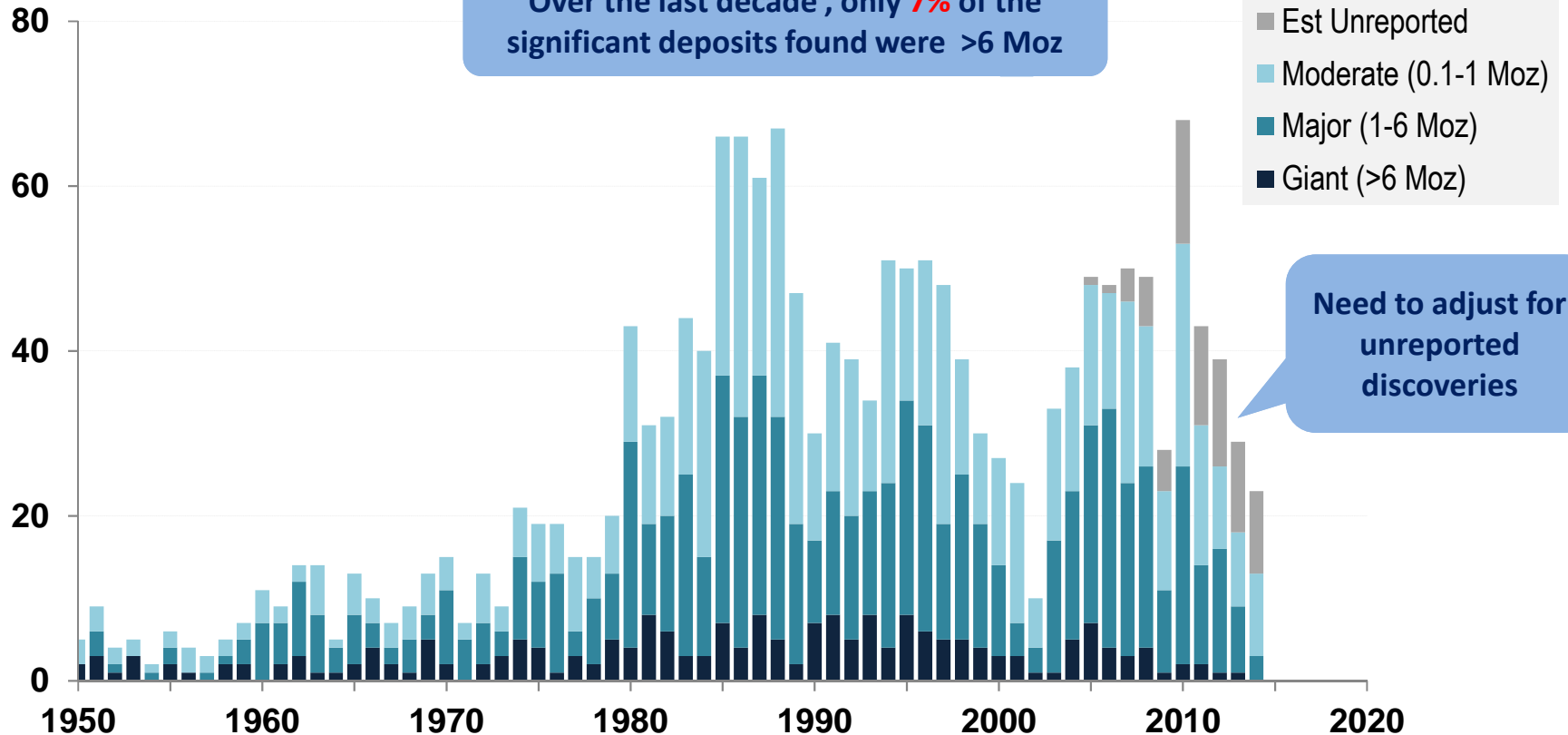
Note: Discoveries are for Primary gold deposits >0.1 Moz Au
Excludes satellite deposits within existing camps

Source: MinEx Consulting © October 2015

Number of Gold Discoveries: World

Primary Gold Deposits by Size : 1950-2014

Number of Deposits

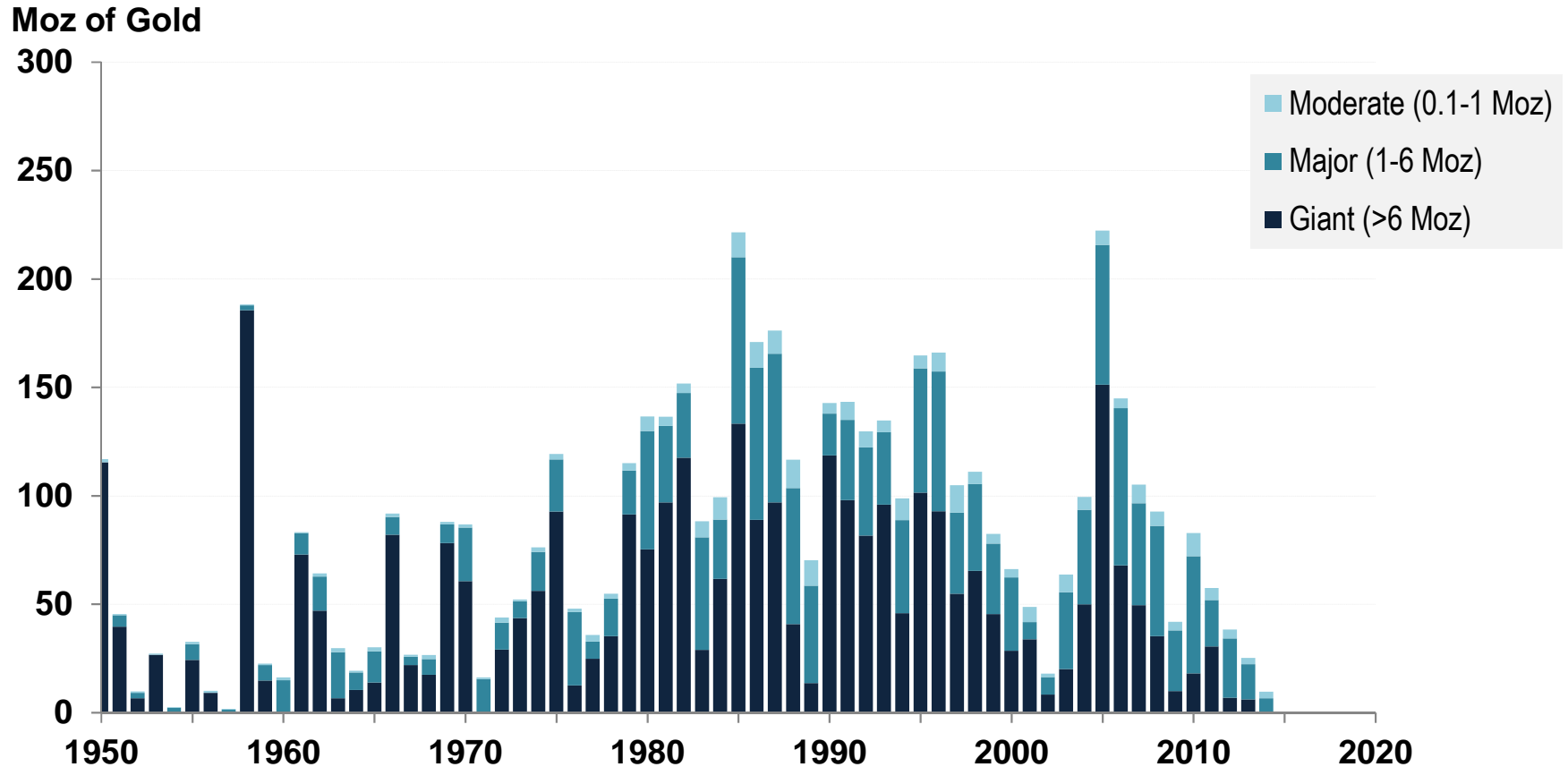


Note: Discoveries are for Primary gold deposits >0.1 Moz Au
Excludes satellite deposits within existing camps
Data from 2005 onwards have been adjusted for unreported discoveries

Source: MinEx Consulting © October 2015

Amount of Gold Discovered: World

Primary Gold by Size : 1950-2014

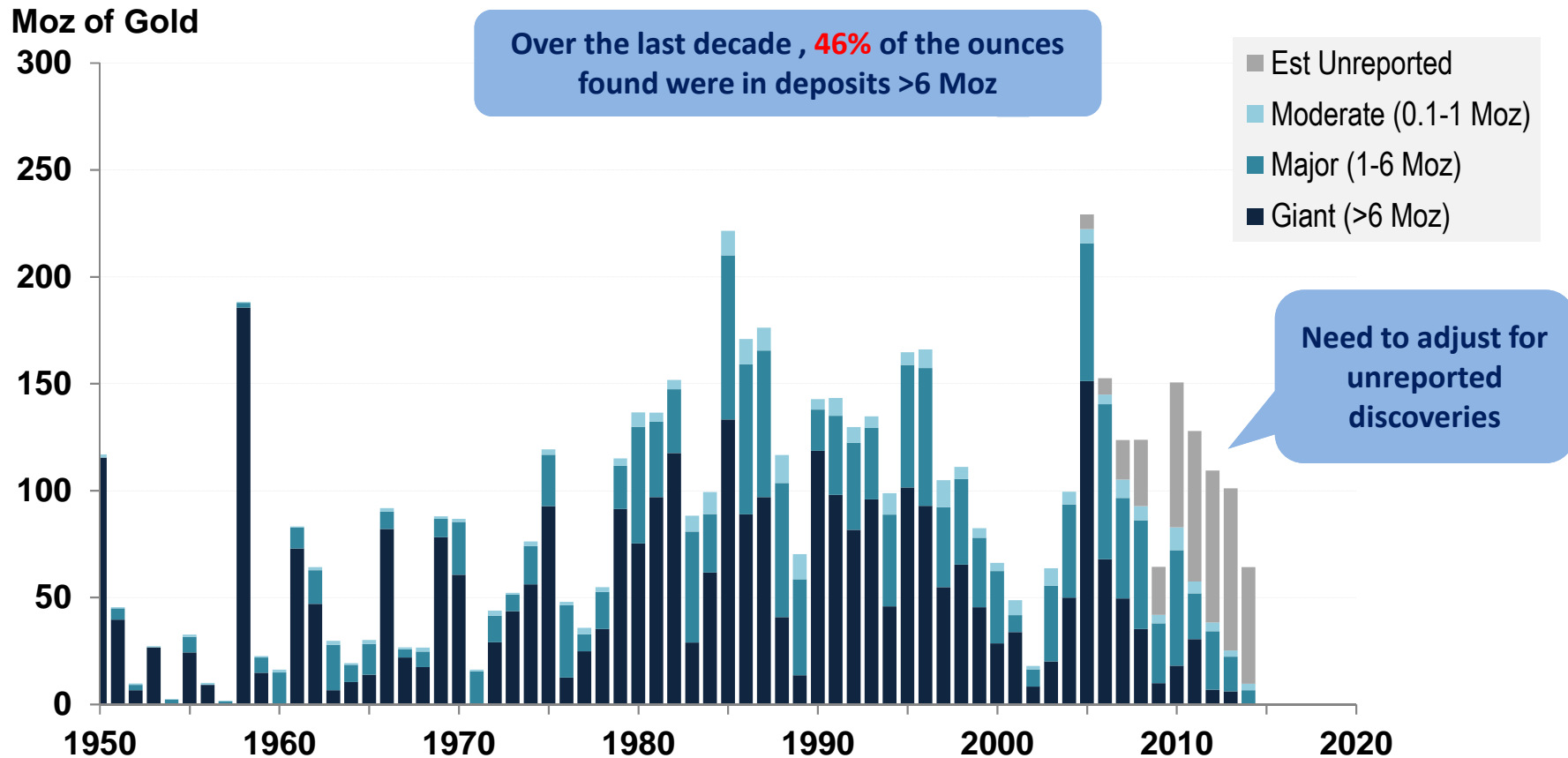


Note: Excludes by-product gold associated with base metal and other discoveries
Excludes satellite deposits within existing camps
Data from 2005 onwards have been adjusted for unreported discoveries

Source: MinEx Consulting © October 2015

Amount of Gold Discovered: World

Primary Gold by Size : 1950-2014



Note: Excludes by-product gold associated with base metal and other discoveries
Excludes satellite deposits within existing camps
Data from 2005 onwards have been adjusted for unreported discoveries

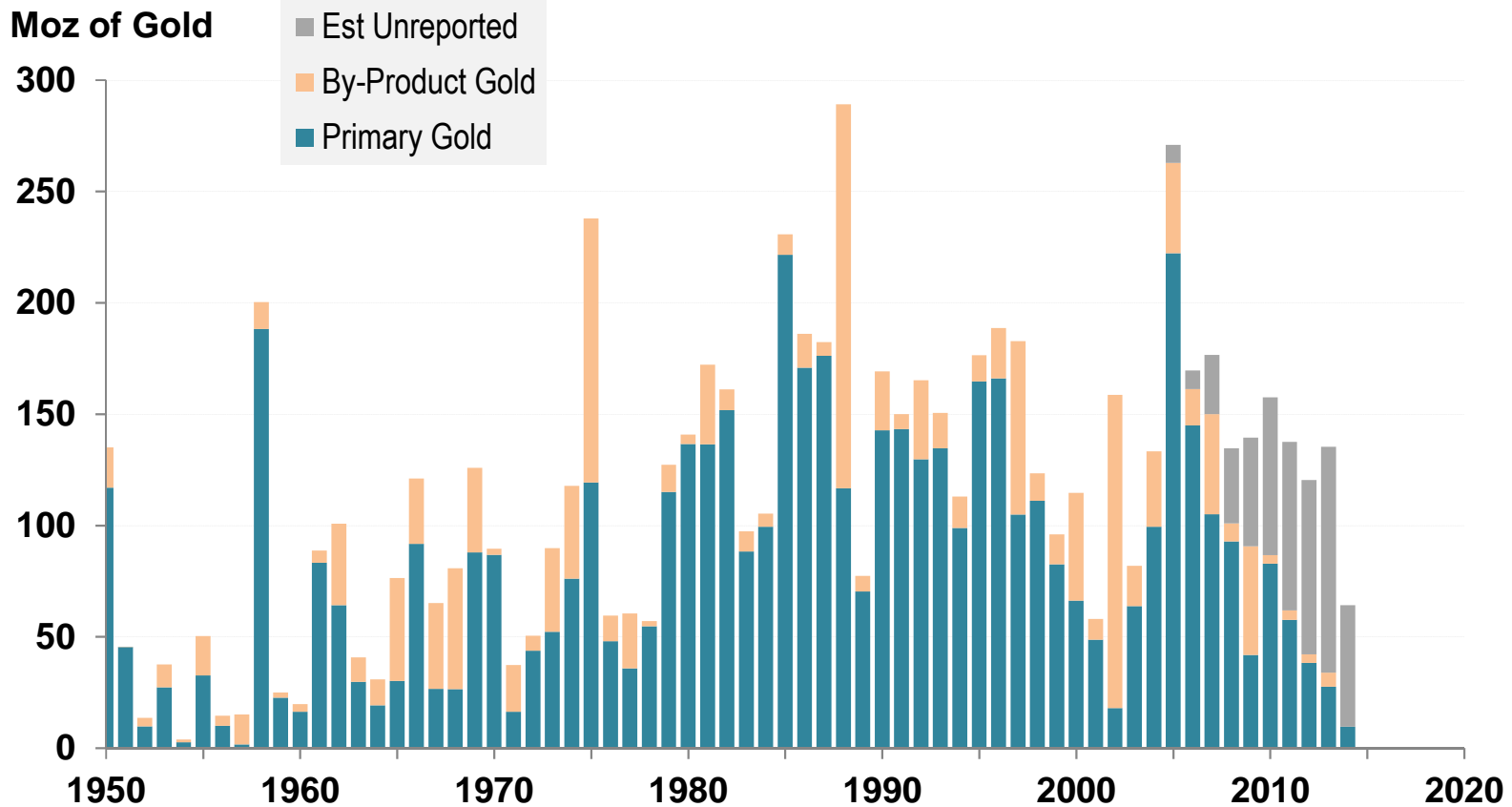
Source: MinEx Consulting © October 2015

Need to take into account by-Product Gold

Industry also finds gold in base-metal and other deposits

Amount of Gold Discovered: World

Primary & By-Product Gold : 1950-2014

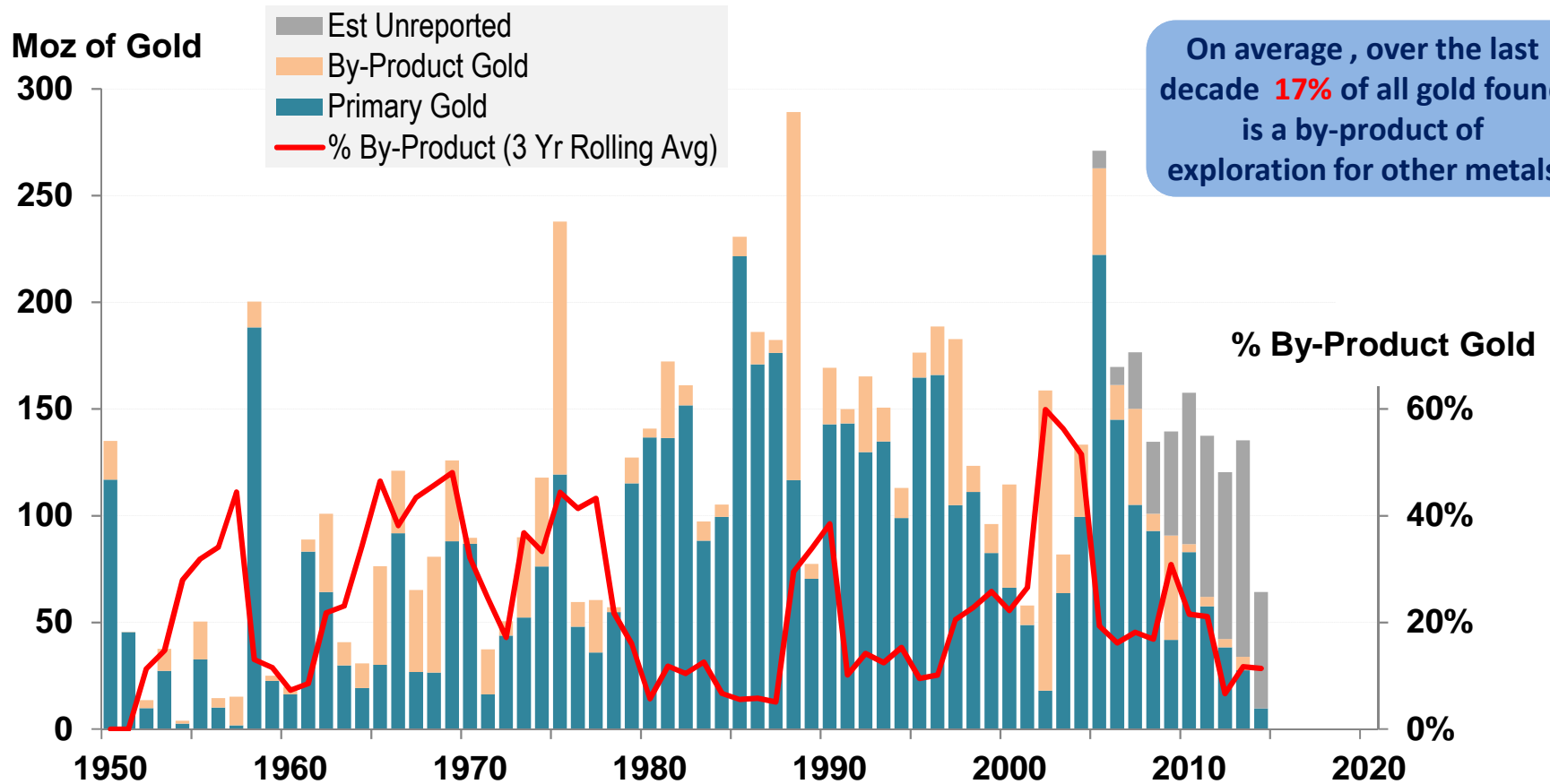


Note: Excludes satellite deposits within existing camps
 Data from 2005 onwards includes estimate for unreported discoveries

Source: MinEx Consulting © October 2015

Amount of Gold Discovered: World

Primary & By-Product Gold : 1950-2014

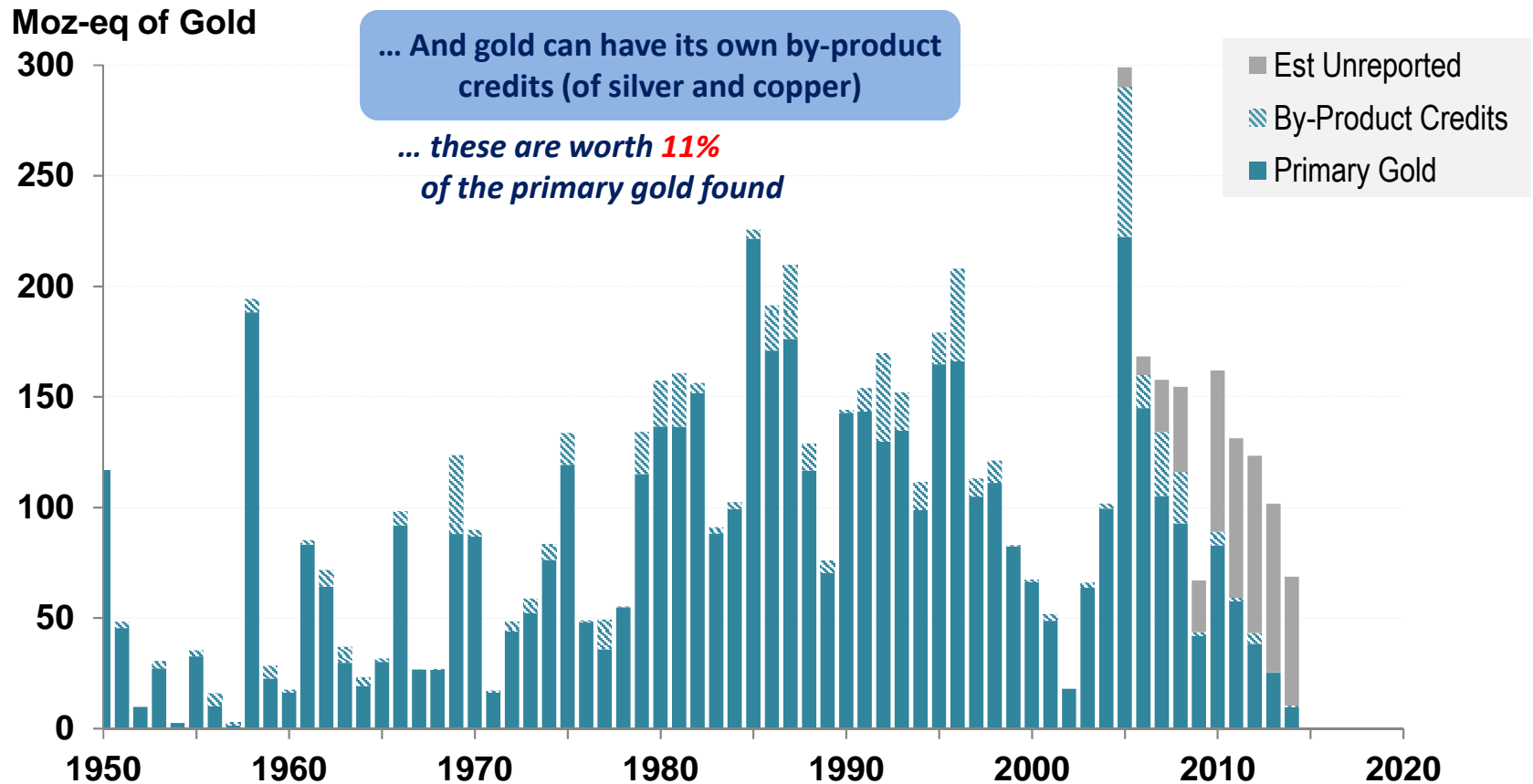


Note: Excludes satellite deposits within existing camps
 Data from 2005 onwards includes estimate for unreported discoveries

Source: MinEx Consulting © October 2015

Amount of Gold Discovered: World

Primary Gold plus associated By-Product Credits : 1950-2014



Note: Excludes by-product gold associated with base metal and other discoveries
Includes gold –equivalent value of base metal and other credits associated with the primary gold deposit
Data from 2005 onwards have been adjusted for unreported discoveries

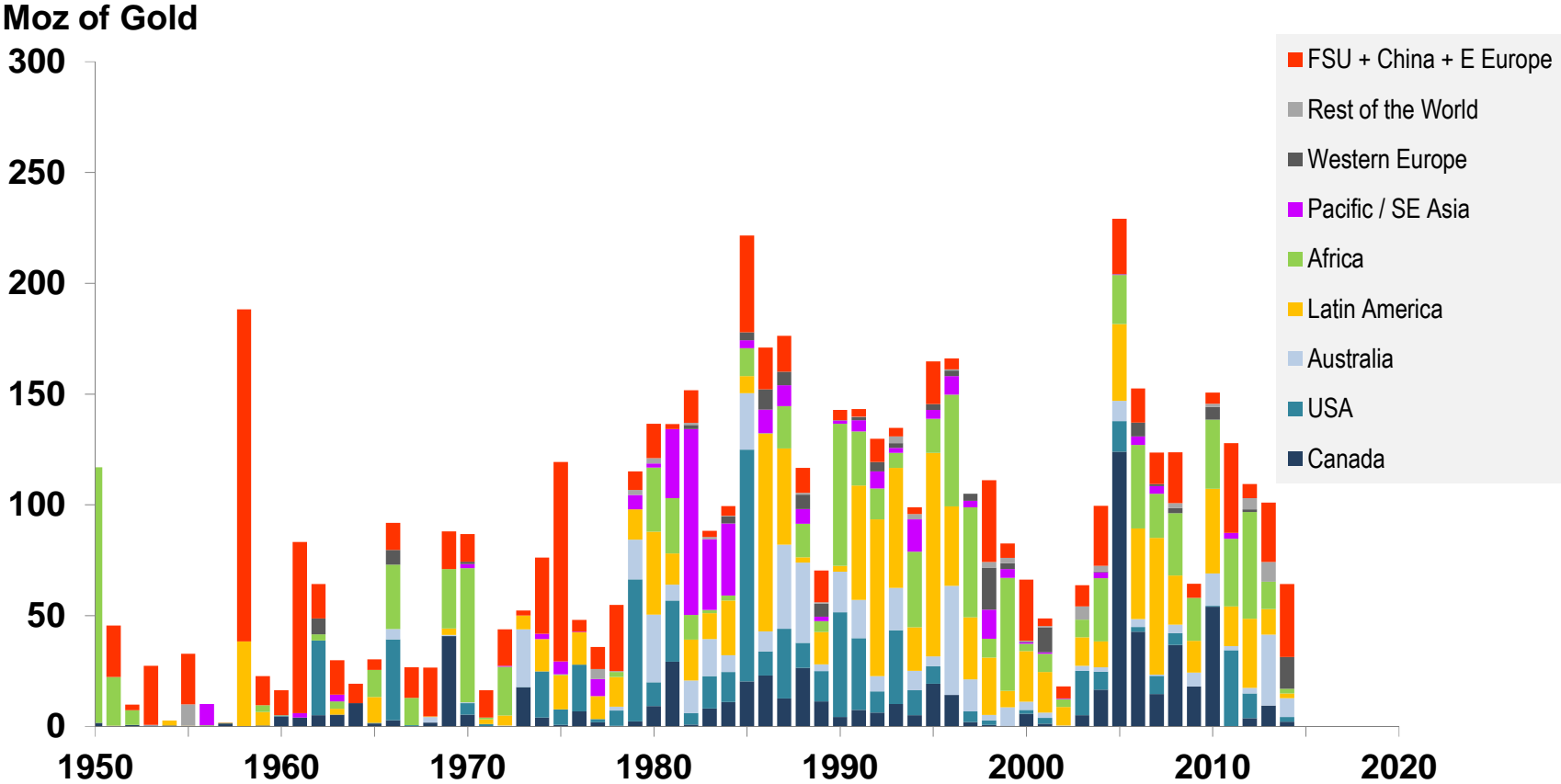
Source: MinEx Consulting © October 2015

There has been a progressive geographic shift in where gold is being discovered in the World

4. TRENDS IN THE LOCATION OF DISCOVERIES

Ounces discovered by Region

Primary Gold deposits found : 1950-2014



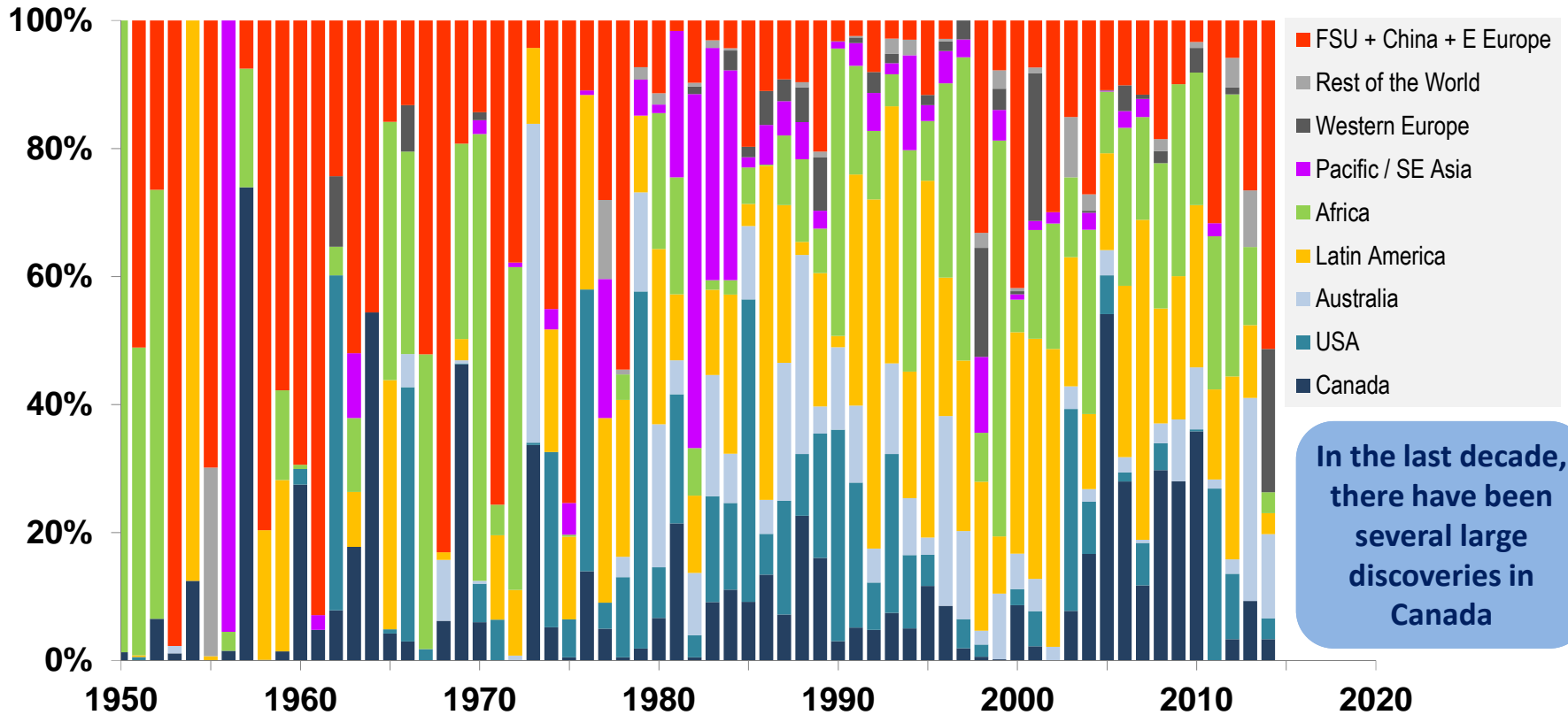
Note: Includes an adjustment for unreported discoveries in recent years
Excludes by-product credits

Source: MinEx Consulting © October 2015

Ounces discovered by Region

Primary Gold deposits found : 1950-2014

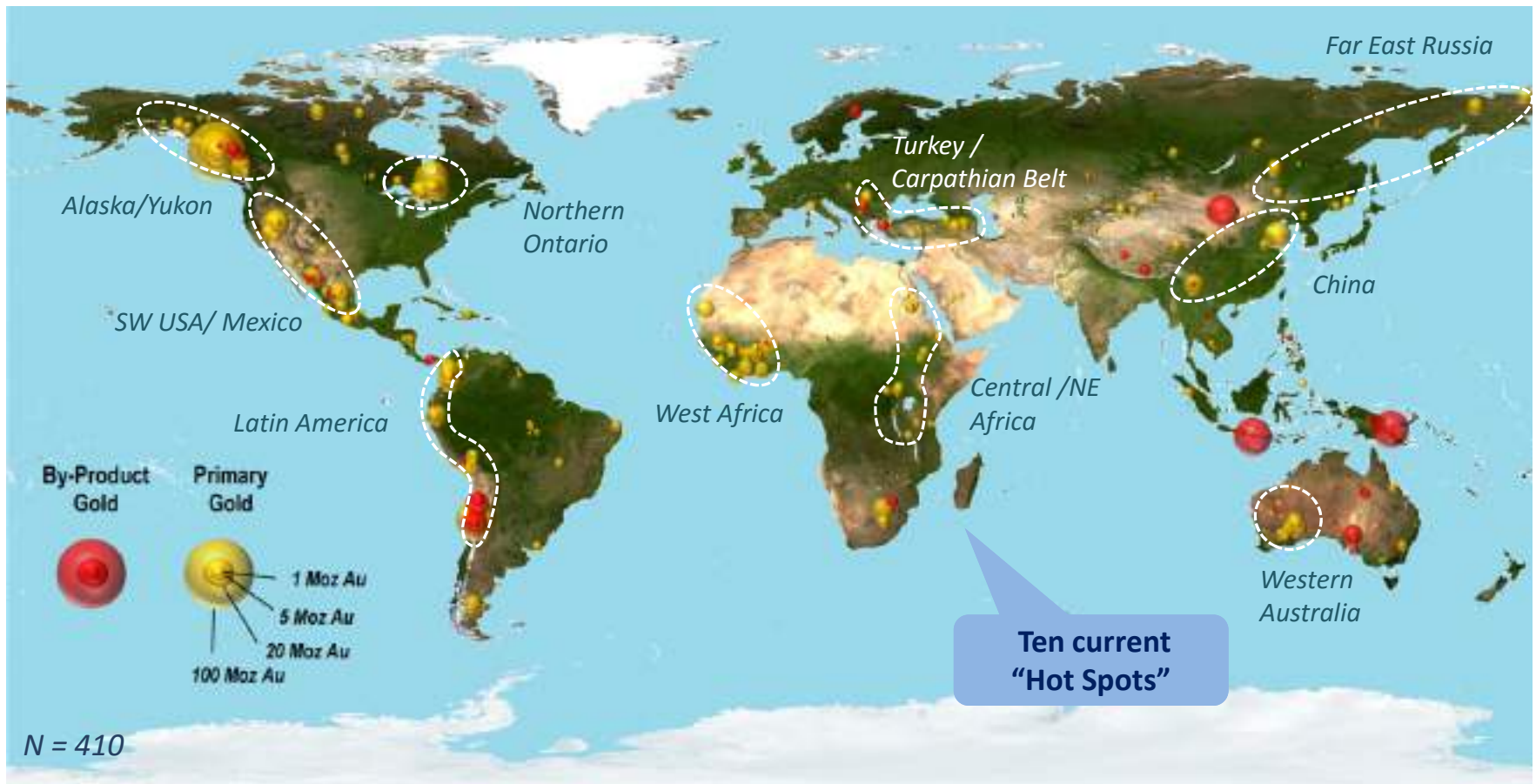
Percentage of ounces found



Note: Includes an adjustment for unreported discoveries in recent years
Excludes by-product credits

Source: MinEx Consulting © October 2015

Gold discoveries in the world: 2005-Present



Note: Based on deposits containing >0.1 Moz of gold

Source: MinEx Consulting © October 2015

Recent Tier 1 discoveries

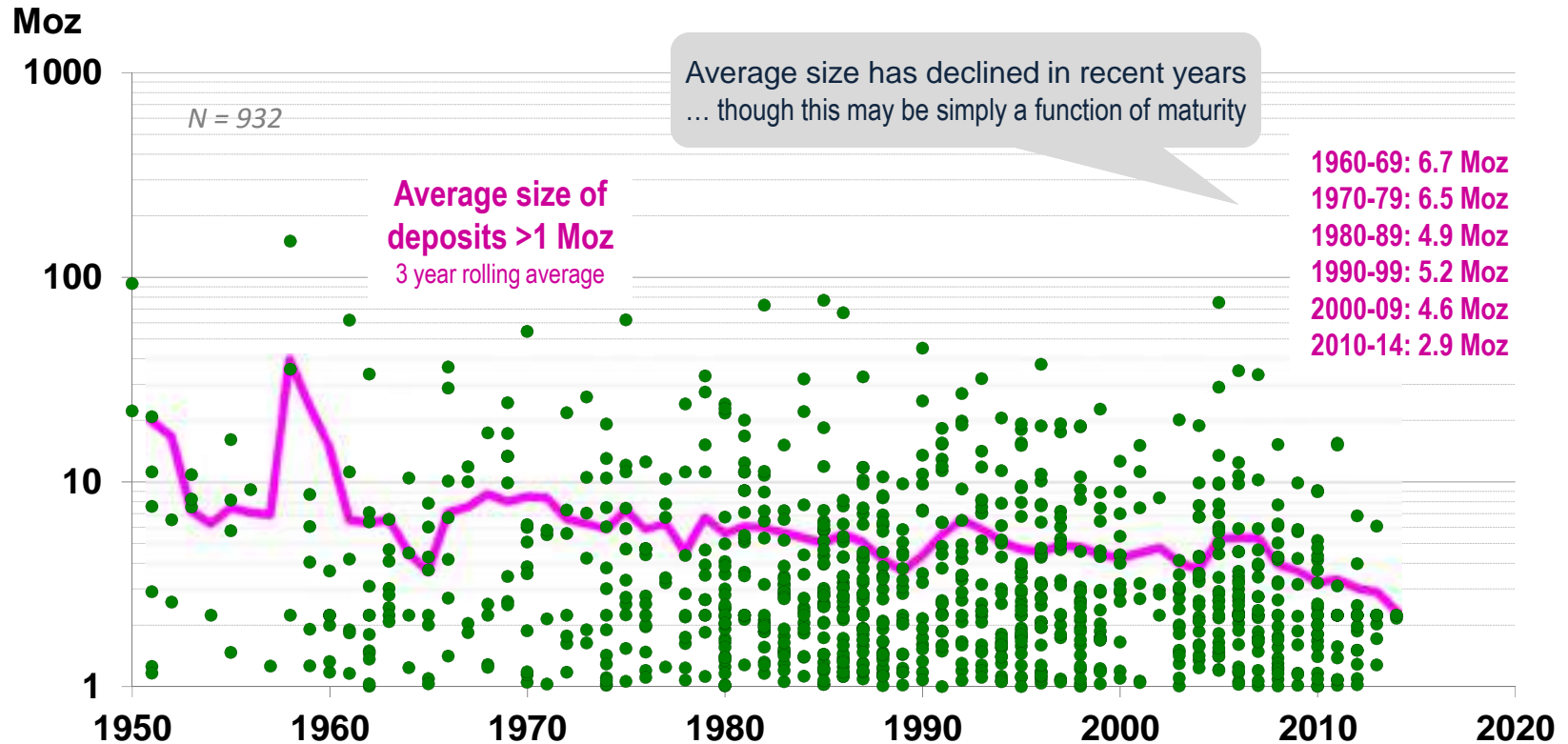
- Red Hill/Goldrush
 - Discovered in 2011 by Barrick next to its existing operation in Nevada. Current Resource is 96 Mt @ 5.0 g/t Au = 15.4 Moz
- Cote
 - Discovered in 2010 by Trelawney Mining & Exploration in Ontario. Current Resource is 331 Mt @ 0.80 g/t Au = 9.0 Moz
- Haiyu
 - Discovered in 2011 by Laizhou Ruihai in Shandong Province in China. Reported to contain 67 Mt @ 7.0 g/t = 15.1 Moz
 - A further 10 Moz has been found along strike in the district

There has been a slow decline in the size of deposits found.
Grades have remained fairly constant

5. TRENDS IN THE SIZE & GRADE OF GOLD DISCOVERIES

Trend in the average size of gold deposit discovered

All primary gold discoveries >1 Moz in the World: 1950-2014

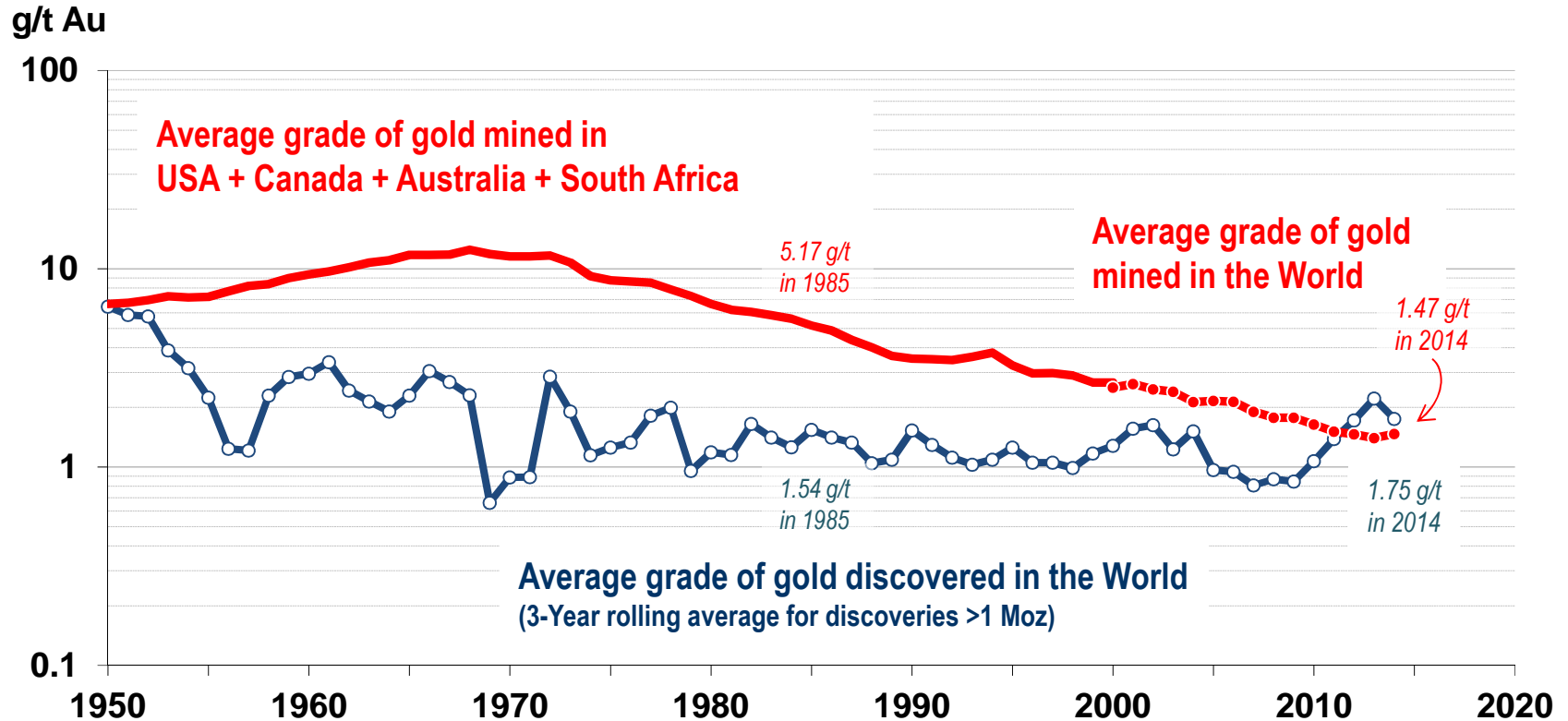


Note: Excludes deposits where gold is a by-product.
No adjustment made for growth in recent discoveries

Source: MinEx Consulting © October 2015

Trend in average ore grades

Average ore grade for all primary gold discoveries >1 Moz in the World
versus average head grade of ore mined



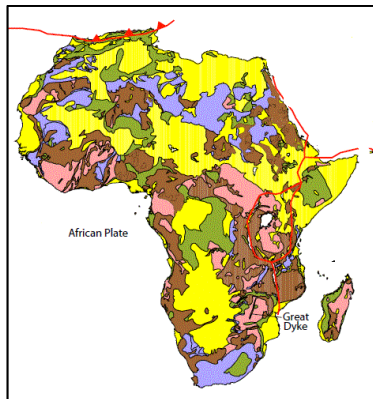
Note: Excludes deposits where gold is a by-product.
Also excludes artisanal mines and retreatment of waste dumps

Sources: MinEx Consulting © October 2015
Mudd (2010) for production data 1950-2000
MinEx Consulting for production data 2000-2014

6. TRENDS IN DISCOVERY METHODS

Trends in exploration methods

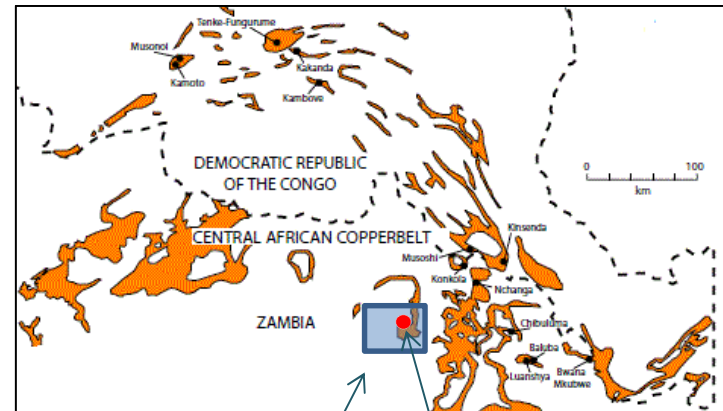
The preferred search method used varies by commodity type, depth of cover and "scale"



Continental-Scale



Province-Scale



District-Scale

Project-Scale

Prospect-Scale

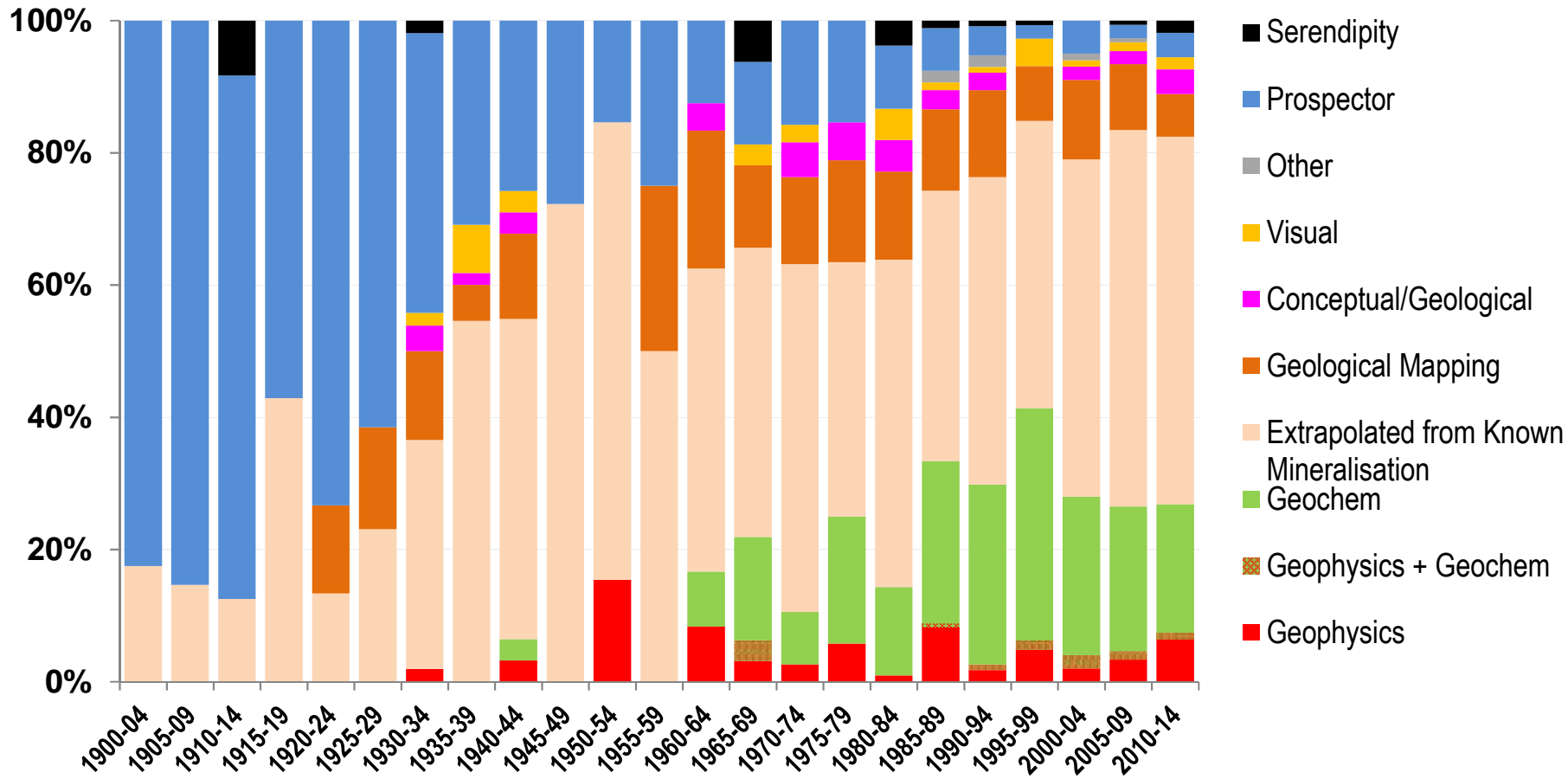
MinEx has carried out a detailed analysis of the discovery history of 1381 primary gold deposits at these two scales

Primary search method used at the project-scale

GOLD discoveries (>0.1 Moz) in the World: 1900-2014

ie What method was used to decide where to peg the leases

Percentage of total discoveries



Note: Analysis based on detailed analysis of 1381 primary gold projects (out of 2179 known discoveries)

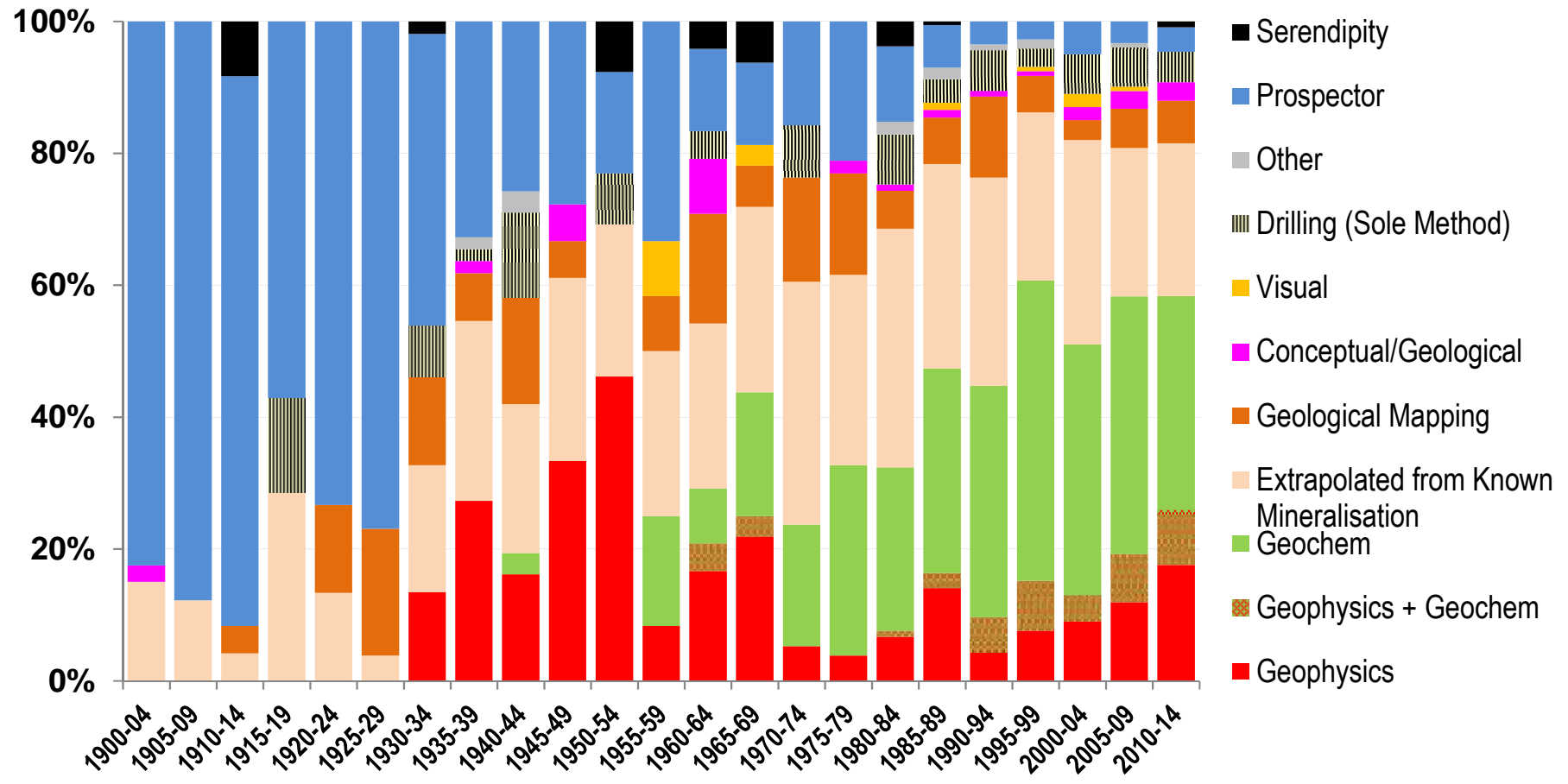
Source: MinEx Consulting © October 2015

Primary search method used at the prospect-scale

GOLD discoveries (>0.1 Moz) in the World: 1900-2014

ie What method was used to decide where to **drill the first hole**

Percentage of total discoveries



Note: Analysis based on detailed analysis of 1381 primary gold projects (out of 2179 known discoveries)

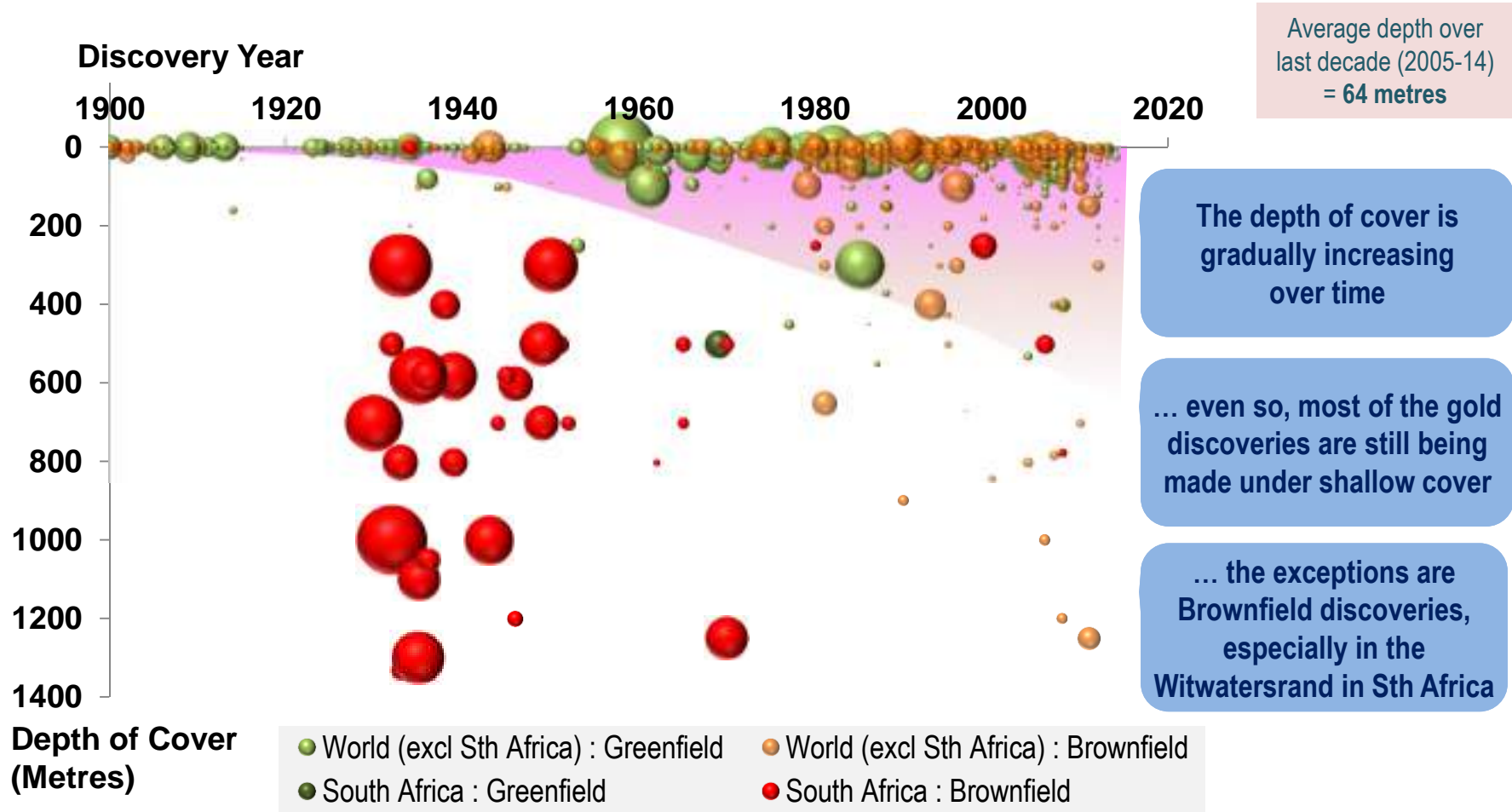
Source: MinEx Consulting © October 2015

We are progressively looking under deeper cover

7. TRENDS IN THE DEPTH OF COVER

We are exploring under progressively deeper cover

Depth of cover for discoveries in World: 1900-2014

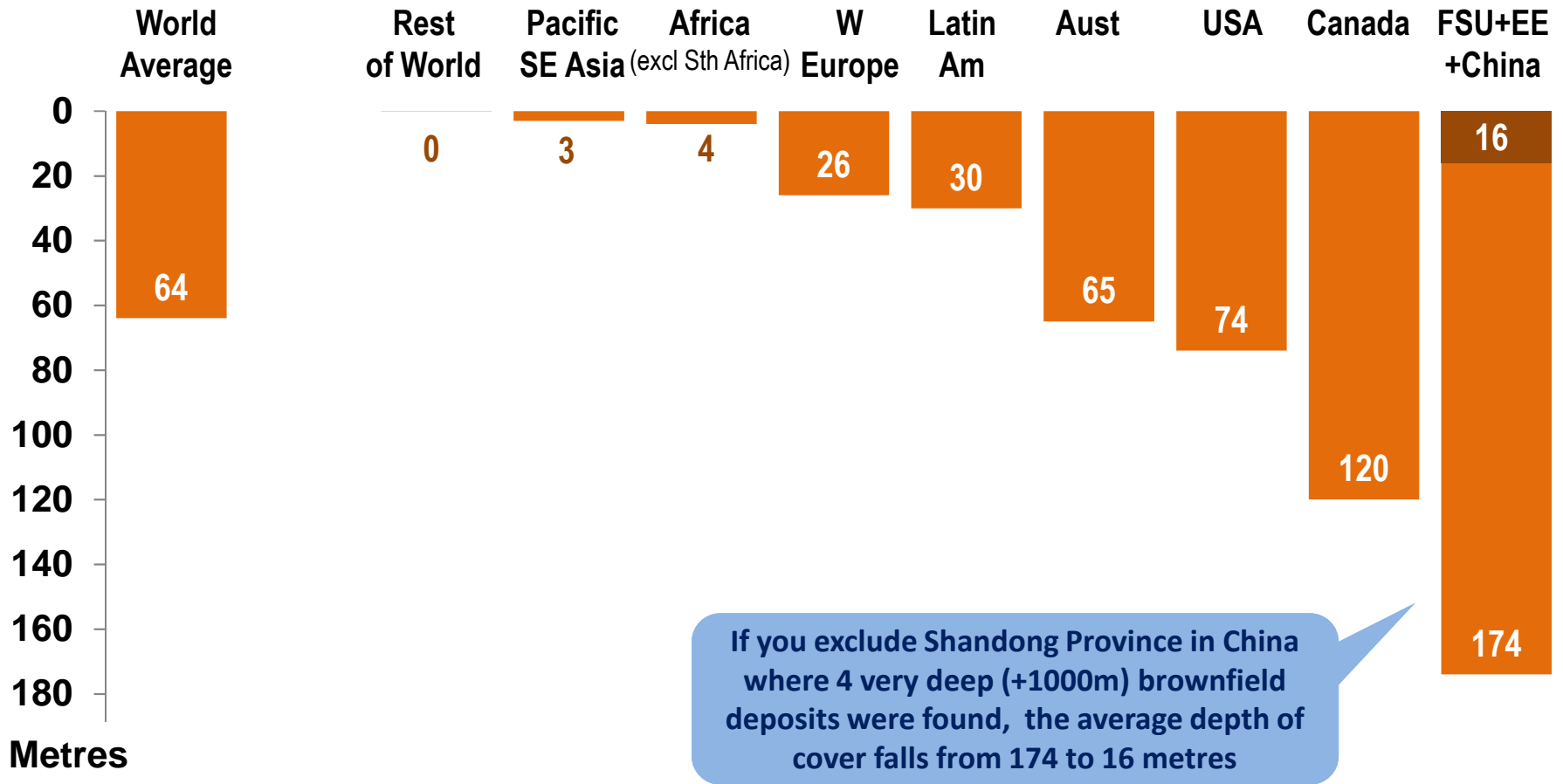


Note: Primary gold deposits > 0.1 Moz. Bubble size refers to Moz of pre-mined Resource
Excludes satellite deposits within existing Camps.

Source: MinEx Consulting © October 2015

Average depth of cover for gold discoveries

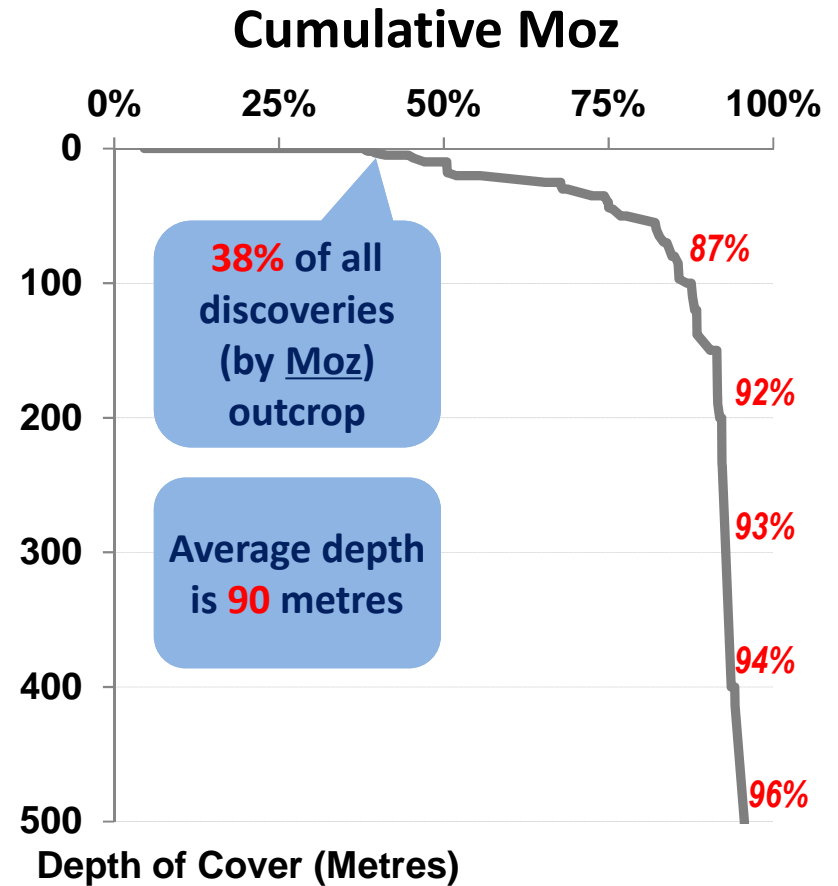
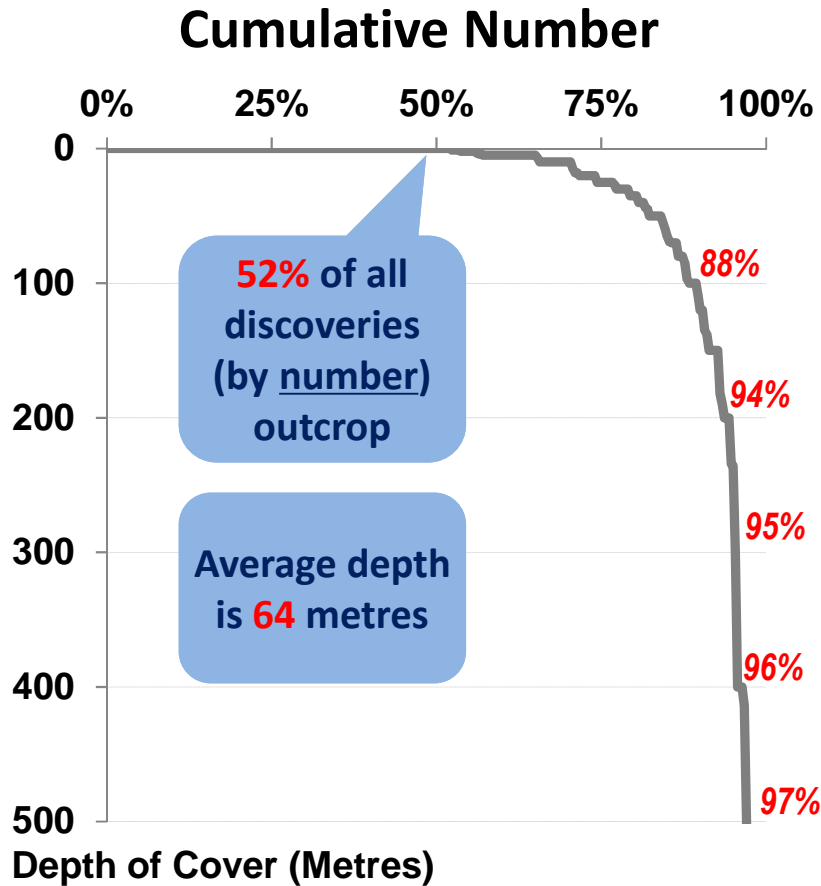
World: 2005-2014



Note: Based on 300 Primary gold deposits with reported depths and > 0.1 moz Au
Excludes satellite deposits in existing Camps

Source: MinEx Consulting © October 2015

Cumulative distribution of depth for primary gold deposits > 0.1 Moz found in the World in 2005-2014



Note: Analysis based on 300 deposits with known depth data and >0.1 Moz.
Includes both Greenfield and Brownfield discoveries

Source: MinEx Consulting © October 2015

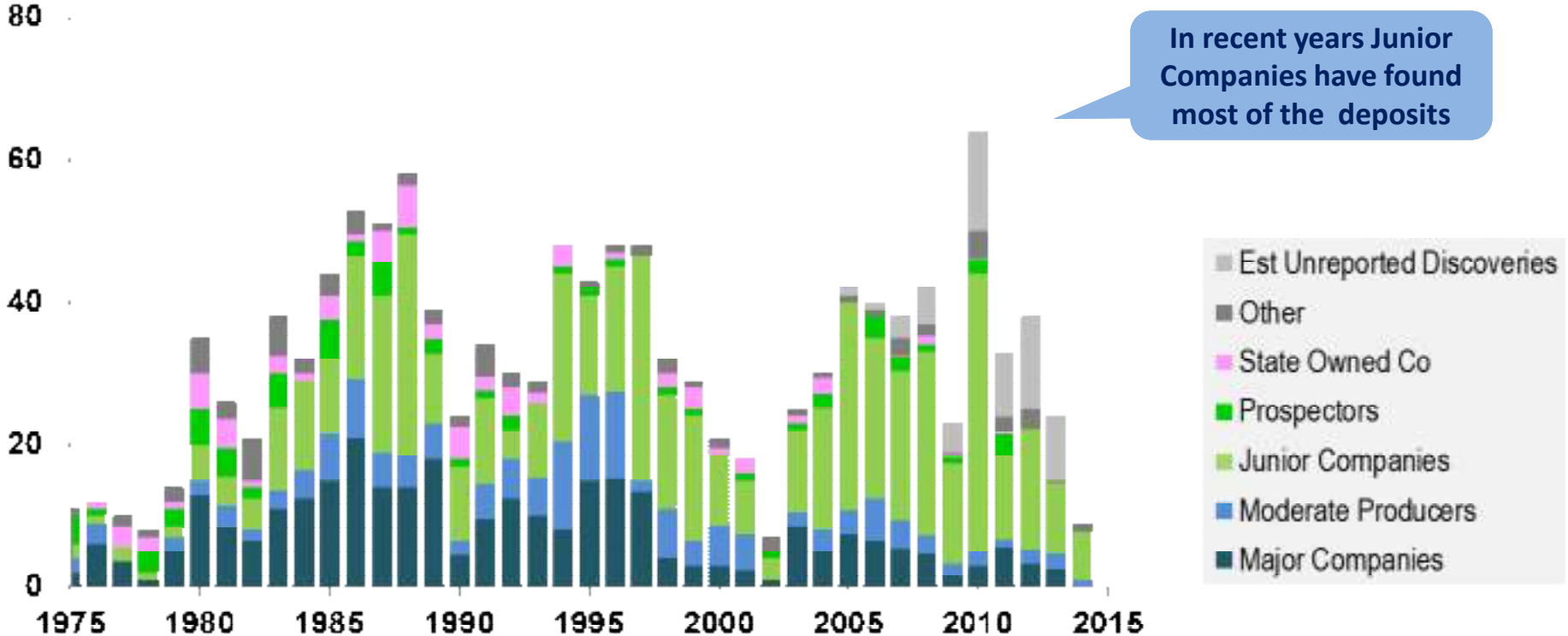
Majors versus Juniors

8. WHO MADE THE DISCOVERIES ?

Number of discoveries made by **Company Type**

Moderate+Major+Giant primary gold discoveries in Western World: 1975-2014

Number of Discoveries



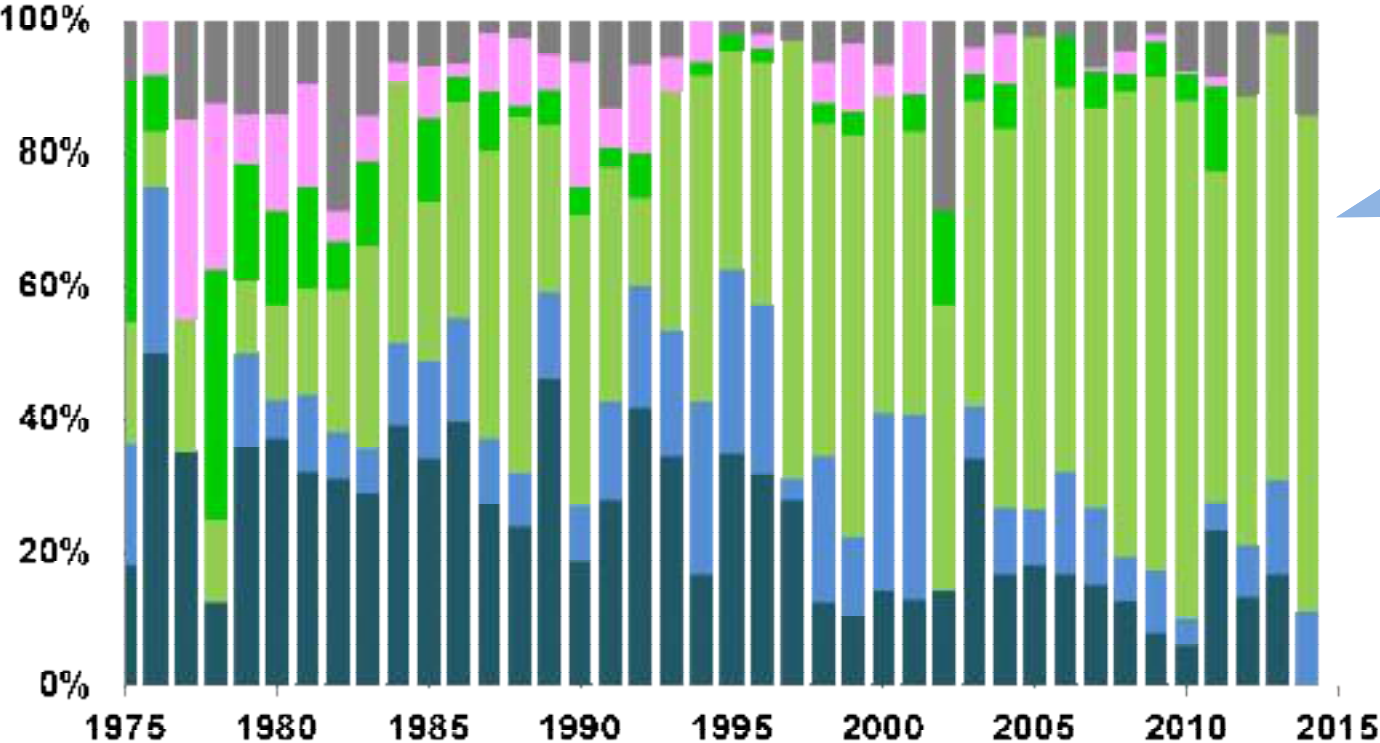
Note: Figures are adjusted for shared discoveries
Excludes satellite deposits within existing Camps

Source: MinEx Consulting © November 2015

Percentage of discoveries made by Company Type

Moderate+Major+Giant primary gold discoveries in Western World: 1975-2014

Number of Discoveries



Junior Companies now account for **65-75%** of all discoveries (**by number**) in the Western World

- Other
- State Owned Co
- Prospectors
- Junior Companies
- Moderate Producers
- Major Companies

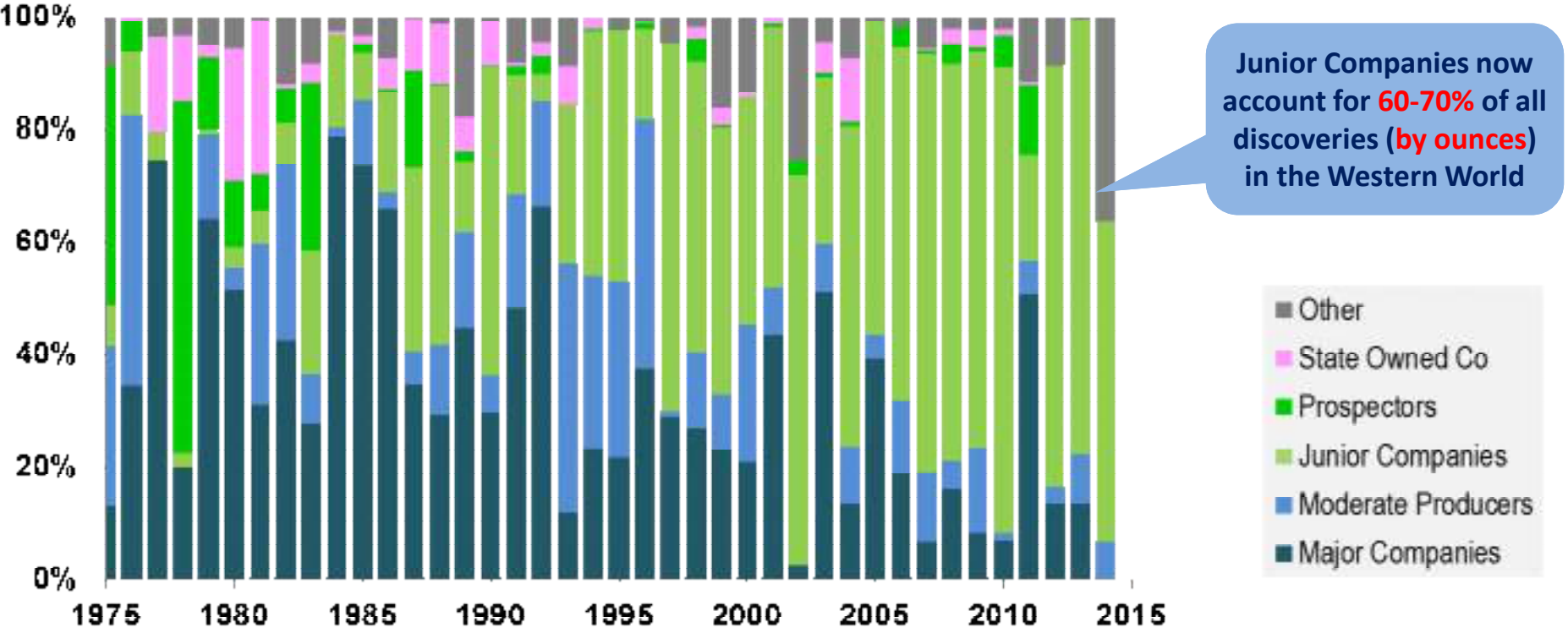
Note: Figures are adjusted for shared discoveries
Excludes satellite deposits within existing Camps

Source: MinEx Consulting © November 2015

Percentage of Ounces found by **Company Type**

Moderate+Major+Giant primary gold discoveries in Western World: 1975-2014

Number of Discoveries



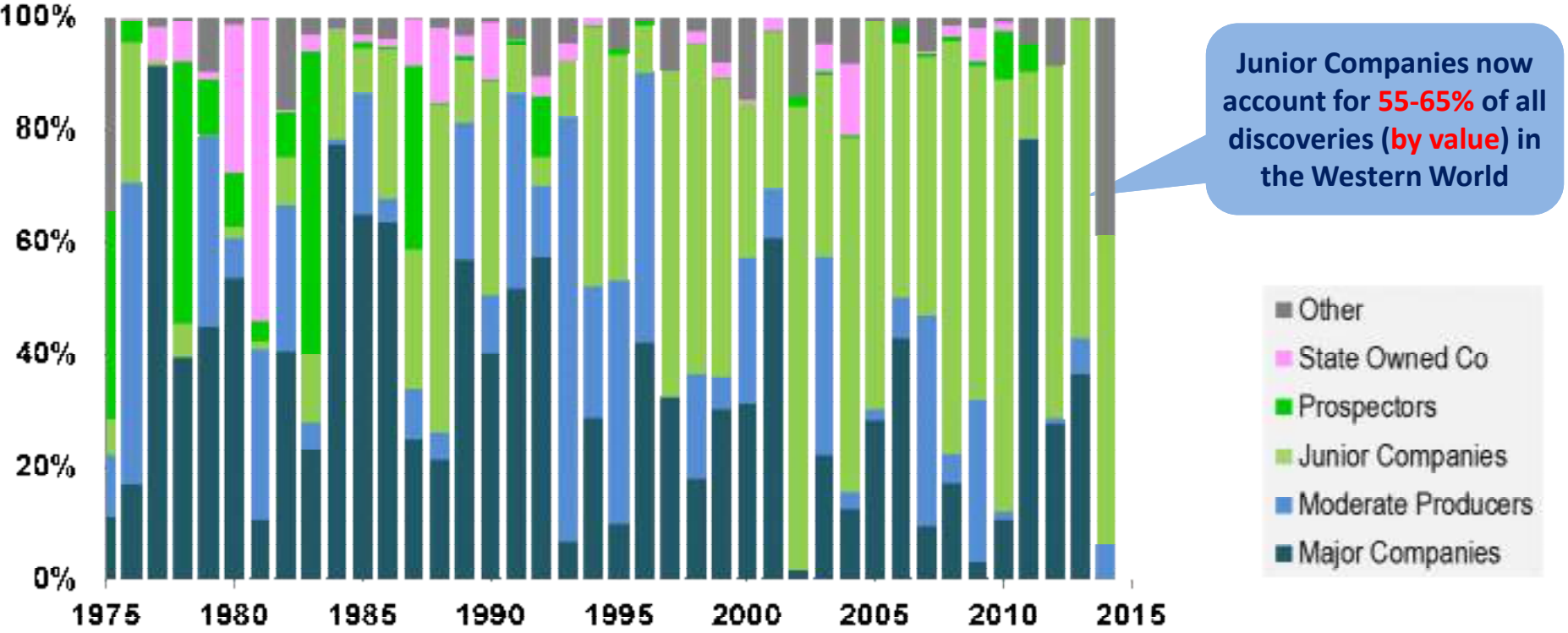
Note: Figures are adjusted for shared discoveries
Excludes satellite deposits within existing Camps

Source: MinEx Consulting © November 2015

Value created made by **Company Type**

Moderate+Major+Giant discoveries in Australia: 1975-2014

Value of Discoveries



Note: Figures are adjusted for shared discoveries

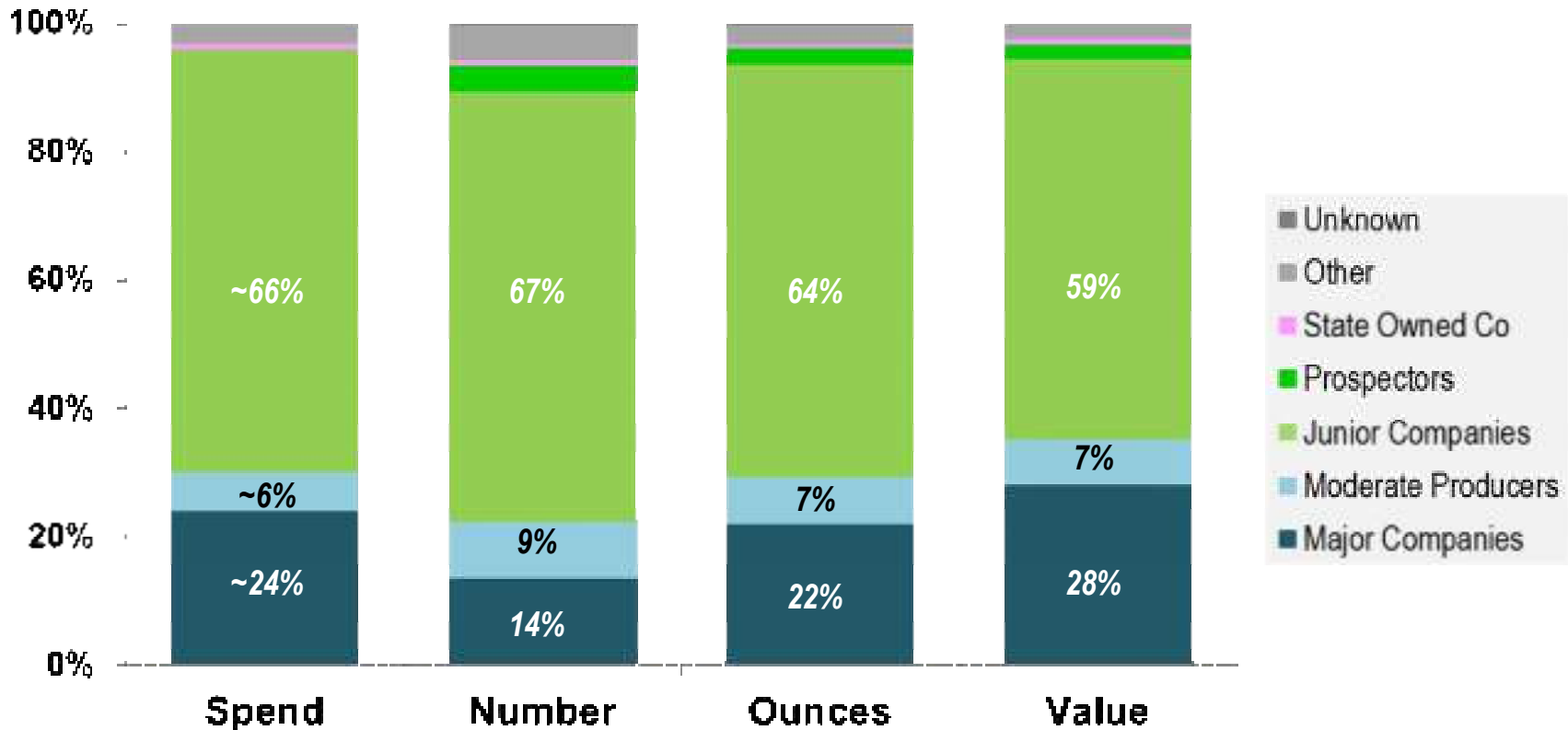
Excludes satellite deposits within existing Camps

Assumes an average value of US\$2000m for Tier-1, \$500m for Tier-2, \$80m for Tier-3 and \$10m for Other discoveries

Source: MinEx Consulting © November 2015

Majors versus Juniors

Western World: 2005-2014



Note: Figures are adjusted for shared discoveries
 Excludes satellite deposits within existing Camps
 Exploration expenditures are approximate only

Source: MinEx Consulting © November 2015

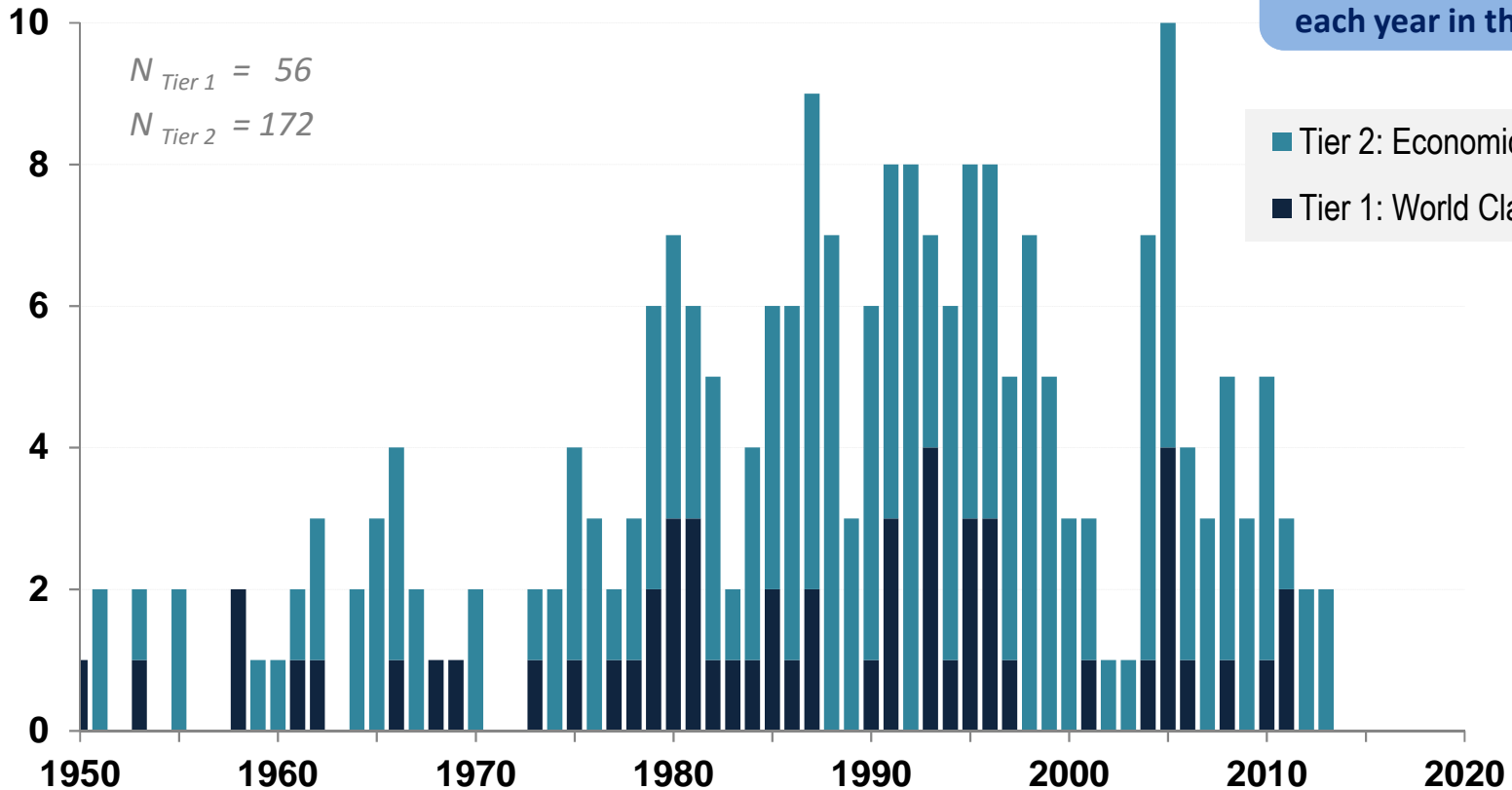
Tier 1 discoveries are rare but valuable

9. TRENDS IN THE QUALITY OF DISCOVERIES

Number of Tier 1 & 2 Gold Discoveries: World

Primary Gold Deposits: 1950-2014

Number of Deposits



On average, only 2-3 Tier 1&2 discoveries are made each year in the World

Note: Primary gold deposits only
 Caution: No adjustment made for unreported discoveries

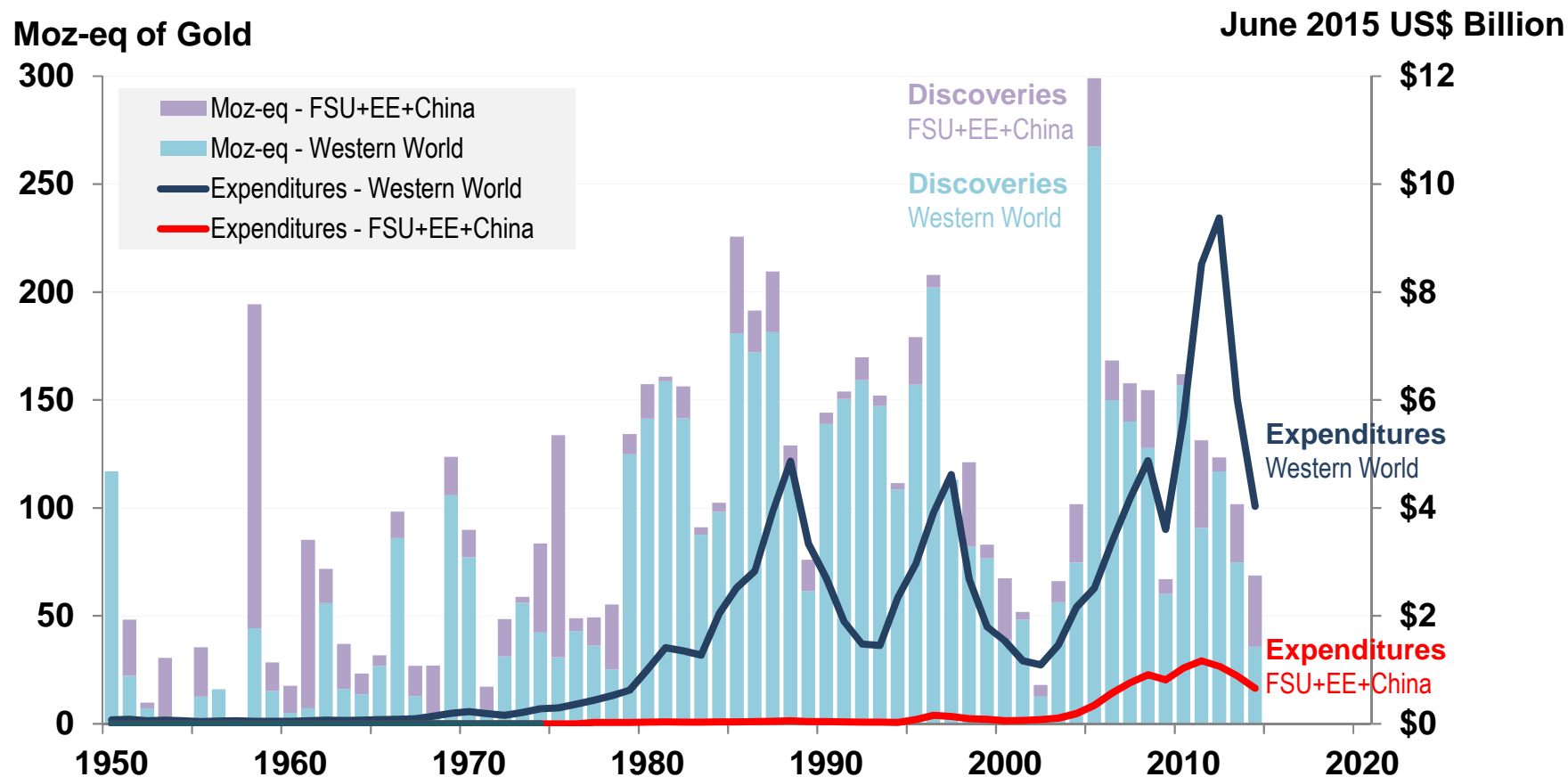
Source: MinEx Consulting © October 2015

Discovery cost per ounce has doubled in the last decade

10. TRENDS IN UNIT DISCOVERY COSTS

Exploration Expenditures and Gold Discovered

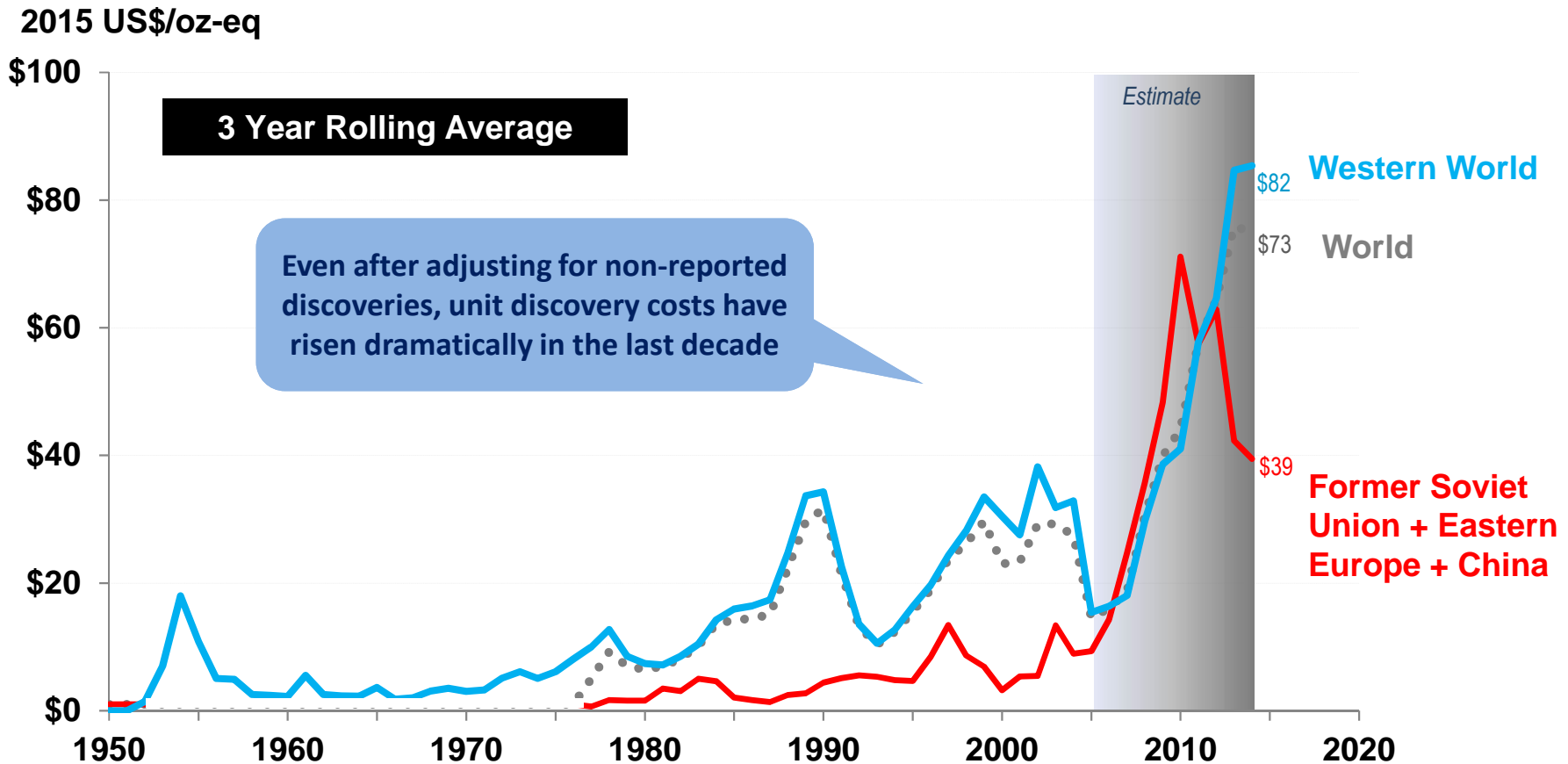
Primary Gold : 1950-2014



Note: Primary gold discoveries only, adjusted for Cu, Ag and Other by-product credits
 Data from 2005 onwards have been adjusted for unreported discoveries
 No expenditure data available for The FSU + Eastern Europe + China prior to 1975

Source: MinEx Consulting © October 2015

Unit Discovery Costs for Gold : 1950-2014



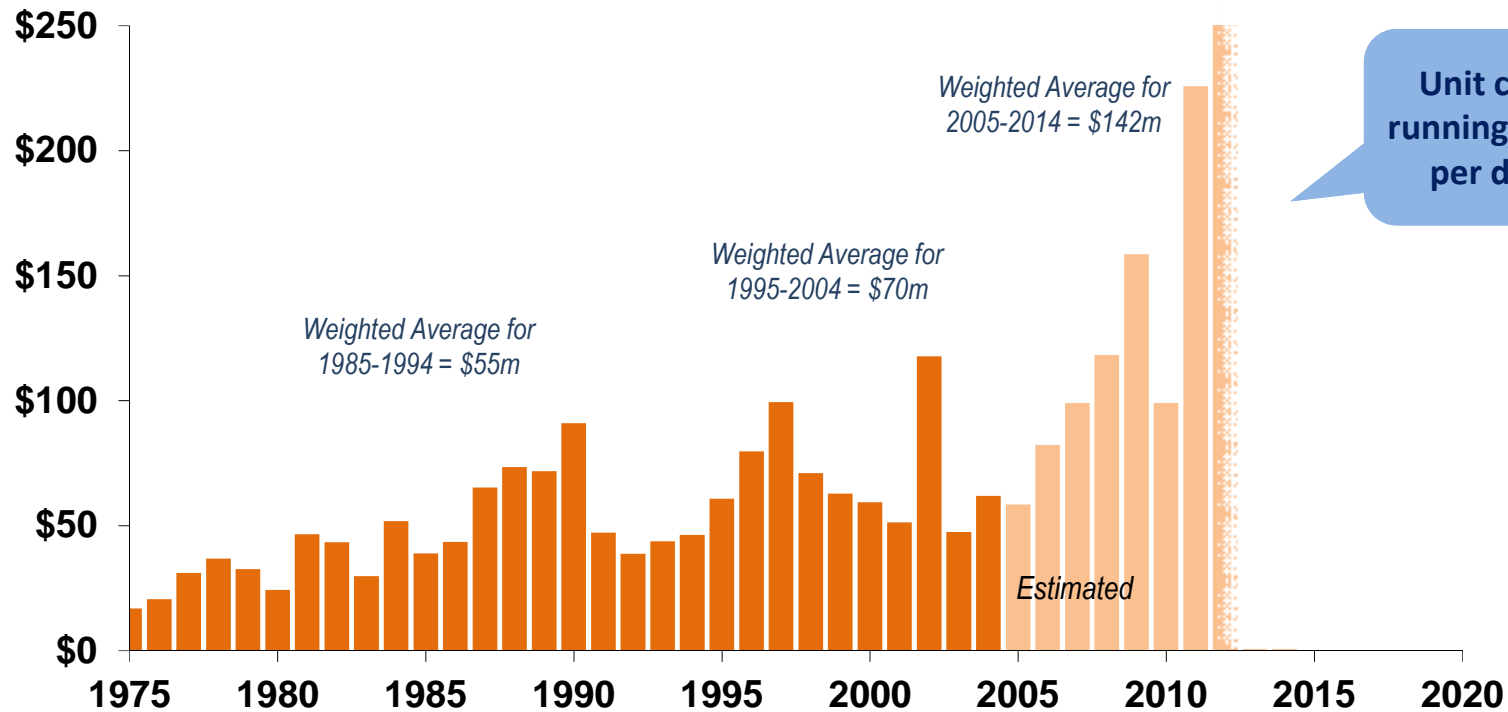
Note Includes value of by-product credits from other metals associated with the primary gold deposit
 Data from 2005 onwards have been adjusted for unreported discoveries

Source: MinEx Consulting © October 2015

Trend in Unit Discovery costs: 1975-2014

Western World Primary Gold Deposits > 0.1 Moz

Average Cost per Discovery (2015 US\$m)



Note: Discoveries are for Primary gold deposits >0.1 Moz Au
Data from 2005 onwards have been adjusted for unreported discoveries

Source: MinEx Consulting © October 2015

Discovery performance by Region: 2005-2014

Canada had lowest discovery costs, PAC/SEA was highest

Region	Explorn Spend (2015 \$b)		Adjusted No of Discoveries		Adjusted Moz found				Avg Size Moz-eq	Cost US\$/oz-eq
					Au	BP Credits	Moz-eq			
Australia	\$5.3	9%	48	11%	83	4	86	6%	1.8	\$61
Canada	\$11.6	19%	46	11%	306	75	380	27%	8.3	\$31
USA	\$5.7	9%	19	4%	78	3	80	6%	4.2	\$71
Latin America	\$14.4	24%	82	19%	275	78	353	25%	4.3	\$41
Pacific/SE Asia	\$4.0	7%	10	2%	10	2	12	1%	1.2	\$334
Africa	\$9.5	16%	128	30%	252	1	252	18%	2.0	\$38
W Europe	\$1.4	2%	16	4%	31	5	36	3%	2.3	\$38
FSU+EE+China	\$8.2	14%	64	15%	196	17	213	15%	3.3	\$38
Rest of World	\$0.5	1%	7	2%	18	3	21	1%	2.9	\$26
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
TOTAL	\$60.5	100%	420	100%	1246	187	1433	100%	3.4	\$42

Note:..Includes adjustment for unreported discoveries

Source: MinEx Consulting © November 2015

Discovery performance by Region: Spend & performance by Region: 2005-2014

PAC/SEA was **below average**. Canada performed **best**

i.e. "Bang-per-Buck"

Region	Exploration Spend (2014 \$b)		No of Discoveries #		Tier 1+2 Discoveries		Estimated Value (2015 \$b)		Value / Spend
	\$	%		%		%	\$	%	
Australia	\$5.3	9%	48	11%	5	14%	\$4.6	11%	0.87
Canada	\$11.6	19%	46	11%	9	24%	\$11.1	27%	0.96
USA	\$5.7	9%	19	4%	3	8%	\$2.8	7%	0.49
Latin America	\$14.4	24%	82	19%	10	27%	\$8.3	20%	0.57
Pacific/SE Asia	\$4.0	7%	10	2%	0	0%	\$0.4	1%	0.09
Africa	\$9.5	16%	128	30%	6	16%	\$6.3	16%	0.67
W Europe	\$1.4	2%	16	4%	0	0%	\$0.5	1%	0.36
FSU+EE+China	\$8.2	14%	64	15%	4	11%	\$6.7	16%	0.82
Rest of World	\$0.5	1%	7	2%	0	0%	\$0.2	1%	0.43
	-----	-----	-----	-----	-----	-----	-----	-----	-----
TOTAL	\$60.5	100%	360	100%	79	100%	\$40.9	100%	0.68

Note: Estimated values are **indicative** only

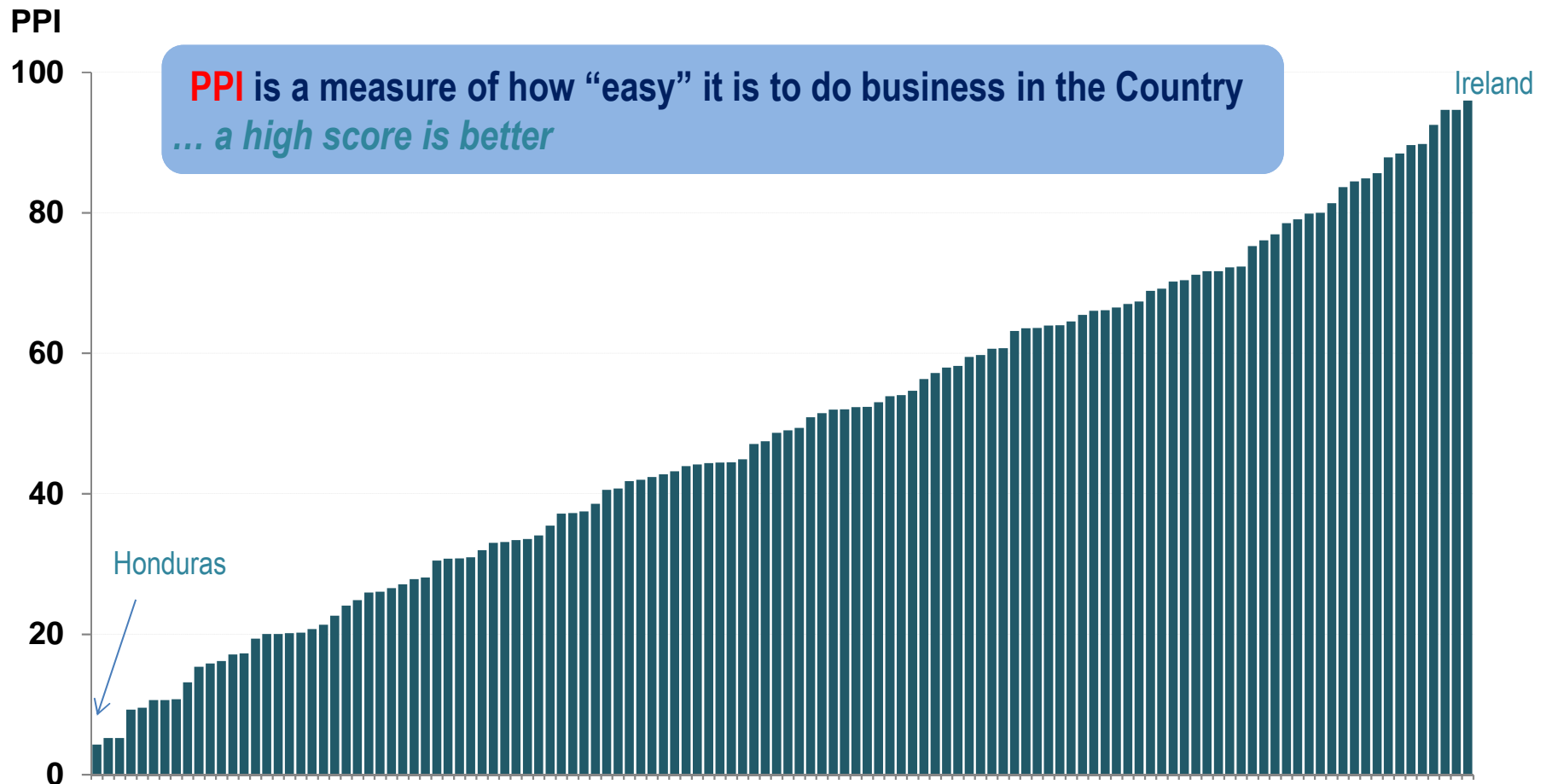
Source: MinEx Consulting © November 2015

The expectation is that companies should generate a better return from operating in riskier countries

11. TRENDS IN COUNTRY RISK

Policy Perception Index: March 2015

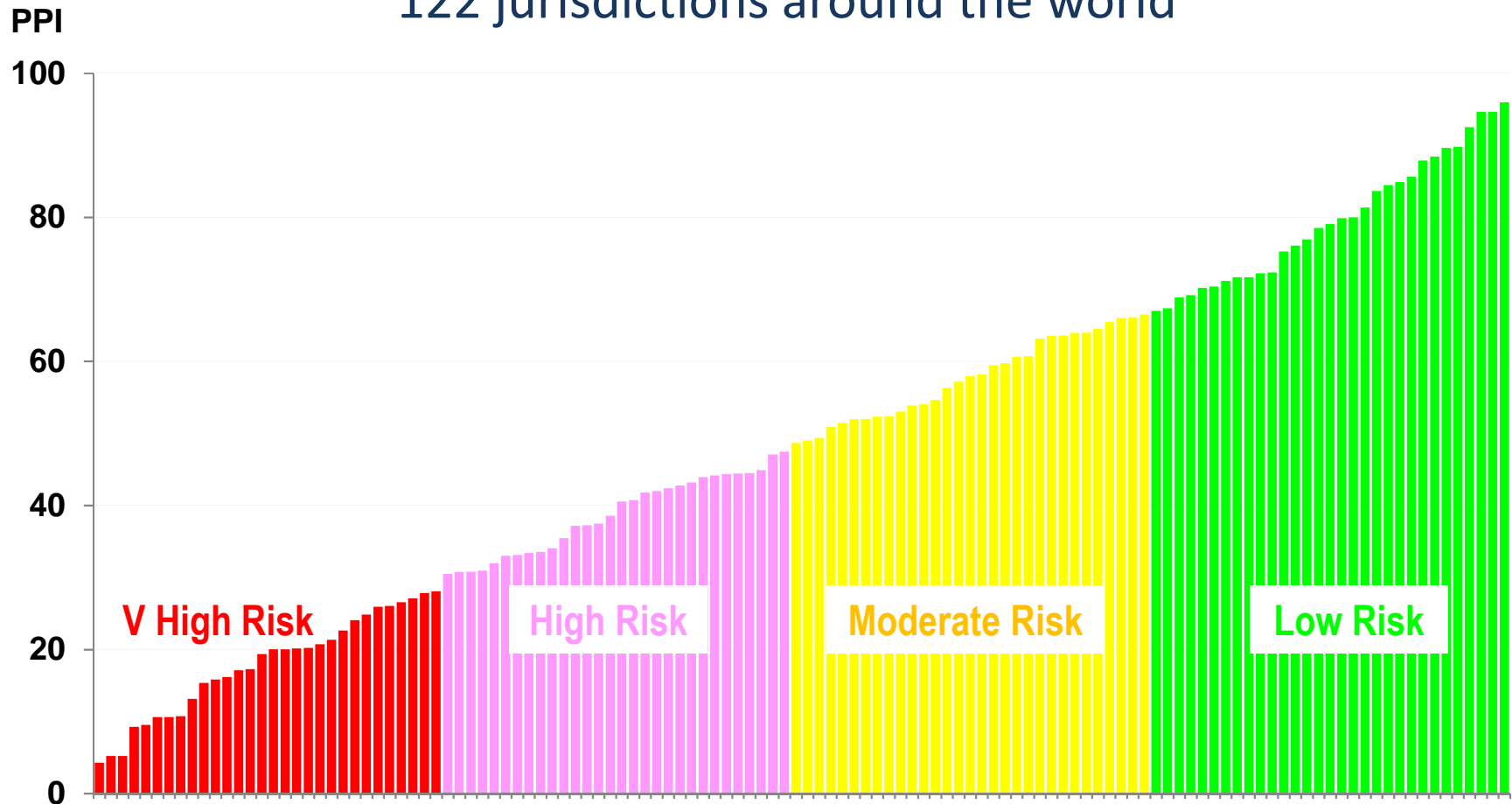
122 jurisdictions around the world



Source: Fraser Institute March 2015

Policy Perception Index: March 2015

122 jurisdictions around the world

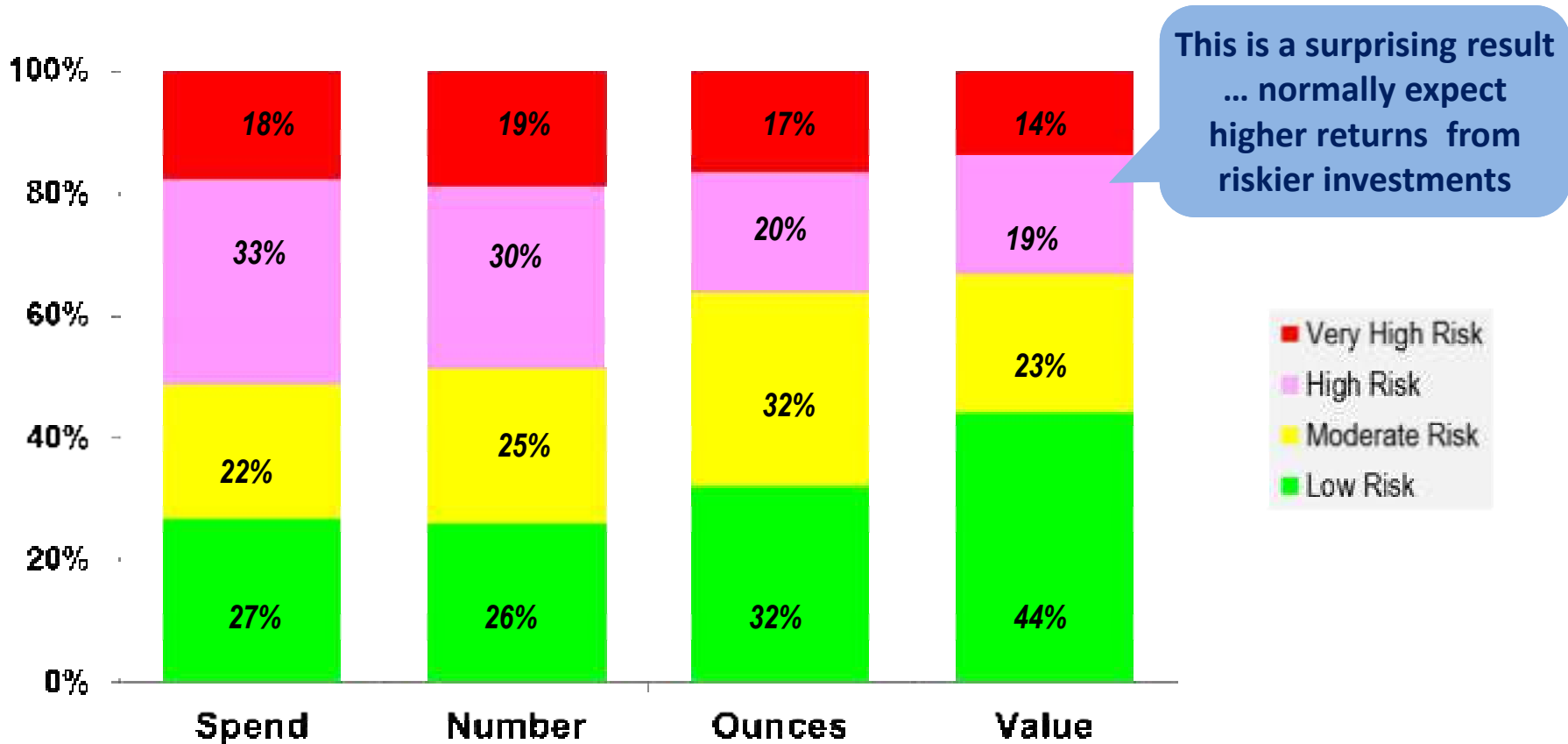


Note: Ratings will change from year to year

Source: Fraser Institute March 2015

Country Risk versus Reward

Western World: 2005-2014



Note: Excludes FSU and China

Source: MinEx Consulting © November 2015

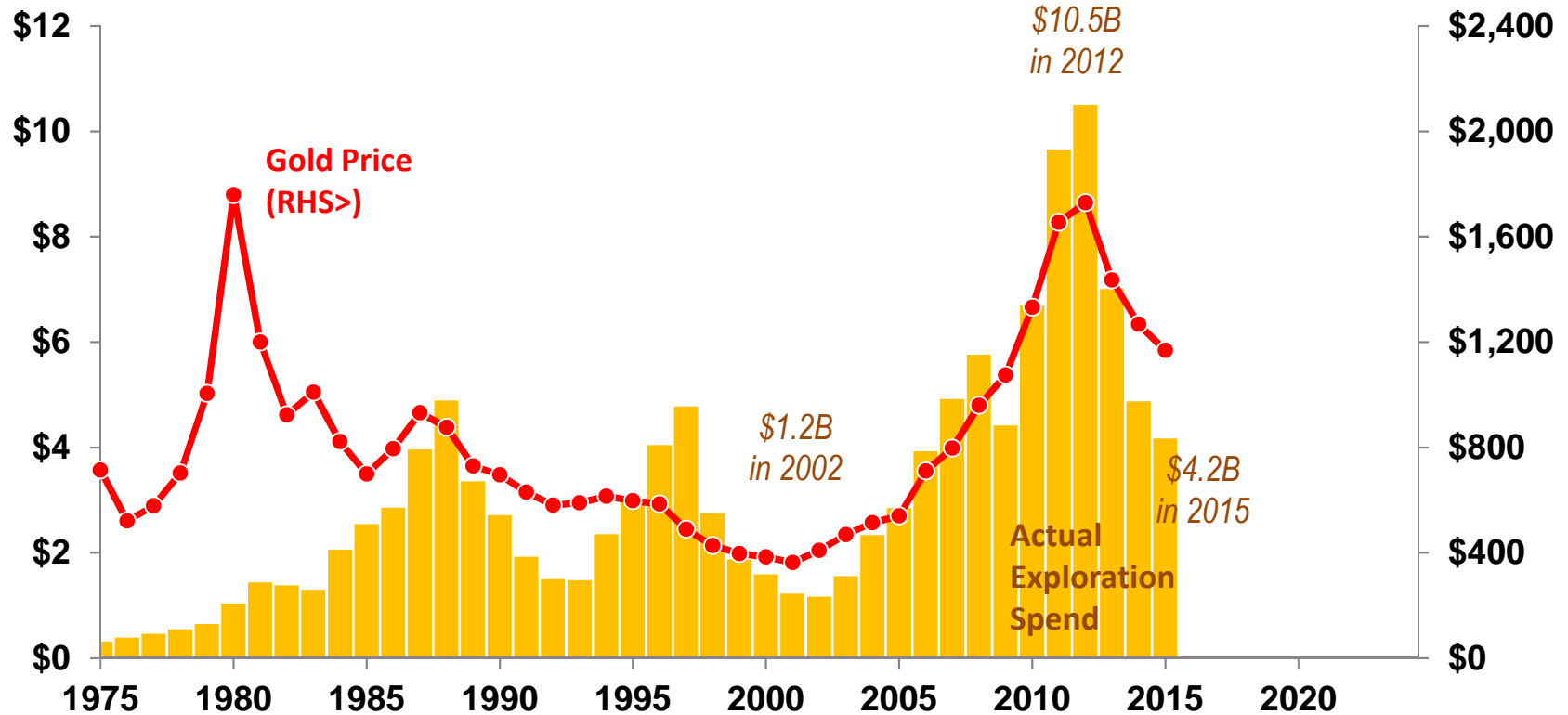
12. OUTLOOK FOR AUSTRALIA

Exploration spend is closely linked to commodity prices

World gold exploration expenditures versus gold price

Exploration Expenditures
(June 2015 US\$ billion)

Gold Price
(June 2015 US\$/oz)



Sources: MinEx Consulting © June 2016, LME

Exploration spend is closely linked to commodity prices

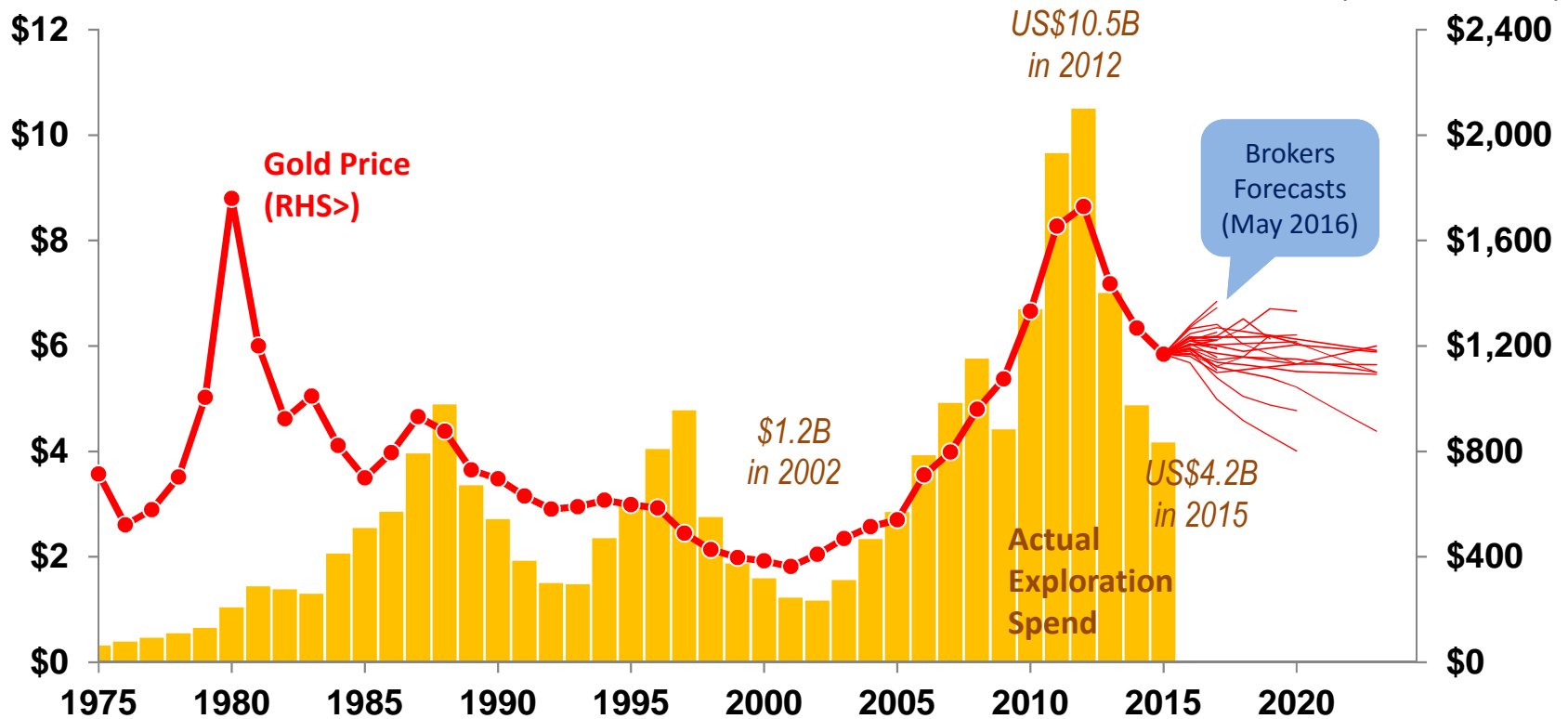
World gold exploration expenditures versus gold price

Exploration Expenditures

(June 2015 US\$ billion)

Gold Price

(June 2015 US\$/oz)

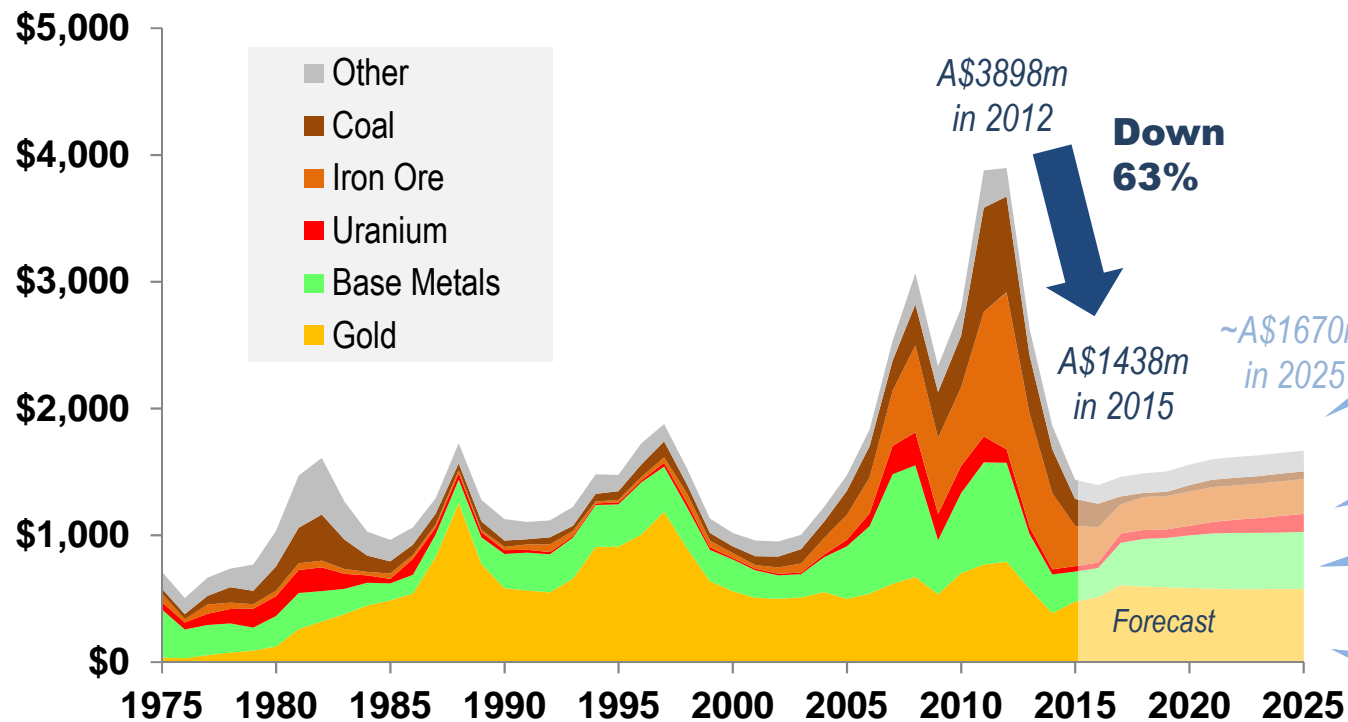


Sources: MinEx Consulting © June 2016, LME

Forecast exploration expenditures: Australia

by Commodity : 1975-2025

2015 A\$ Million



CAUTION: The Forecast doesn't capture the short-term volatility in spend

- Coal exploration is set to shrink further
- Spend on uranium is projected to increase
- Spending on Base Metals to rebound
- Gold is projected to rise 27% then flat line

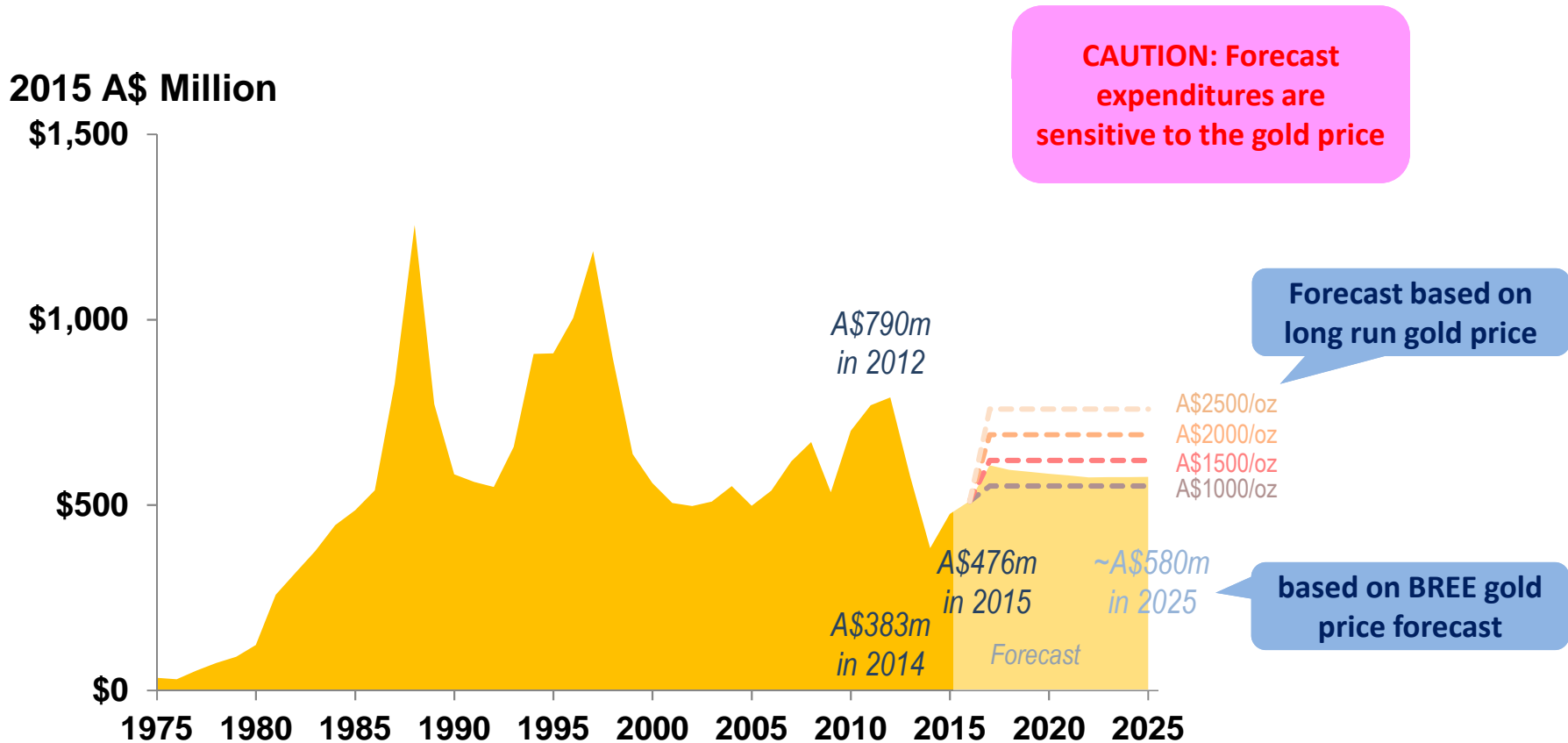
Note: Forecast based on a Multiple-Regression analysis of data from 1990-2015 with $R^2 = 0.82$

Source: MinEx Consulting estimates © June 2015, based on commodity price forecasts from BREE March 2016

BREE forecasts that the nominal gold price will drop to A\$1400/oz (= A\$1253/oz in real terms) by 2021

Forecast exploration expenditures: Australia

GOLD : 1975-2025



Note: Forecast based on a Multiple-Regression analysis of data from 1990-2015 with $R^2 = 0.82$

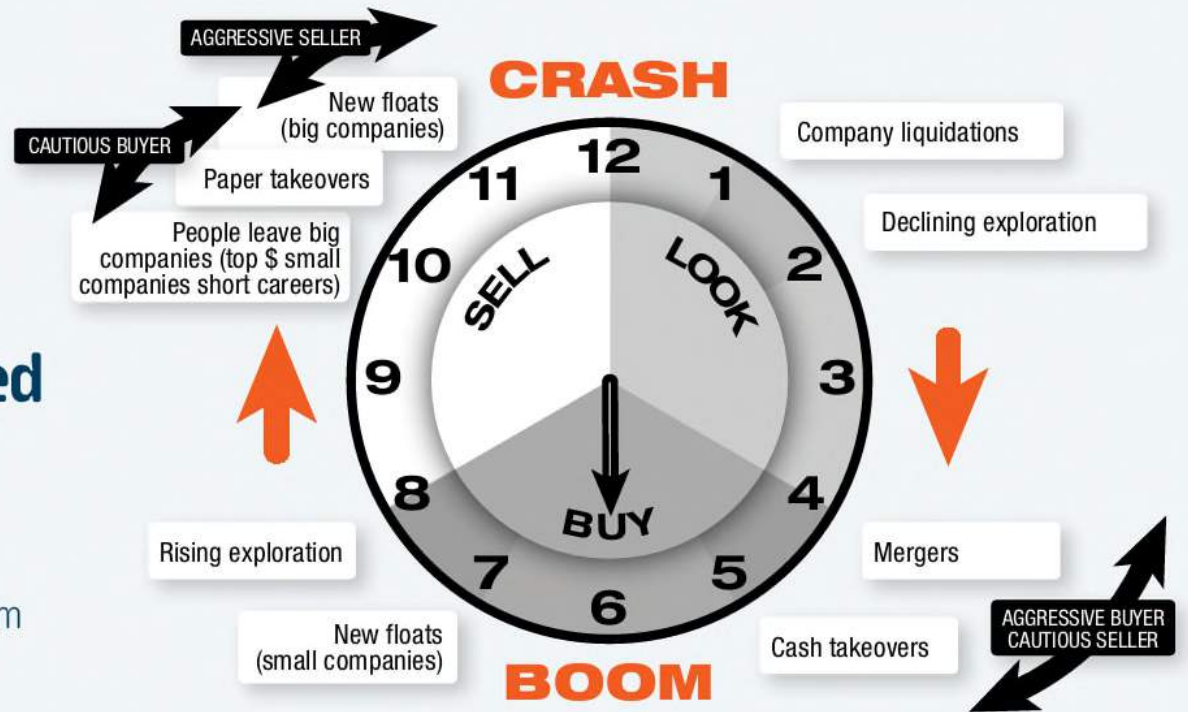
Source: MinEx Consulting estimates © June 2015, based on commodity price forecasts from BREE March 2016

BREE forecasts that the nominal gold price will drop to A\$1400/oz (= A\$1253/oz in real terms) by 2021

The next boom has already started !

Lion Clock moves to 6 o'clock – the boom has started

There is no need for charts and detailed discussion. The evidence is strikingly clear – sentiment has swung back to miners, and the boom phase of the cycle is underway.



Source: Lion Selection Group © May 2016

Summary / Conclusions : 1/4

1. Trends in exploration expenditures

- Gold exploration expenditures are extremely cyclical
- Global spend was US\$4.2 b in 2015, down 60% from its peak in 2012 (of \$10.5b)
- Expenditures are mainly driven by commodity prices and availability of funds

2. Trends in the number of discoveries and ounces

- The number of deposits and contained ounces found in the last decade (2005-2014) were at the same level as that of the boom period of the 1980s and 1990s
- Over the last decade 1246 Moz was found in 420 primary gold deposits (>0.1 Moz). This includes an adjustment for unreported discoveries
- 46% of the ounces found were in deposits >6Moz, but these only accounted for 7% by number
- In addition, 250 Moz was found as by-product gold associated with base metal and other deposits ... that's 17% of all gold found in the decade

3. Trends in the location of discoveries

- Over the last decade Canada did well (at the expense of Latin America)
- By number, 11% of the discoveries were in Canada, 11% in Australia and 30% in Africa
- In terms of contained gold, 27% was found in Canada, 6% in Australia and 18% in Africa
- Top 10 “Hot Spots” are Alaska/Yukon, SW USA/Mexico, Northern Ontario, Latin America, West Africa, NE/Central Africa, Turkey / Carpathian Belt, China, Far East Russia and Western Australia

Summary / Conclusions : 2/4

4. Size and grade of discoveries

- Average size of discovery is falling (3.4 Moz in last decade versus ~5 Moz in 1980s and 1990s)
- Average grade was steady at ~1.5 g/t – but improved in last 5 years to 1.7 g/t due to some last high grade discoveries (Red Hill/Gold Rush 15.4 Moz @ 5.0 g/t, and Haiyu 15.1 Moz @ 7.0 g/t)
- Average grade mined has been steadily declining (1.7 g/t in last decade versus 3.3 g/t in 1990s)

5. Trends in discovery methods

- At the Project-scale level (i.e. deciding where to peg leases), the main targeting method is based on the presence of prior known mineralisation ... i.e. targeting is based on “nearology”
- At the Prospect-scale level (i.e. deciding where to drill the first hole) the two main methods are geochemistry (35%) and extrapolation from known mineralisation (23%). As we go deeper, geophysics becomes more important (13% versus 5% in the 1990s)

6. Depth of cover for discoveries

- Depth is gradually increasing over time.
- Over the last decade the average depth of cover was 64 metres (and 65 metres in Australia) ... but half of the deposits found were outcropping (and most of these were in Africa)

Summary / Conclusions : 3/4

7. Who made the discoveries?

- Over the last decade Junior companies accounted for 69% of the exploration spend, 67% of gold discoveries (by number), 64% of the ounces and 59% of the value created
- Major companies were mainly focused on finding giant deposits. Over the last decade, they accounted for 24% of the spend, 14% of the discoveries, 22% of the ounces and 28% of the value

8. Quality of the discoveries

- Most of the value created was tied-up in Tier-1 and -2 discoveries. These are rare – with only 2-3 being found each year in the World

9. Trends in unit discovery costs

- Unit discovery costs have progressively risen over time - from US\$14/oz Au-eq in the 1980s to \$20/oz in the 1990s and \$25/oz in 2000s. It is currently running at ~\$60/oz
- Discovery costs vary widely by Region – the lowest was Canada (US\$31/oz) & Africa (\$38/oz), and the highest was US (\$71/oz) & Pacific SE Asia (>\$300/oz). Australia was US\$61/oz
- In terms of Value/Cost (i.e. “Bang-per Buck”) over the last decade the industry created \$0.68 worth of value per each Dollar spent on Exploration. Australia was \$0.87. Hopefully this will improve over time – as costs come down and recent discoveries grow in size

Summary / Conclusions : 4/4

10. Country Risk issues

- Over the last decade **51%** of the total exploration expenditures were in High-Risk and Very-High Risk countries. These accounted for **49%** of the discoveries by number, **37%** of the ounces but only **33%** of the value

This is a surprising result – as one would expect a higher return to compensate for the higher business risk associated with exploring there.

11. Outlook for gold exploration in Australia

- Exploration spending is now bottoming out. The low-point was in 2014 when spending dropped to A\$383m. Based on BREE's gold price forecast, expenditures are set to rise from A\$476m in 2015 to \$608m in 2017 then flat-line at ~\$575m pa in the longer term. *Note: These figures are very sensitive to commodity price assumptions and exploration success.*

IN SUMMARY ... The gold exploration sector has bottomed out and positioning itself for the next boom.

The love affair with gold continues !!



Contact details

Richard Schodde
Managing Director
MinEx Consulting
Melbourne, Australia

Email: Richard@MinExConsulting.com

Website: MinExConsulting.com

**Copies of this and other similar
presentations can be downloaded
from my website**