

# Overview of Exploration in Asia - the rising importance of China

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# Overview

1. Countries covered in the analysis
2. Trends in exploration spend
3. Number of discoveries made – *How many were found and what metal?*
4. Location of deposits – *Where were they found?*
5. Mineral endowment – *How “fertile” is the Region?*
6. Location of discoveries made in last decade
7. Quality and value of the discoveries – *focus on finding Tier 1 & 2 deposits, and does exploration make money?*
8. Conclusions

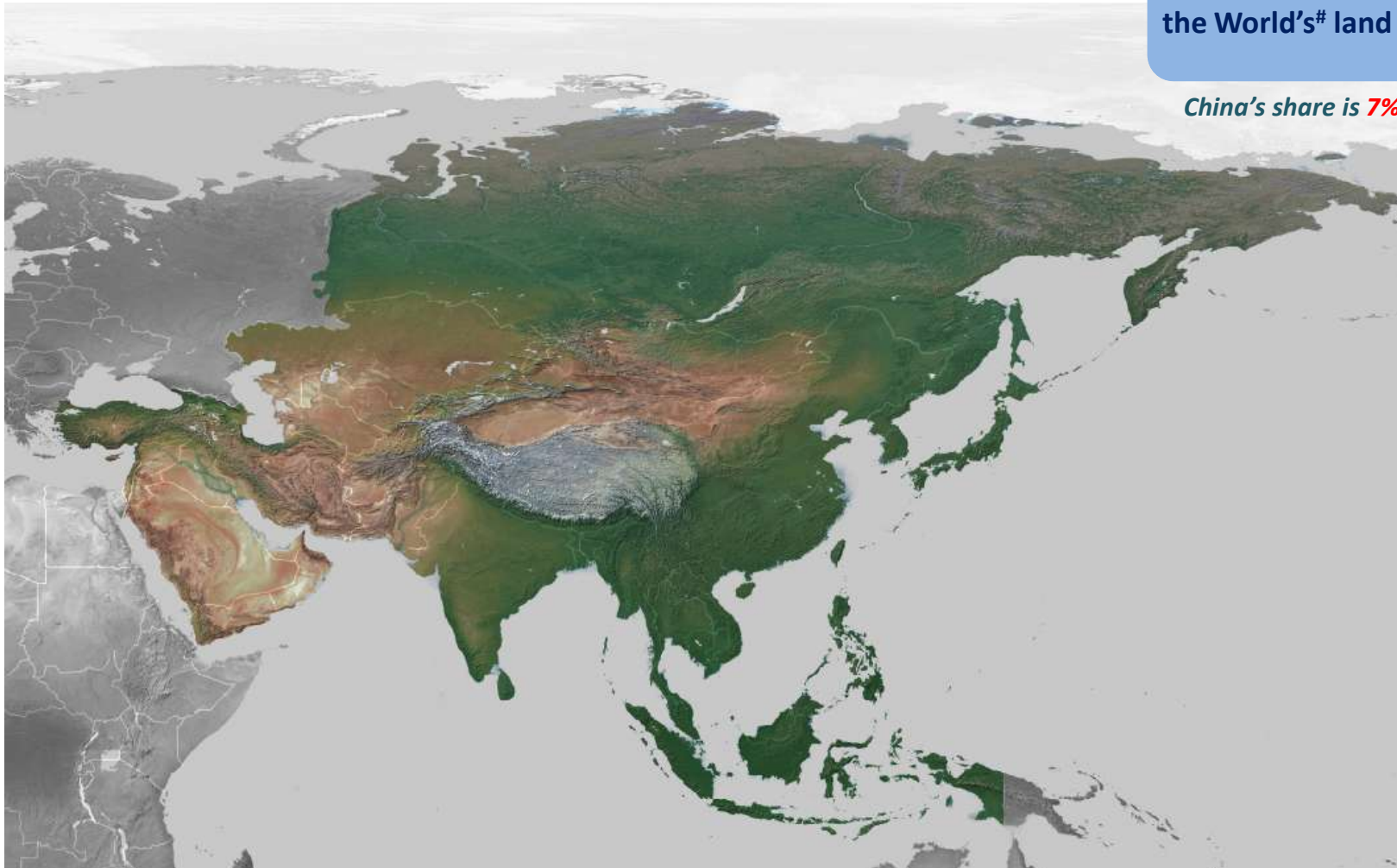
There are 50 countries in Asia and it spans across 1/3<sup>rd</sup> of the World

# **1. COUNTRIES COVERED IN THE ANALYSIS**

# Asia

Asia covers **33.4%** of the World's# land area

*China's share is 7%*



# Excluding Antarctica

# 6 Regions in Asia

- Central Asia**
- Afghanistan
  - Armenia
  - Azerbaijan
  - Georgia
  - Kyrgyzstan
  - Tajikistan
  - Turkmenistan
  - Uzbekistan
  - Pakistan

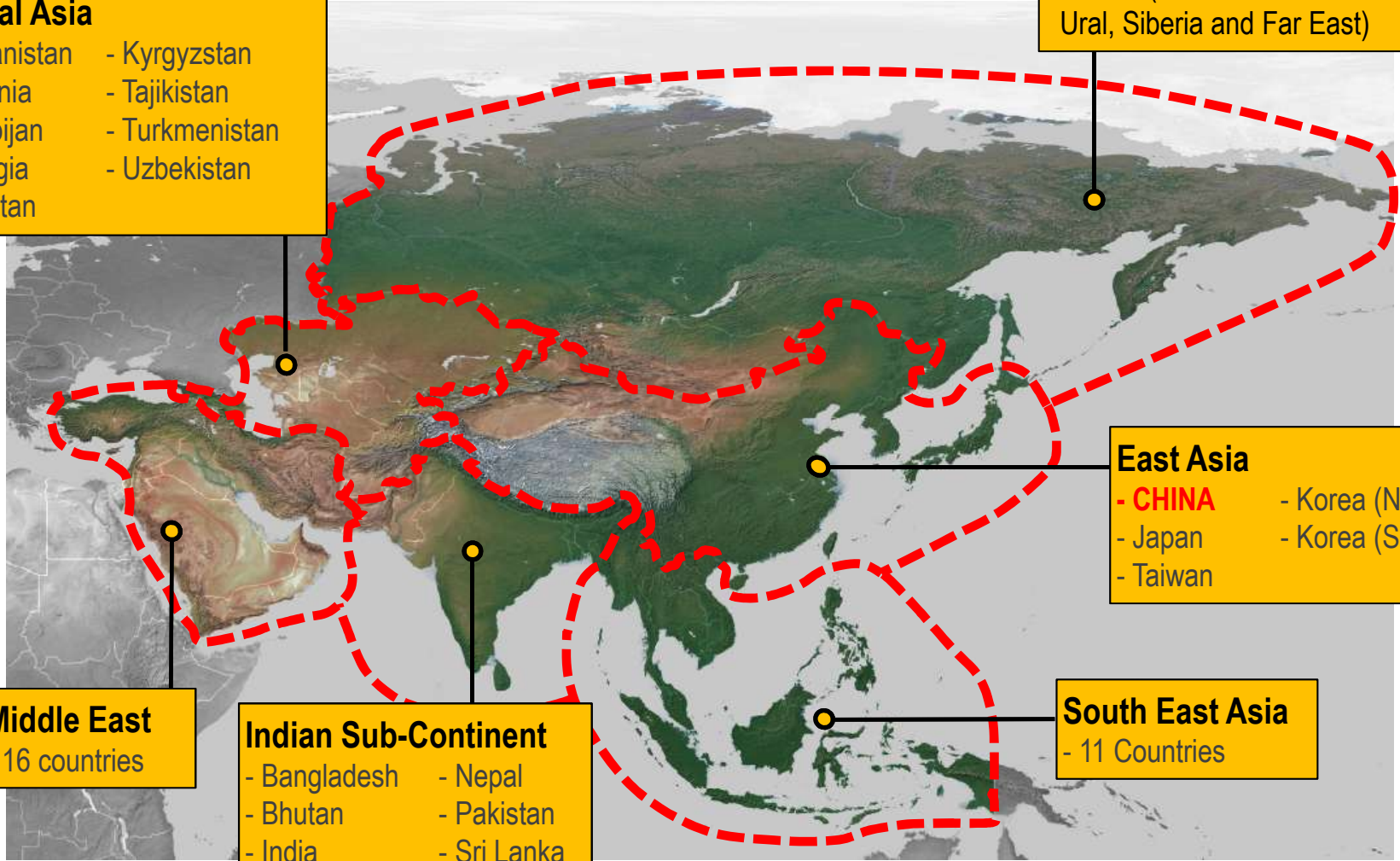
- Far East Asia**
- Mongolia
  - Russia (Federal Districts of Ural, Siberia and Far East)

- Middle East**
- 16 countries

- Indian Sub-Continent**
- Bangladesh
  - Bhutan
  - India
  - Maldives
  - Nepal
  - Pakistan
  - Sri Lanka

- East Asia**
- **CHINA**
  - Japan
  - Taiwan
  - Korea (N)
  - Korea (S)

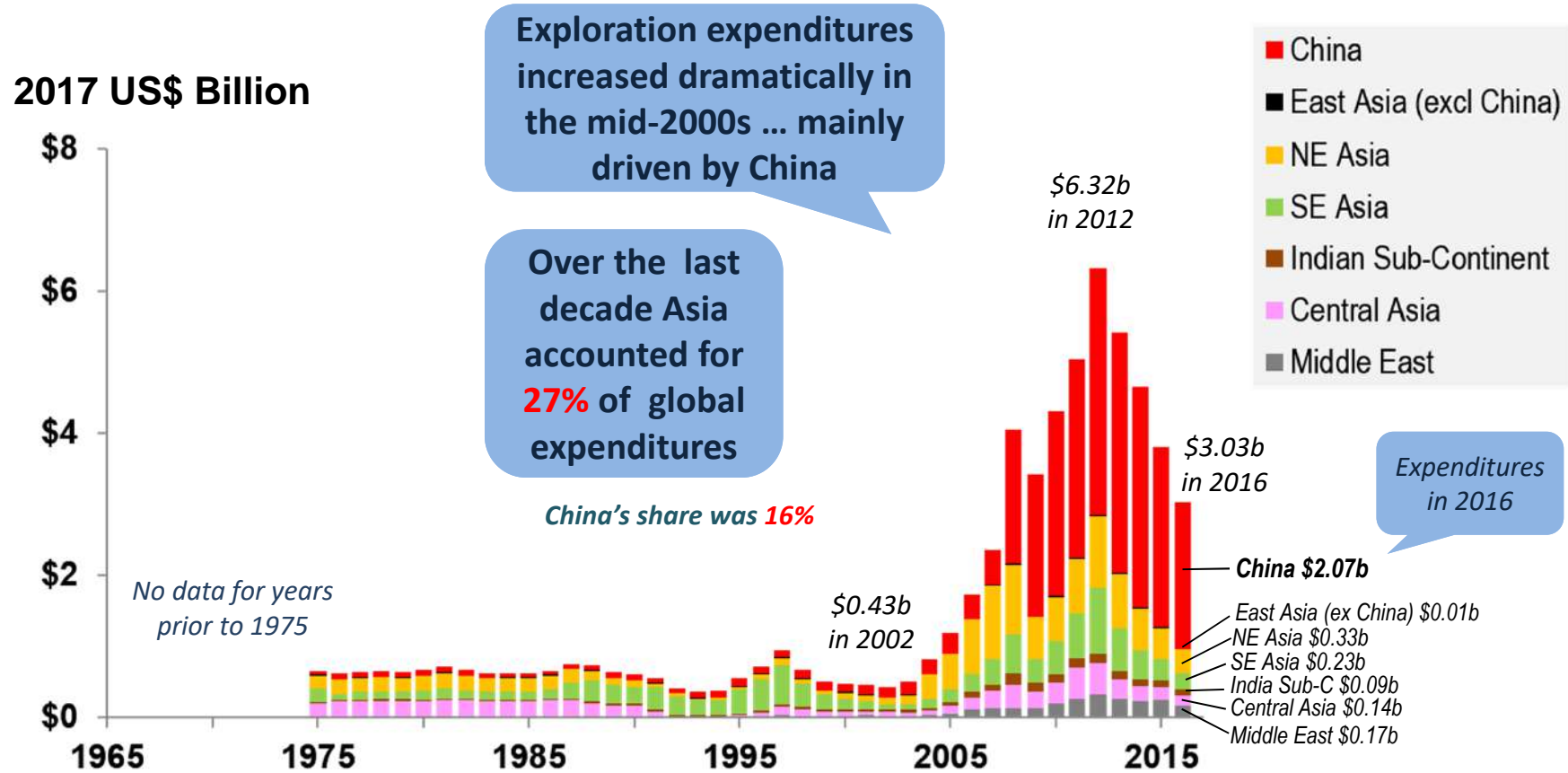
- South East Asia**
- 11 Countries



Exploration expenditures have increased dramatically

## **2. TRENDS IN EXPLORATION SPEND**

# Exploration Expenditures by regions within Asia

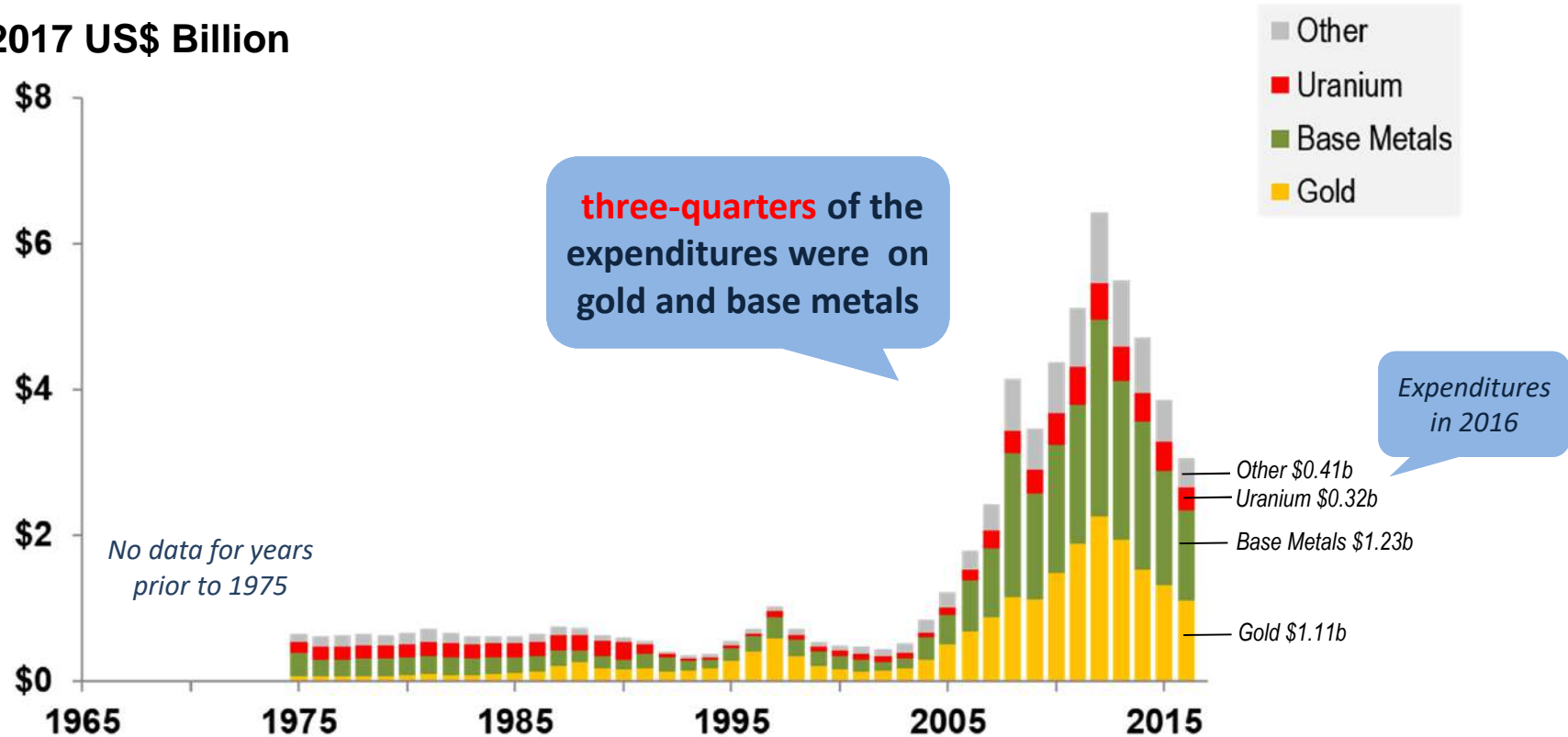


Note: Excludes Bulk Minerals (i.e. bauxite, coal and iron ore)

Source: Estimates by MinEx Consulting © Sept 2017 based on data from the OECD (for uranium), MOLAR (for China) and SNL

# Exploration Expenditures by commodity within Asia

2017 US\$ Billion



Note: Excludes Bulk Minerals (i.e. bauxite, coal and iron ore)

Source: Estimates by MinEx Consulting © Sept 2017 based on data from the OECD (for uranium), MOLAR (for China) and SNL

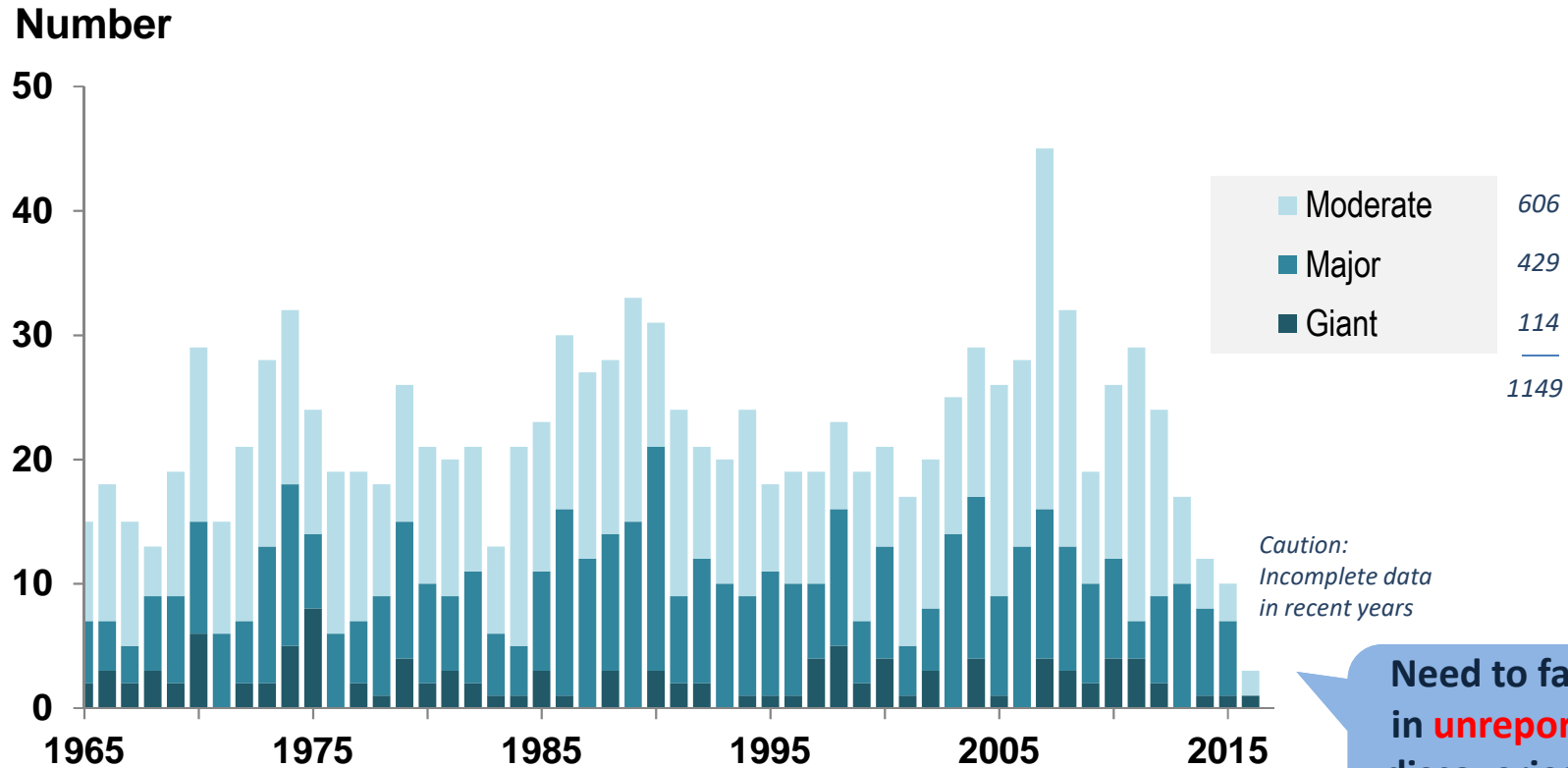


Since 1965, 1197 significant deposits were found in Asia,  
including 265 in the last decade

### **3. NUMBER OF DISCOVERIES MADE**

# Number of discoveries by size

Mineral discoveries in Asia: 1965-2016



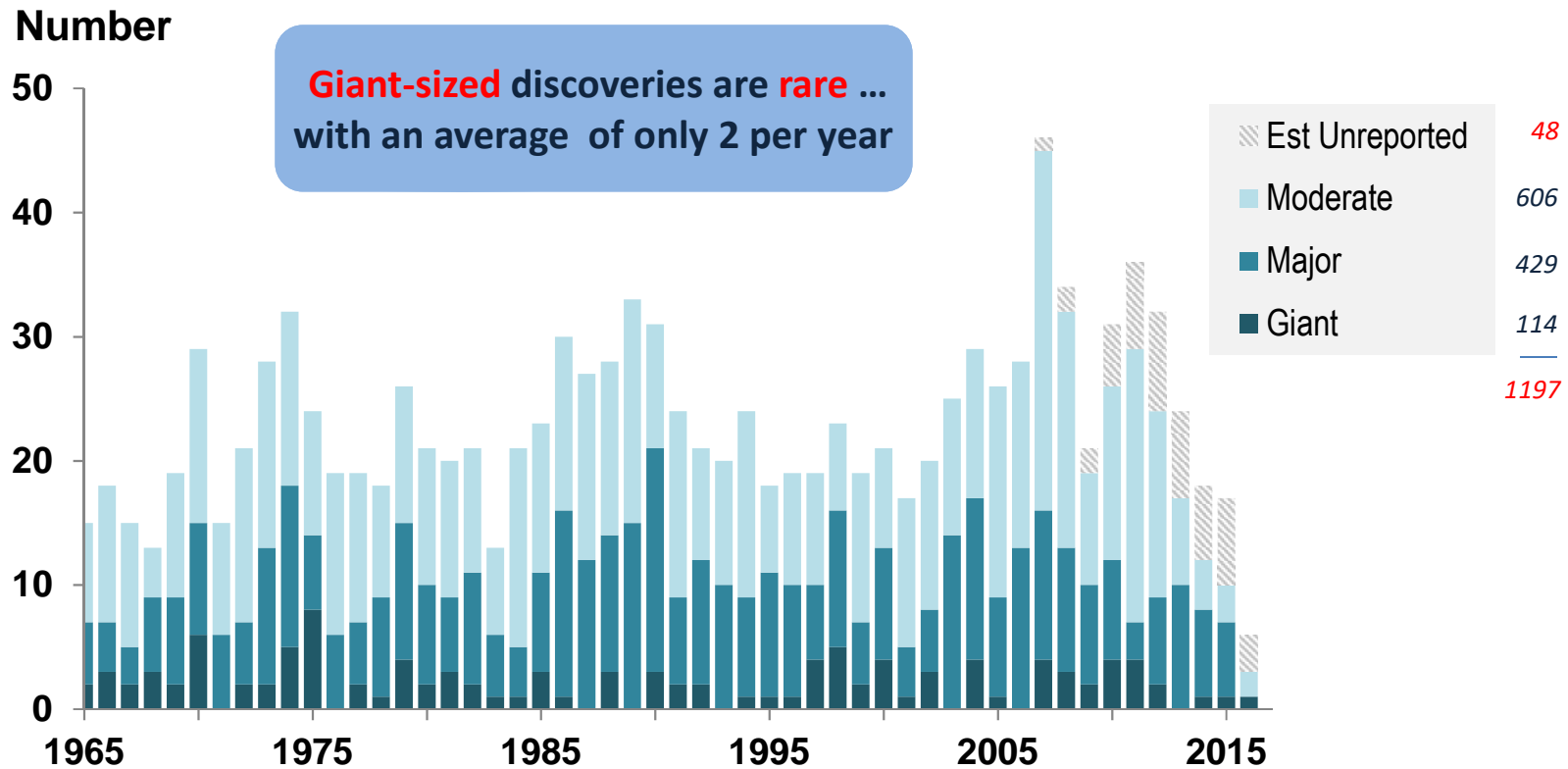
**Need to factor in unreported discoveries for recent years**

Note: Excludes Bulk Mineral discoveries (i.e. bauxite, coal and iron ore)  
 "Moderate" >100koz Au, >10kt Ni, >100Kt Cu equiv, 250kt Zn+Pb, >5kt U<sub>3</sub>O<sub>8</sub>  
 "Major" >1Moz Au, >100kt Ni, >1Mt Cu equiv, 2.5Mt Zn+Pb, >25kt U<sub>3</sub>O<sub>8</sub>  
 "Giant" >6Moz Au, >1Mt Ni, >5Mt Cu equiv, 12Mt Zn+Pb, >125kt U<sub>3</sub>O<sub>8</sub>

Source: MinEx Consulting © September 2017

# Number of discoveries by size

Mineral discoveries in Asia: 1965-2016

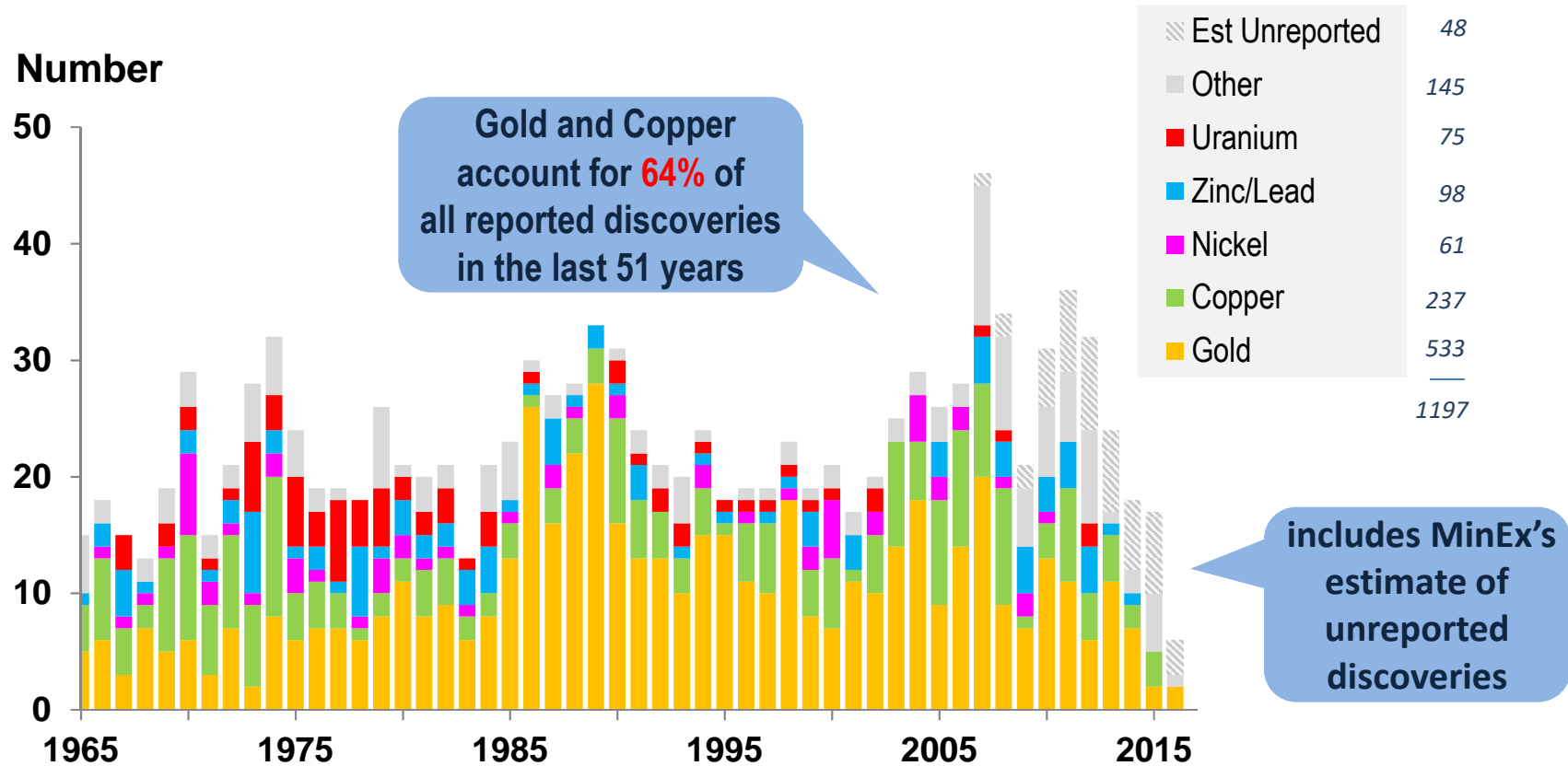


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Source: MinEx Consulting © September 2017

# Number of discoveries by commodity

Mineral discoveries in Asia: 1965-2016

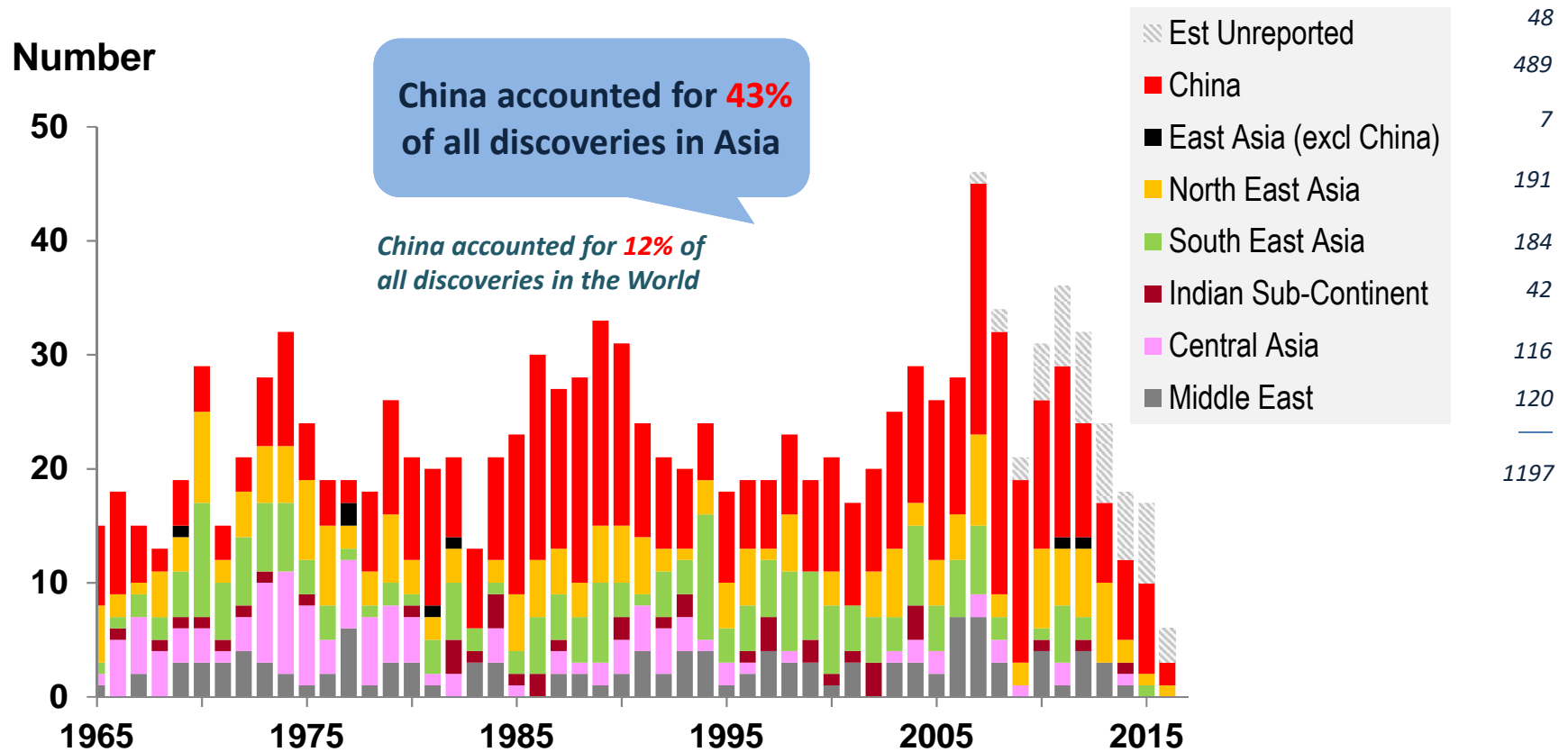


Note: Based on Moderate-, Major- and Giant-sized deposits  
Excludes Bulk Minerals (such as bauxite, coal and iron ore)  
Excludes satellite deposits in existing camps

Source: MinEx Consulting © September 2017

# Number of discoveries by location

Mineral discoveries in Asia: 1965-2016

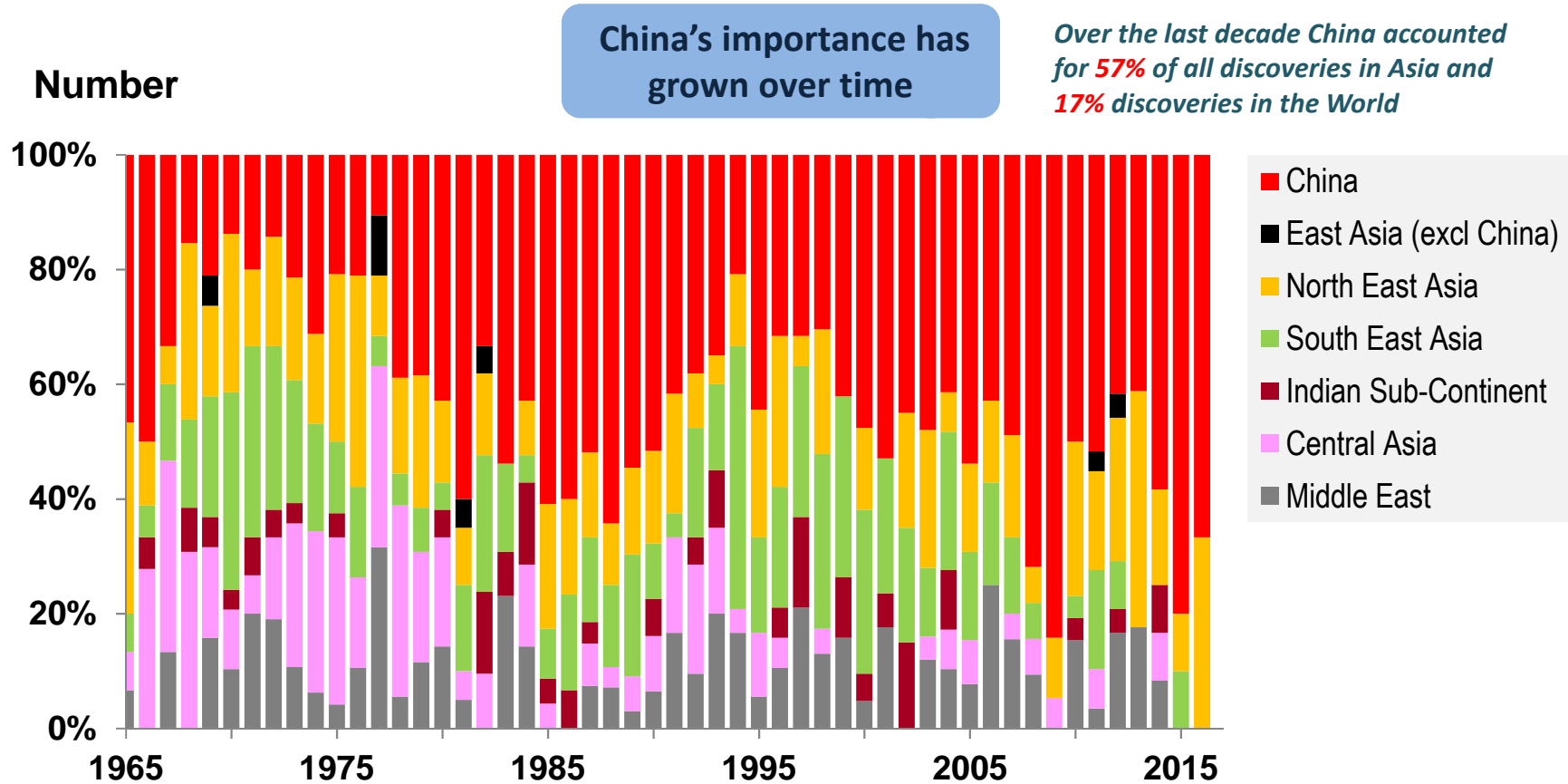


Note: Based on Moderate-, Major- and Giant-sized deposits  
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Source: MinEx Consulting © September 2017

# Number of discoveries by location

Mineral discoveries in Asia: 1965-2016



Note: Based on Moderate-, Major- and Giant-sized deposits  
Excludes Bulk Minerals (such as bauxite, coal and iron ore)  
Excludes satellite deposits in existing camps

Source: MinEx Consulting © September 2017

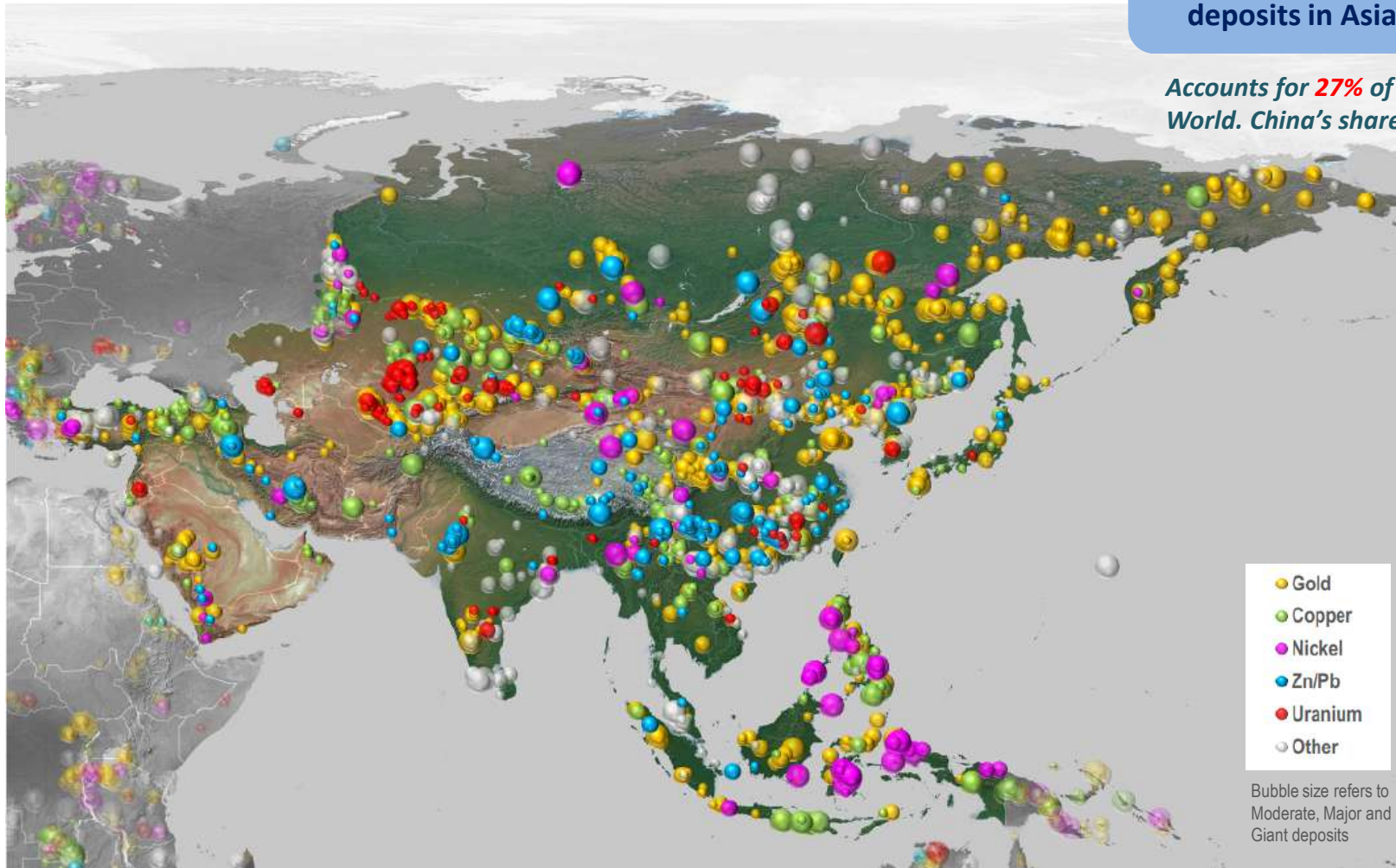
Over a quarter of the World's mineral deposits are in Asia

## **4. LOCATION OF DEPOSITS**

# Asia – known deposits : All Years

There are **2158** significant# mineral deposits in Asia

Accounts for **27%** of the World. China's share is **10%**

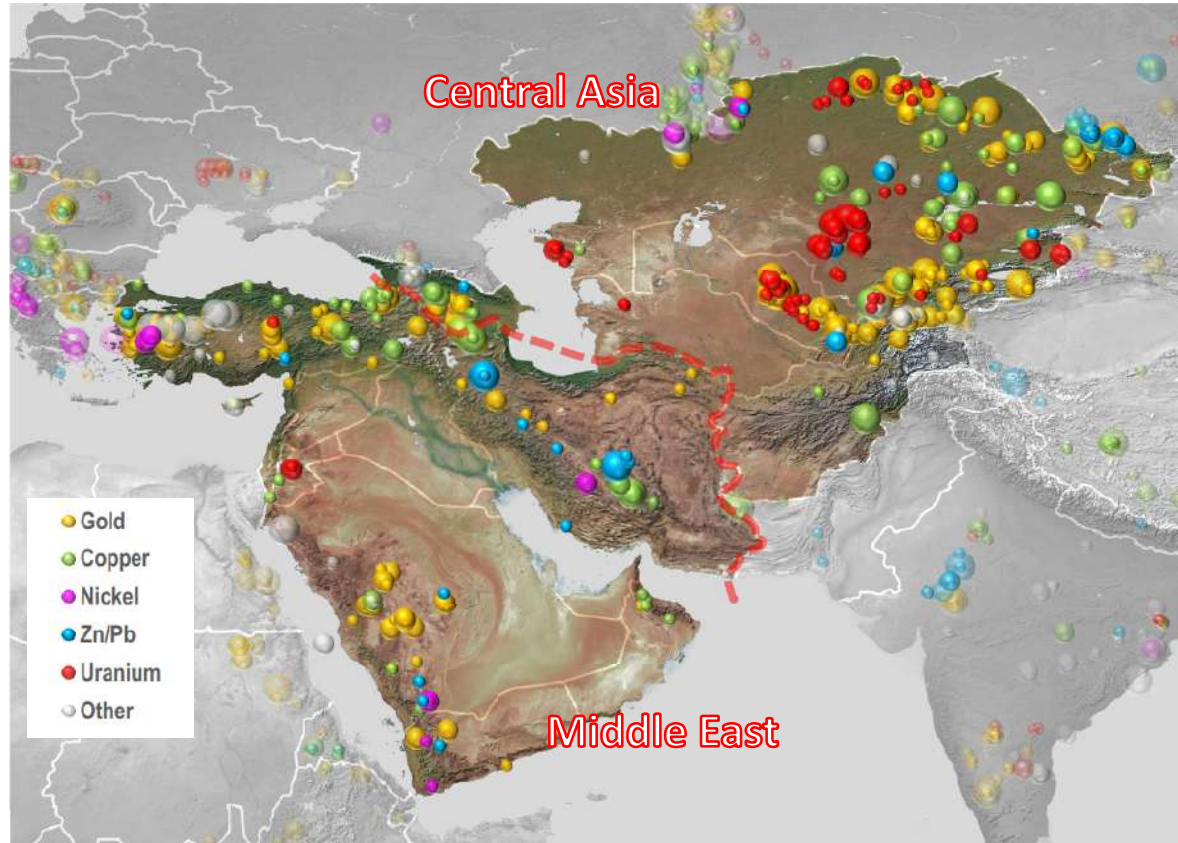


# Significant defined as “>=Moderate” i.e. Pre-mined resources >100koz Au, >10kt Ni, >100kt Cu equiv, 250kt Zn+Pb, >5kt U<sub>3</sub>O<sub>8</sub>

Source: MinEx Consulting © September 2017



# Middle East & Central Asia : All Years



## Middle East (16 Countries, including Turkey)

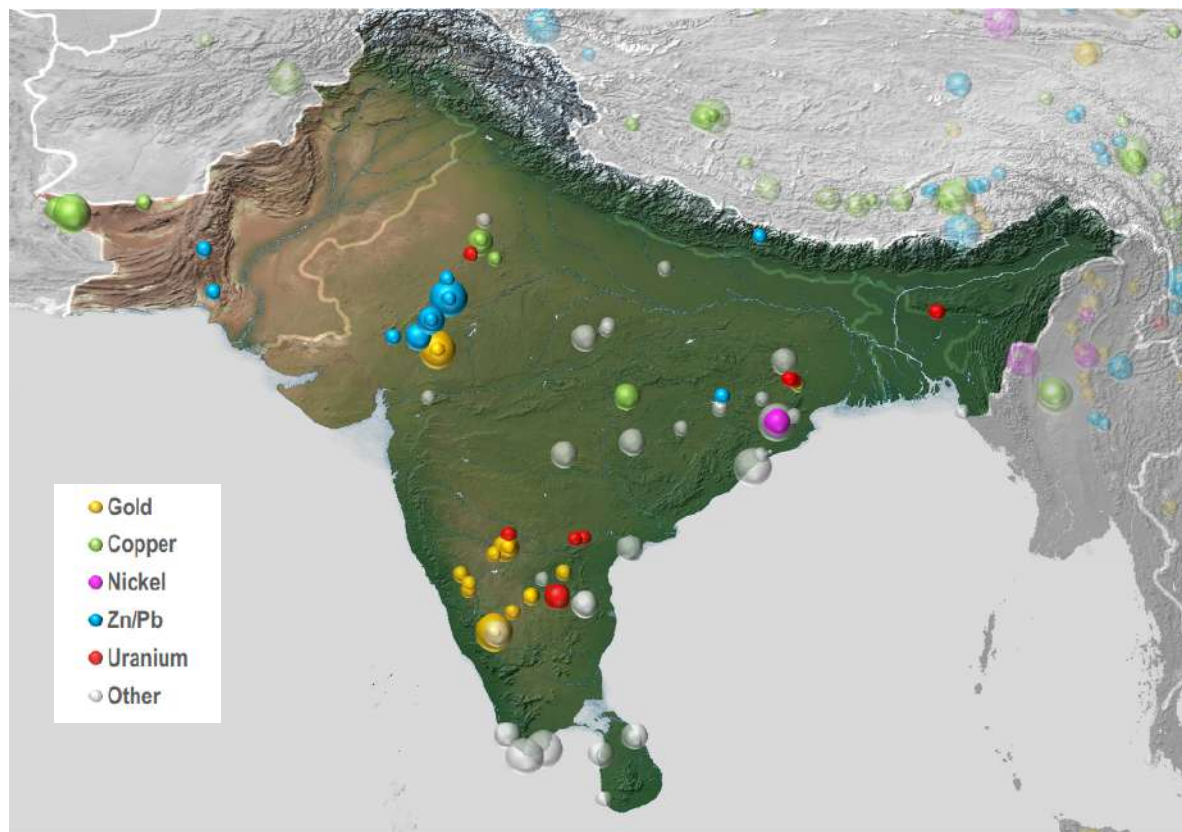
	Au	Cu	Ni	Zn/Pb	U	Other	TOTAL
No.	76	41	7	16	3	18	161
Metal	137 Moz	59 Mt	2.1 Mt	61 Mt	98 kt U	xx	

## Central Asia (9 Countries)

	Au	Cu	Ni	Zn/Pb	U	Other	TOTAL
No.	157	62	2	14	63	22	320
Metal	598 Moz	126 Mt	1.1 Mt	73 Mt	1430 kt U	xx	

Source: MinEx Consulting © September 2017

# Indian Sub-Continent : All Years



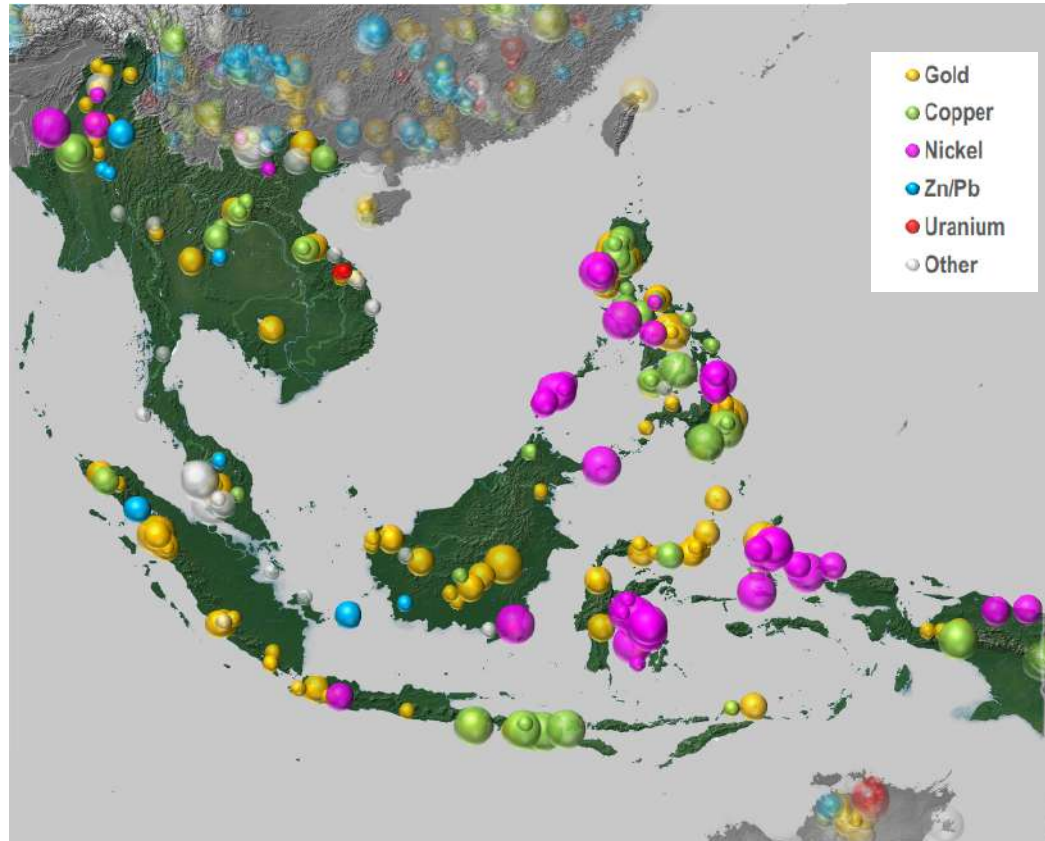
Caution: National boundaries are approximate only

## Indian Sub-Continent (7 Countries)

	Au	Cu	Ni	Zn/Pb	U	Other	TOTAL
No.	18	12	1	13	11	31	86
Metal	93 Moz	37 Mt	0.4 Mt	57 Mt	157 kt U	xx	

Source: MinEx Consulting © September 2017

# South East Asia : All Years



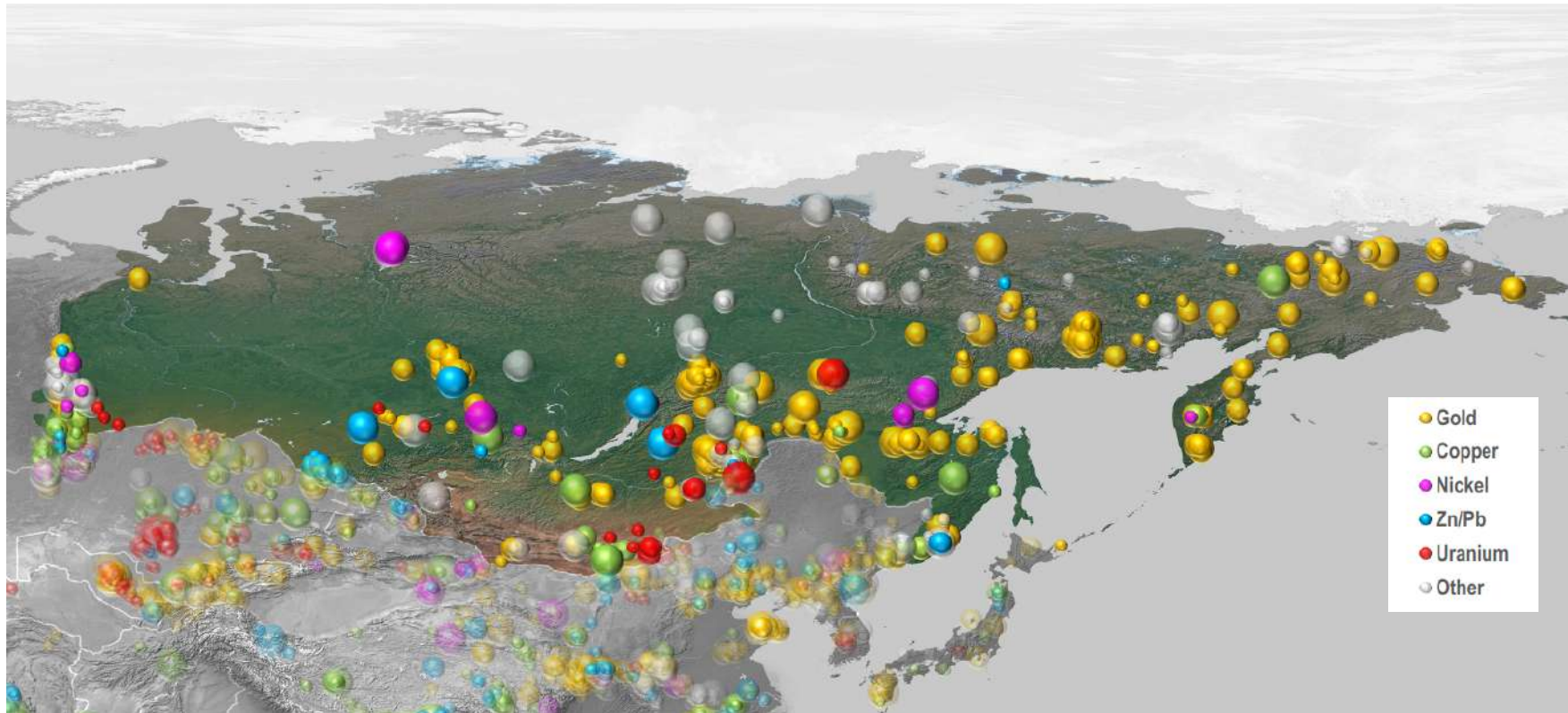
Caution: National boundaries are approximate only

## SE Asia (11 Countries)

	Au	Cu	Ni	Zn/Pb	U	Other	TOTAL
No.	137	74	45	8	2	31	297
Metal	552 Moz	182 Mt	53.8 Mt	21 Mt	151 kt U	xx	

Source: MinEx Consulting © September 2017

# North East Asia : All Years



Caution: National boundaries are approximate only

## NE Asia (2 Countries – Russia (east of the Urals) and Mongolia)

	Au	Cu	Ni	Zn/Pb	U	Other	TOTAL
No.	249	51	14	19	18	67	418
Metal	972 Moz	188 Mt	31.5 Mt	102 Mt	901 kt U	xx	

Source: MinEx Consulting © September 2017

# East Asia : All Years



## East Asia (5 Countries, including China)

	Au	Cu	Ni	Zn/Pb	U	Other	TOTAL
No.	416	153	21	107	22	157	876
Metal	646 Moz	178 Mt	10.0 Mt	102 Mt	282 kt U	xx	

## China

	Au	Cu	Ni	Zn/Pb	U	Other	TOTAL
No.	394	142	21	104	19	146	826
Metal	557 Moz	170 Mt	10.0 Mt	252 Mt	244 kt U	xx	

Source: MinEx Consulting © September 2017

# Asia versus the World

Number of significant deposits and contained metal (on a pre-mined resource basis)

	Land Area	Au	Cu	Ni	Zn/Pb	U	Other	TOTAL
		<b>Number of Deposits</b>						
<b>World</b> (including Asia)	<b>135 M km<sup>2</sup> #</b>	<b>4115</b>	<b>1297</b>	<b>414</b>	<b>530</b>	<b>380</b>	<b>1310</b>	<b>8046</b>
<b>Asia</b>	<b>45 M km<sup>2</sup></b> (33%)	<b>1053</b> (26%)	<b>393</b> (30%)	<b>90</b> (22%)	<b>177</b> (33%)	<b>119</b> (31%)	<b>326</b> (25%)	<b>2158</b> (27%)
<b>China</b>	<b>10 M km<sup>2</sup></b> (7%)	<b>394</b> (10%)	<b>142</b> (11%)	<b>21</b> (5%)	<b>104</b> (20%)	<b>19</b> (5%)	<b>146</b> (11%)	<b>876</b> (11%)
		<b>Contained Metal</b>						
<b>World</b> (including Asia)		<b>12,744 Moz</b>	<b>3,834 Mt</b>	<b>339 Mt</b>	<b>1,813 Mt</b>	<b>13,209 kt U</b>		
<b>Asia</b>		<b>2,998 Moz</b> (24%)	<b>769 Mt</b> (20%)	<b>99 Mt</b> (29%)	<b>597 Mt</b> (33%)	<b>3,020 kt U</b> (23%)		
<b>China</b>		<b>557 Moz</b> (4%)	<b>178 Mt</b> (5%)	<b>10 Mt</b> (3%)	<b>252 Mt</b> (14%)	<b>244 kt U</b> (2%)		

While China has lots of deposits, they tend to be small in size

# Excludes 14 million km<sup>2</sup> for Antarctica

Source: MinEx Consulting © September 2017

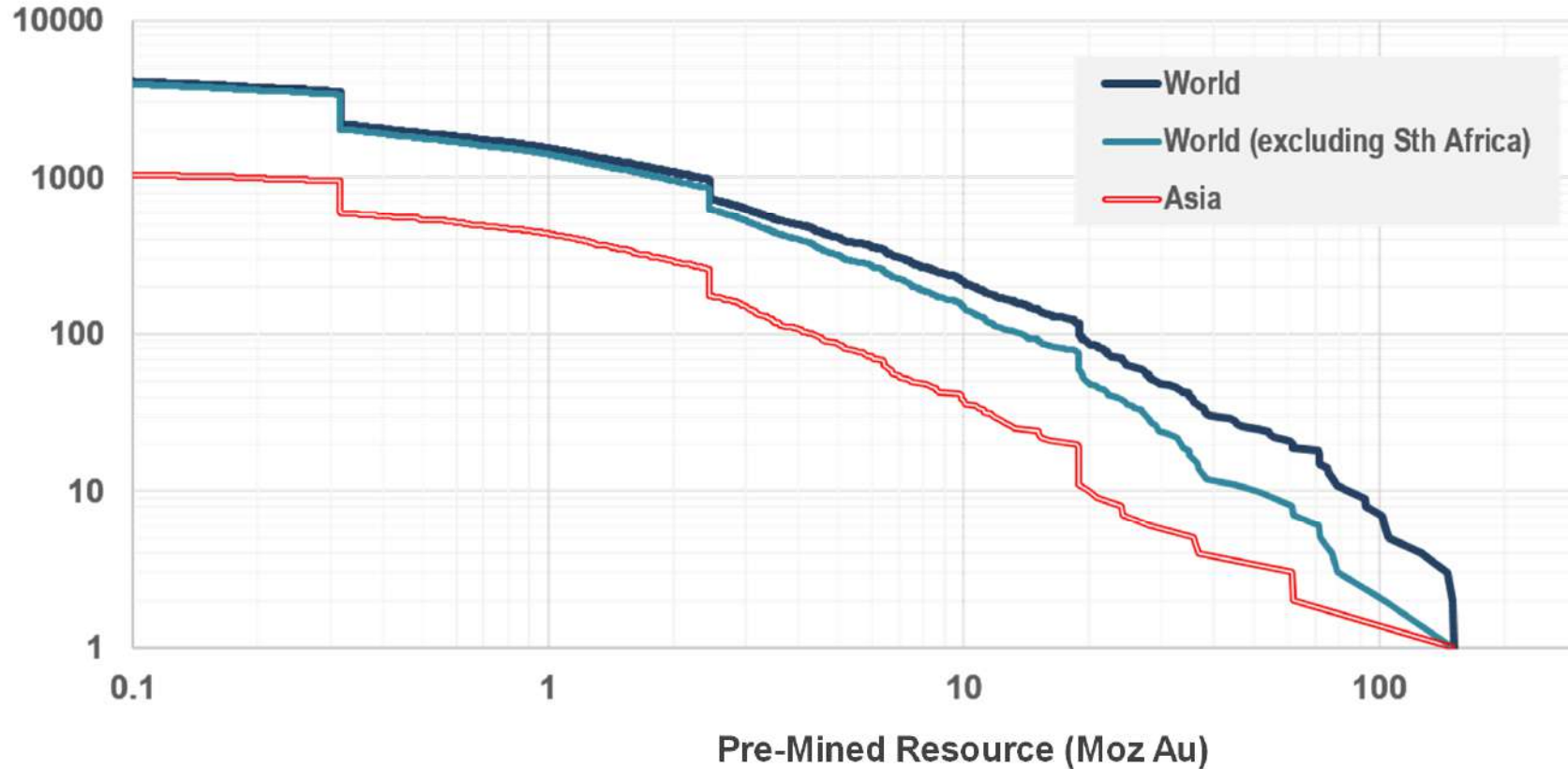
How mineral-rich is Asia?

## **5. MINERAL ENDOWMENT**

# Size/Cumulative Frequency Curve for Gold

## Asia versus the World

Cumulative No of Deposits



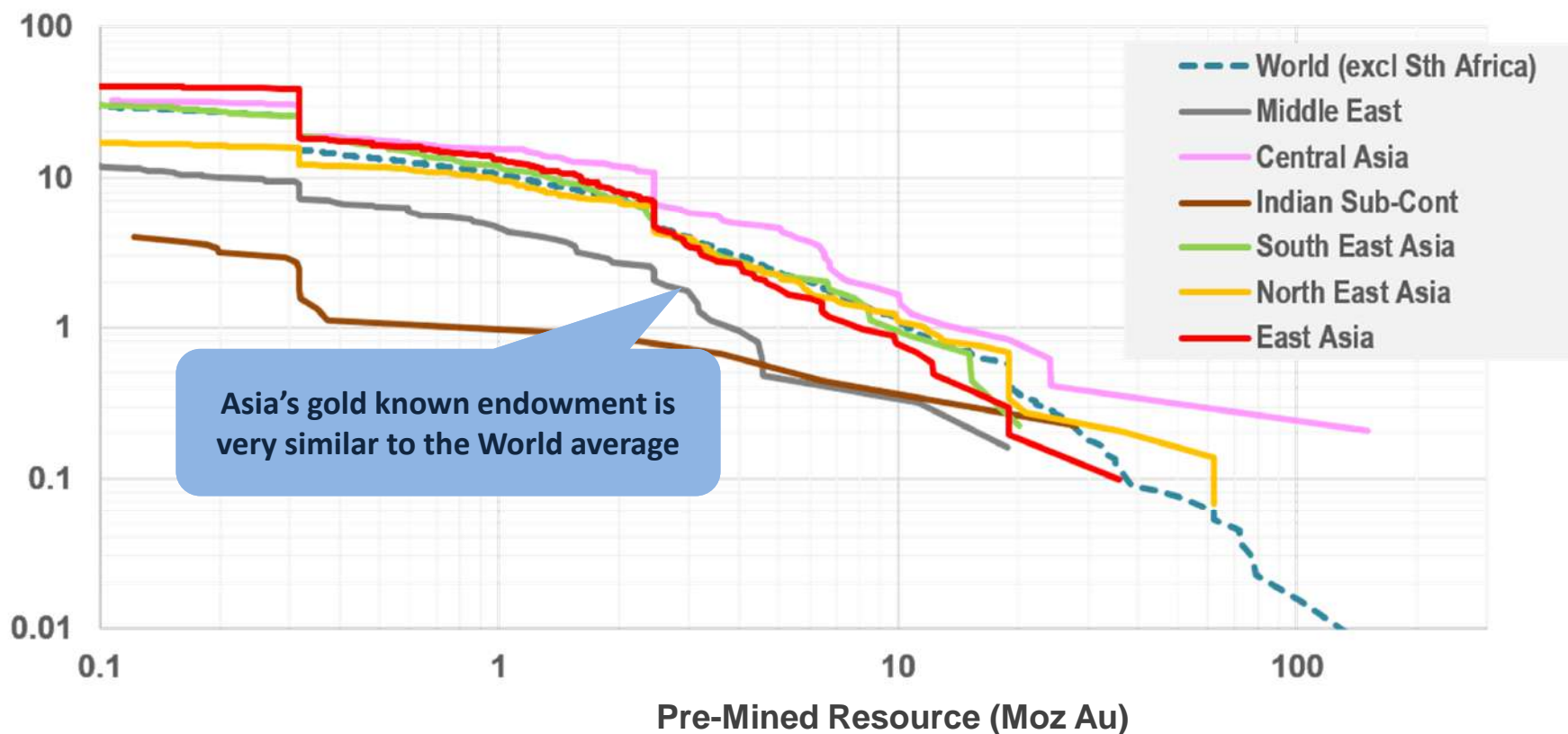
Source: MinEx Consulting © September 2017



# Size/Cumulative Frequency Curve for Gold

Asia versus the World – adjusted for land area

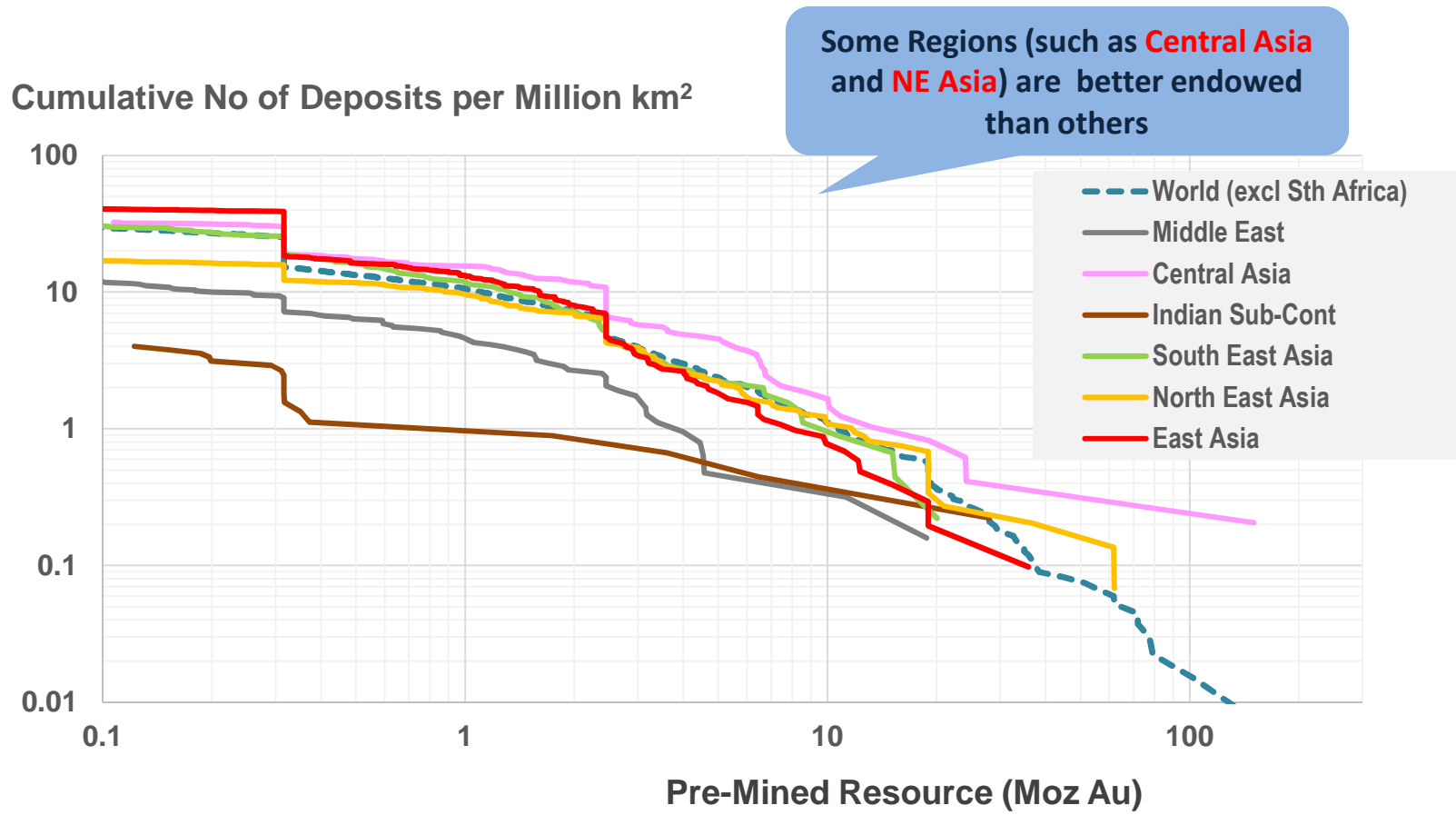
Cumulative No of Deposits per Million km<sup>2</sup>



Source: MinEx Consulting © September 2017

# Size/Cumulative Frequency Curve for Gold

## Asia versus the World - adjusted for land area



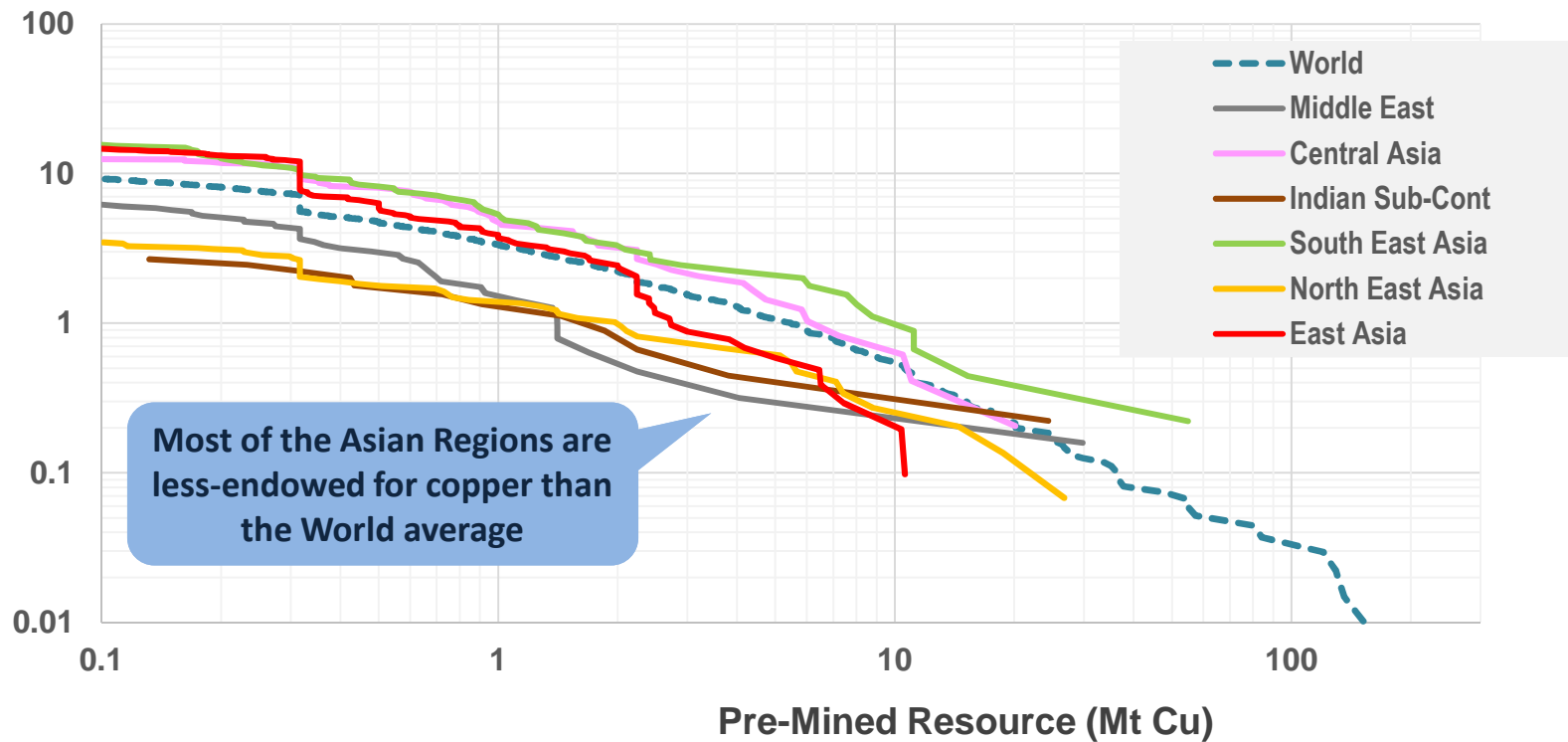
Note: No allowance made for by-product credits

Source: MinEx Consulting © September 2017

# Size/Cumulative Frequency Curve for Copper

## Asia versus the World – adjusted for land area

Cumulative No of Deposits per Million km<sup>2</sup>

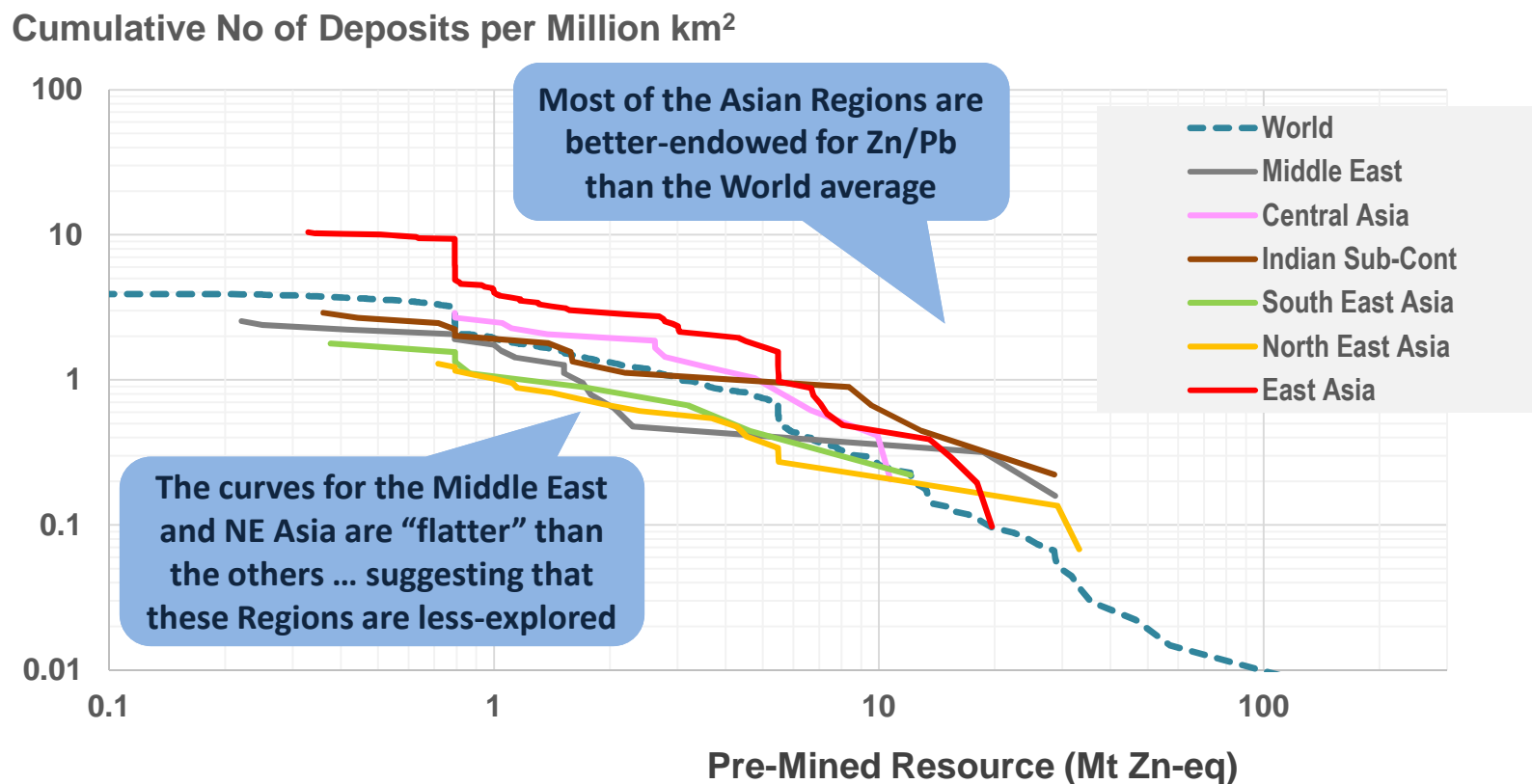


Note: No allowance made for by-product credits

Source: MinEx Consulting © September 2017

# Size/Cumulative Frequency Curve for Zinc/Lead

## Asia versus the World – adjusted for land area



*... As a general rule ‘in a new district the bigger deposits tend to get found first’ ... resulting in a flatter curve*

Source: MinEx Consulting © September 2017

Note: Have converted Pb and by-product metals into Zinc-equivalent

## Total contained metal per km<sup>2</sup> : by region

Based on current  
known endowment

	Oz Au	t Cu	t Ni	t Zn+Pb	t U
<b>WORLD</b> <sup>a</sup>	<b>74</b> <sup>b</sup>	<b>28.4</b>	<b>2.5</b>	<b>13.4</b>	<b>0.10</b>
ASIA TOTAL	67	17.1	2.2	13.3	0.07
Middle East	22	9.3	0.3	9.8	0.02
Central Asia	124	25.9	0.2	15.1	0.30
Indian Sub-Continent	20.7	8.3	0.1	12.7	0.04
South East Asia	123	40.5	12.0	4.7	0.03
North East Asia	66	12.8	2.1	7.1	0.06
East Asia	63	17.4	1.0	27.3	0.03
- China	(58)	(17.7)	(1.0)	(26.2)	(0.03)

(a): Analysis based on total land area of 135 million km<sup>2</sup> for the World which excludes Antarctica (14 million km<sup>2</sup>)

(b): Gold data excludes South Africa, Including South Africa  
increases the global figure to 94 Oz/km<sup>2</sup>

Source: MinEx Consulting © September 2017

## Total contained metal per km<sup>2</sup> : by region

Based on current  
known endowment

	Oz Au	t Cu	t Ni	t Zn+Pb	t U
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South East Asia	123	40.5	12.0	4.7	0.03
North East Asia	66	12.8	2.1	7.1	0.06
East Asia - China	63 (58)	17.4 (17.7)	1.0 (1.0)	27.3 (26.2)	0.03 (0.03)

(a), (b) : See comments on previous slide

Relative to the WORLD

<0.2x

0.2-0.5x

0.5-2x

2-5x

6-10x

>10x

Source: MinEx Consulting © September 2017

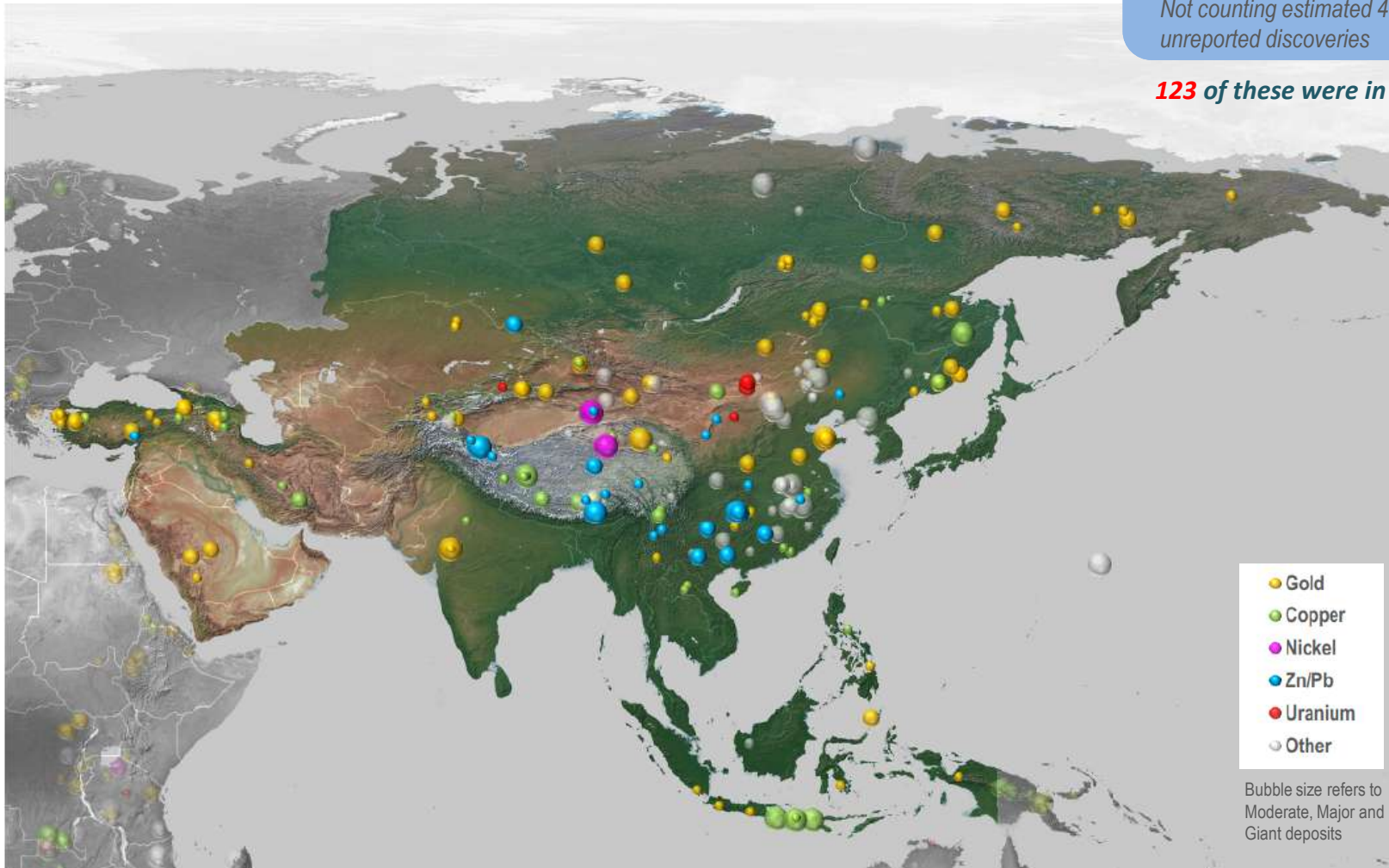
Over the last decade (2007-16) a total of 217 significant deposits were found in Asia

## **6. LOCATION OF DISCOVERIES MADE IN LAST DECADE**

# Asia Discoveries: 2007-2016 by size

**217 known  
discoveries in Asia**  
*Not counting estimated 48  
unreported discoveries*

**123 of these were in China**



Base on  $\geq$  Moderate-sized deposits  $>100\text{koz Au}$ ,  $>10\text{kt Ni}$ ,  $>100\text{kt Cu equiv}$ ,  $250\text{kt Zn+Pb}$ ,  $>5\text{kt U}_3\text{O}_8$

Source: MinEx Consulting © September 2017

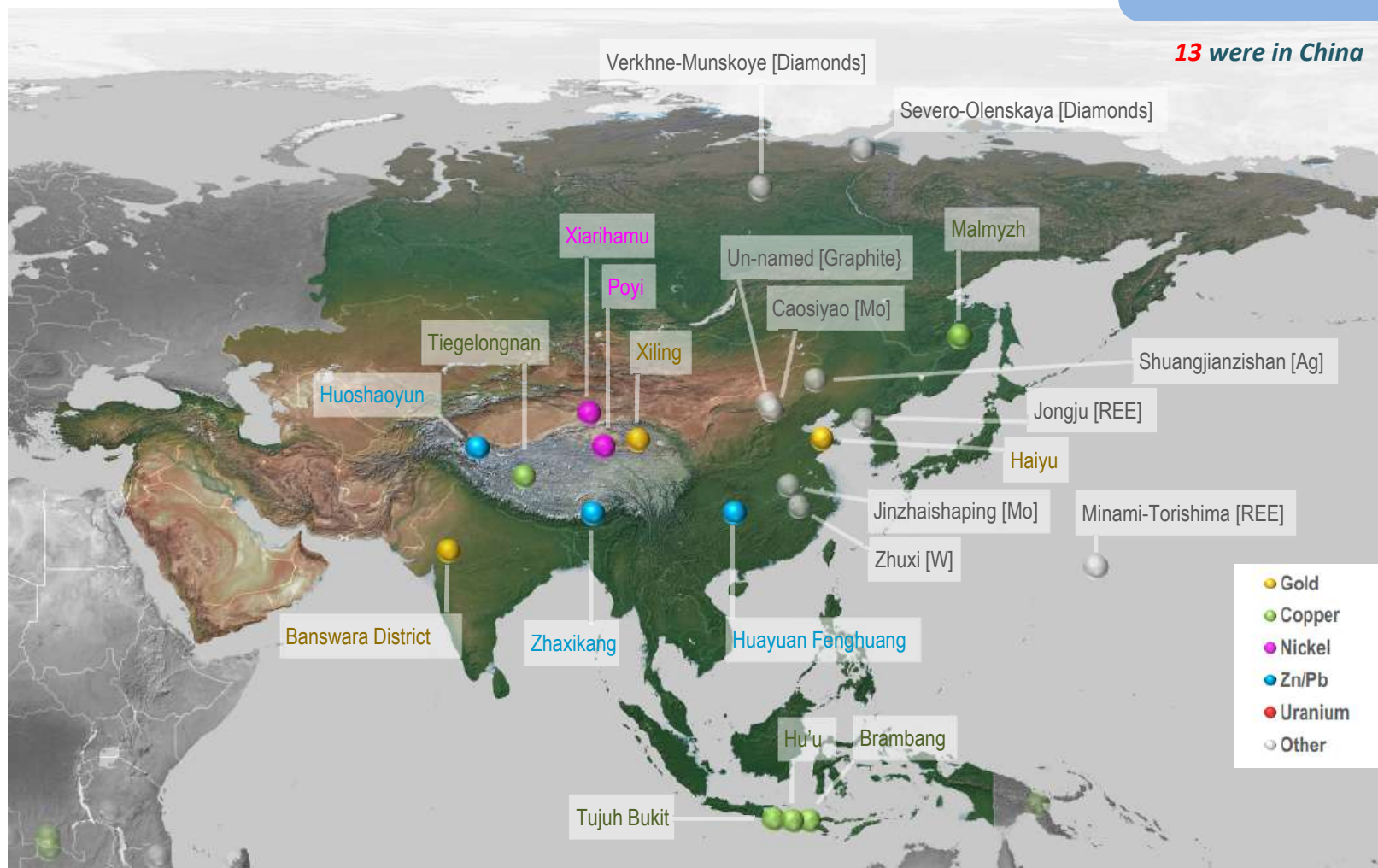


# Asia Discoveries: 2007-2016

## Giant Deposits only

**22** discoveries  
were Giants

**13** were in China

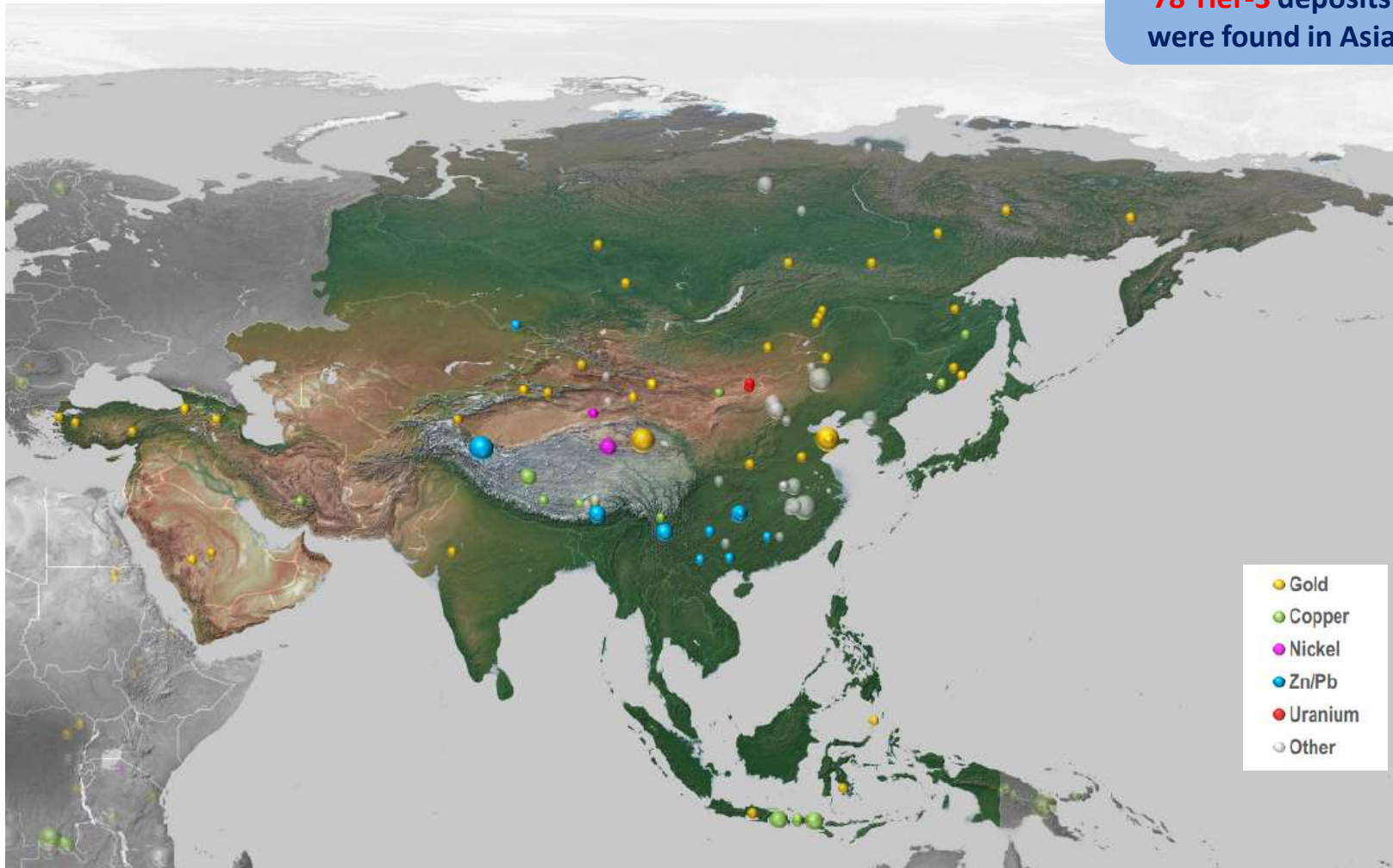


"Giant" defined as >6Moz Au, >1Mt Ni, >5Mt Cu equiv, 12Mt Zn+Pb, >125kt U<sub>3</sub>O<sub>8</sub>

Source: MinEx Consulting © September 2017

# Asia Discoveries: 2007-2016 by Tier

A total of **5 Tier-1** deposits, **14 Tier-2** and **78 Tier-3** deposits were found in Asia



Bubble size refers to Tier-1, Tier-2 and Tier-3 deposits.  
See Slide 38 for definitions of the different Tiers

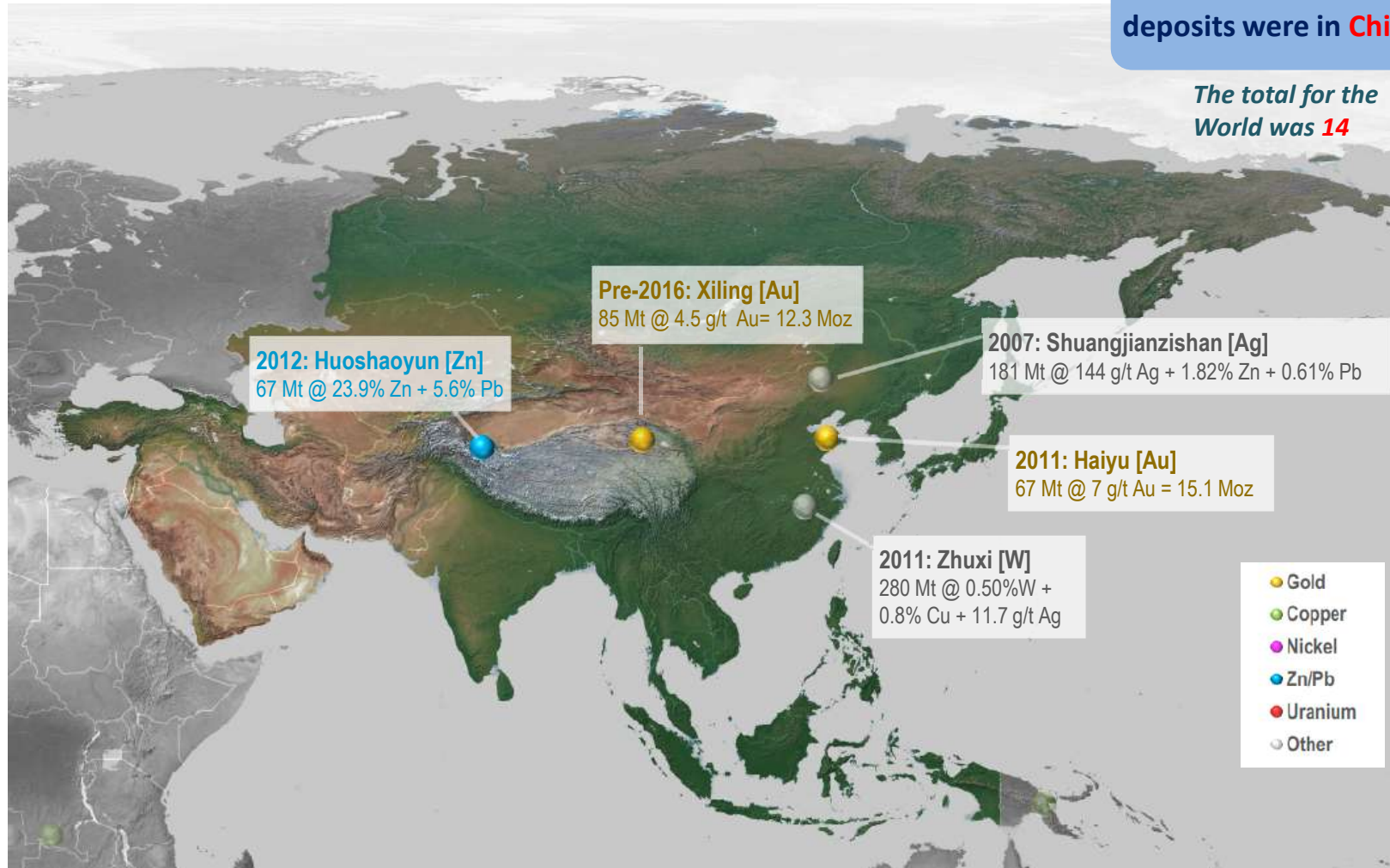
Source: MinEx Consulting © September 2017

# Asia Discoveries: 2007-2016

## Tier-1 only

All 5 of the Tier-1 deposits were in **China**

The total for the World was **14**



See Slide 38 for a definition of a Tier-1 deposit

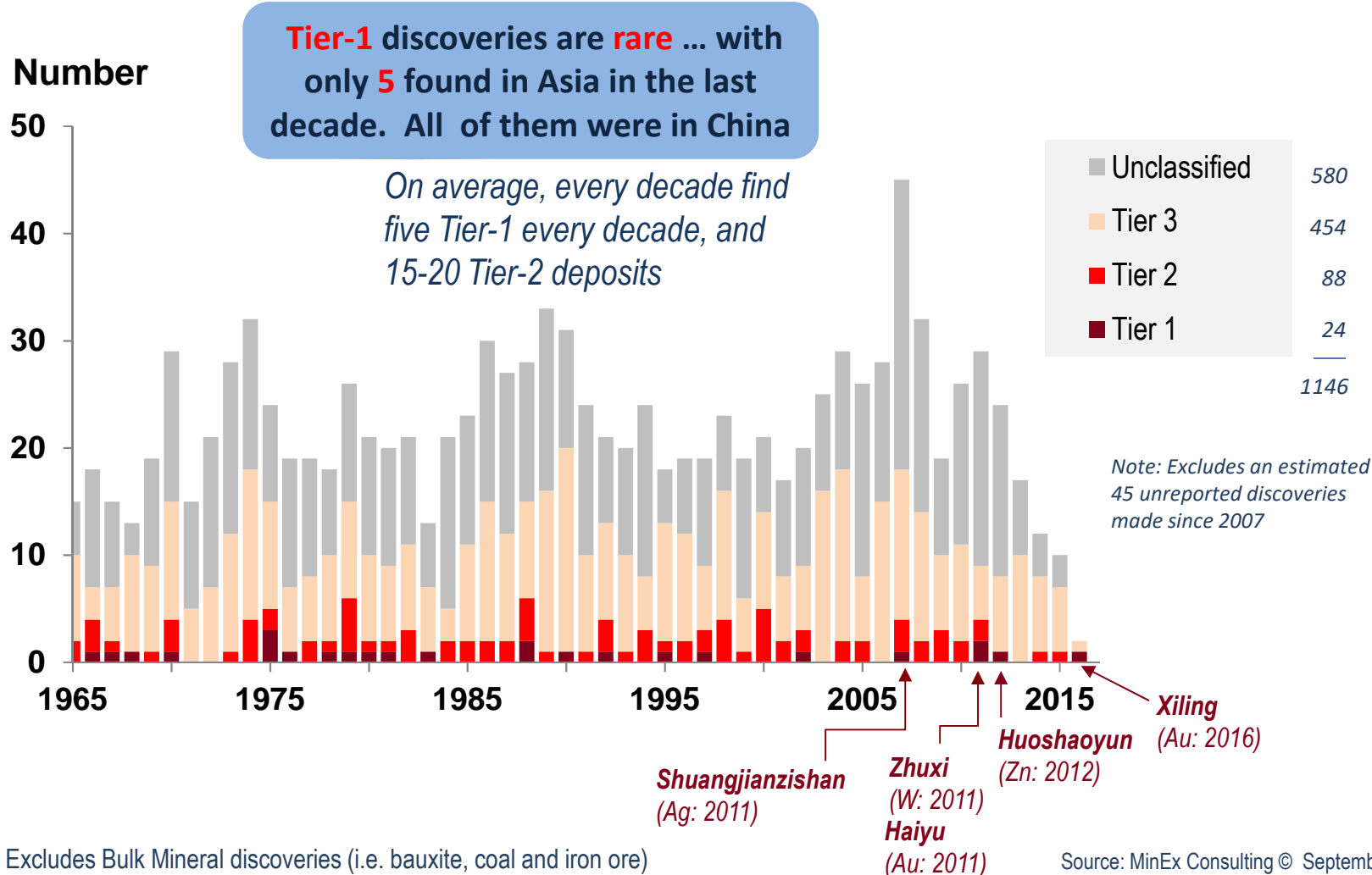
Source: MinEx Consulting © September 2017

How many Tier 1, 2 and 3 deposits were found in Asia? What are they worth? And was it enough to cover the cost of exploring for them?

## **7. QUALITY AND VALUE OF DEPOSITS FOUND**

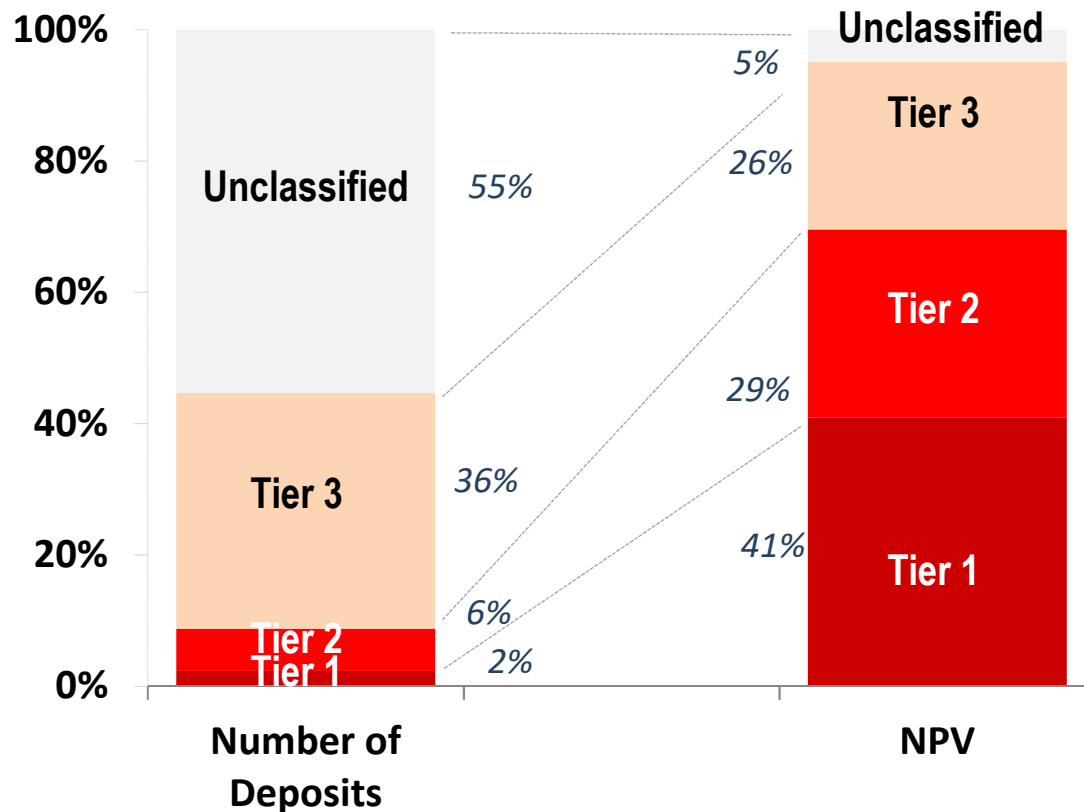
# Number of discoveries by quality

Tier 1, 2 and 3 discoveries in Asia: 1965-2016



# Most of the wealth created are in Tier 1 and 2 discoveries

Estimated value of 217 discoveries found in Asia between 1997-2016



Note: Limited to deposits >="Moderate" in size  
 NPV values refer to the Net Present Value at the Decision-to-Build stage  
 EV = Expected Value, which is the weighted average value of the NPV range  
 Values are based on long run commodity prices as prevailing at Jan 2013

Caution: Values are indicative / approximate-only

## Definitions

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

*Example: Red Rabbit [Gold]*

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

*Example: Dornod [Uranium]*

**'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

*Example: Chatree [Gold]*

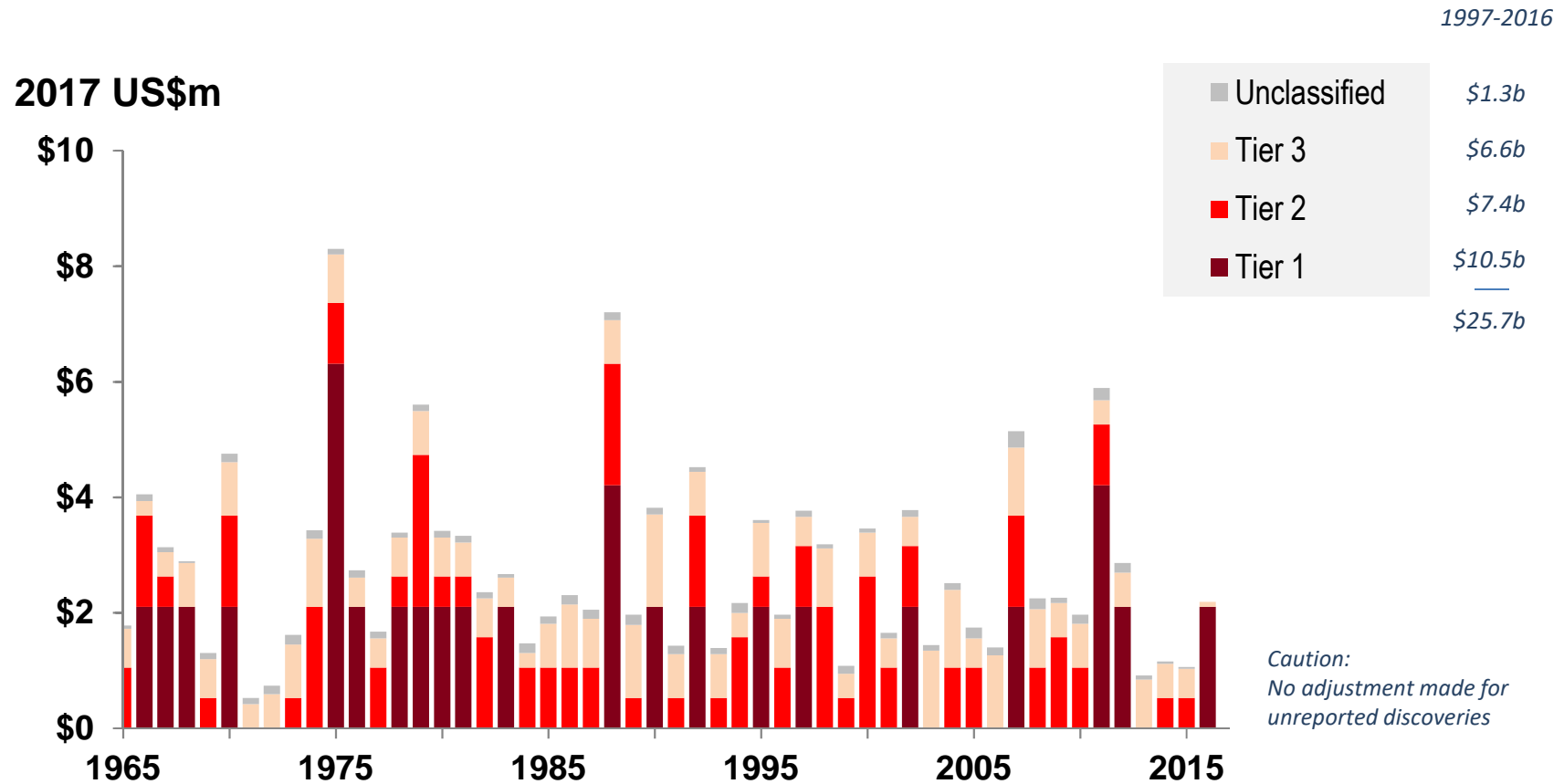
**'Tier 1 deposits'** are "Company making" mines. They are large, long life and low cost. ... ie >20 Years, >200 ktpa Cu or >250koz pa Au, and Bottom Quartile costs. Have an NPV of >\$1000m, and EV of ~\$2000m in 2013 Dollars

*Example: Oyu Tolgoi [Copper]*

Source: MinEx Consulting © September 2017

# Estimated value of discoveries

## Tier 1, 2 and 3 discoveries in Asia: 1965-2016



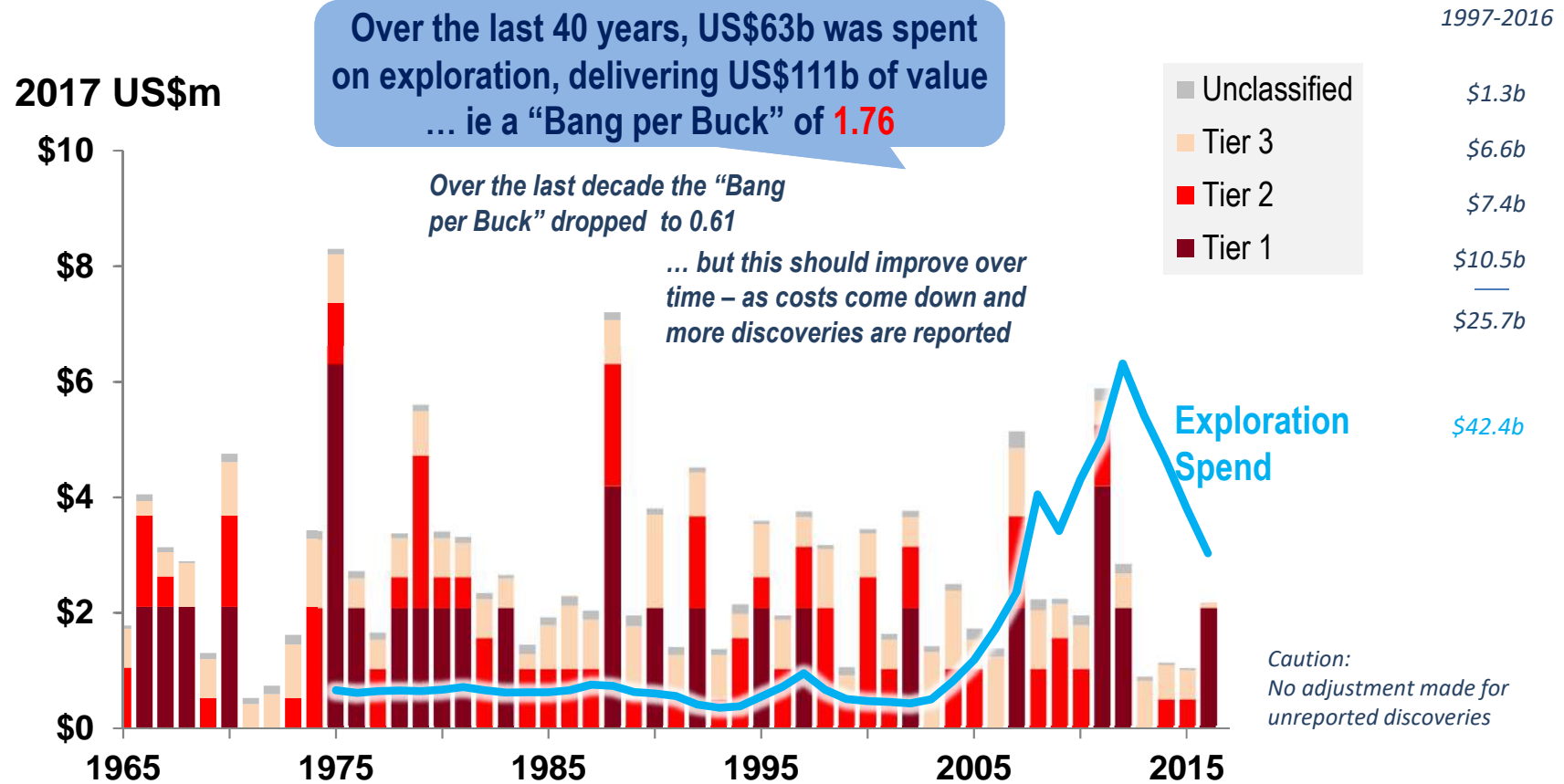
Note: Excludes Bulk Mineral discoveries (i.e. bauxite, coal and iron ore)

Source: MinEx Consulting © September 2017

Caution: Values are indicative / approximate-only

# Estimated value of discoveries

Tier 1, 2 and 3 discoveries in Asia: 1965-2016



Note: Excludes Bulk Mineral discoveries (i.e. bauxite, coal and iron ore)

Caution: Values are indicative / approximate-only

Source: MinEx Consulting © September 2017



# The returns vary widely across the Region

## Spend & performance by Countries within Asia: 2007-2016

Over the last decade the best performing region was East Asia (i.e. China)

Region	Exploration Spend (2017 \$b)		No of Discoveries #		Tier 1+2 Discoveries		Estimated Value (2017 \$b)		Value / Spend
Middle East	\$2.14	5%	23	11%	0	0%	\$0.83	3%	0.39
Central Asia	\$2.74	6%	8	4%	0	0%	\$0.16	1%	0.06
Indian S-C	\$1.15	3%	3	1%	0	0%	\$0.11	<1%	0.09
SE Asia	\$4.77	11%	17	8%	2	11%	\$1.58	6%	0.33
NE Asia	\$7.15	17%	14	19%	1	5%	\$2.86	11%	0.40
East Asia	\$24.45	58%	125	58%	16	84%	\$20.17	78%	0.82
(China)	\$24.35	57%	123	57%	15	79%	\$19.64	76%	0.81
	-----	-----	-----	-----	-----	-----	-----	-----	-----
<b>TOTAL Asia</b>	<b>\$42.40</b>	<b>100%</b>	<b>217</b>	<b>100%</b>	<b>19</b>	<b>100%</b>	<b>\$25.70</b>	<b>100%</b>	<b>0.61</b>

Note: Analysis excludes bulk minerals, and excludes satellite deposits found within existing camps  
 Discoveries refer to Moderate-, Major- and Giant-sized deposits.  
 The Estimated Value is approximate only, and ignores the value of unreported discoveries

Source: MinEx Consulting © September 2017

# How does Asia compare to the Rest of the World?

Spend & performance by Region: 2007-2016

China was the **second-best** region (after Africa) to explore in the World

i.e. “Bang-per-Buck”

Region	Exploration Spend (2017 \$b)		No of Discoveries #		Tier 1+2 Discoveries		Estimated Value (2017 \$b)		Value / Spend
Australia	\$13	9%	115	16%	9	12%	\$8	9%	0.59
Canada	\$25	16%	68	9%	12	16%	\$13	15%	0.55
USA	\$11	7%	28	4%	4	5%	\$5	5%	0.44
Latin America	\$35	23%	94	13%	11	15%	\$12	13%	0.33
Africa	\$20	13%	159	22%	15	21%	\$19	22%	0.92
W Europe	\$4	3%	33	5%	1	1%	\$2	2%	0.41
<b>Asia</b>	<b>\$42</b>	<b>27%</b>	<b>217</b>	<b>30%</b>	<b>19</b>	<b>26%</b>	<b>\$26</b>	<b>30%</b>	<b>0.61</b>
Rest of World	\$5	3%	5	1%	2	3%	\$3	4%	0.66
	-----	-----	-----	-----	-----	-----	-----	-----	-----
TOTAL	\$156	100%	719	100%	73	100%	\$87	100%	0.56
<b>China</b>	<b>\$24</b>	<b>16%</b>	<b>123</b>	<b>17%</b>	<b>15</b>	<b>21%</b>	<b>\$20</b>	<b>23%</b>	<b>0.81</b>

Source: MinEx Consulting © September 2017

Note: Analysis excludes bulk minerals, and excludes satellite deposits found within existing camps  
Discoveries refer to Moderate-, Major- and Giant-sized deposits.

The Estimated Value is approximate only, and ignores the value of unreported discoveries

**As more discoveries are drilled-out & reported, these returns should improve over time**

## 9. CONCLUSIONS

# Conclusions: [1/4]

## 1. Countries covered in the analysis

- Asia covers 33% of the earth's surface and spans 50 countries
- Have broken up Asia into 6 Regions
  - Middle East, Central Asia, Indian Sub-Continent, South East Asia, North East Asia and East Asia (which includes China)

## 2. Trends in exploration spend

- Expenditures have grown substantially since the early 2000s.
- In 2016, \$3.1b was spent on exploration in Asia, including \$2.1b in China
- Over the last decade, Asia accounted for 27% of global exploration expenditures on non-bulk minerals
- Most of this was in China (16% of World's total) – currently spending more than Australia or Canada.
- The two main targets are gold and copper

## 3. Number of discoveries made

- There are over 8000 significant deposits in the World. 2158 (27%) of these are in Asia. This includes 826 (10%) deposits in China
- In the last decade 1147 new deposits were found in the World. 217 of these were in Asia, including 123 in China (17% of the World's total).

# Conclusions: [2/4]

## 3. Continued ...

- Over the last decade 65 Giant deposits were found in the World. 22 of these were in Asia, including 13 in China (20%)
- 14 Tier-1 deposits were found in the World. 5 of these were in Asia – all of which were in China (36%)

## 4. Mineral Endowment

- After adjusting for differences in land area, the size-frequency of Asia's current mineral endowment for gold, copper and lead/zinc is comparable to the World average
- Some Regions are better than others
  - Central Asia is best for gold
  - South East Asia is best for copper
  - East Asia and Indian Sub-continent are best for lead/zinc
- Central Asia, Middle East and NE Asia appear to be grossly under-explored

# Conclusions: [3/4]

## 5. Discovery Performance ... value proposition for Exploration

- 70% of the value created by industry comes from finding Tier-1 and Tier-2 deposits (which make up only 8% of the total by number)
- Over the last decade, US\$42.4b was spent on exploration in Asia, delivering US\$14.7b of value ... a “Bang per Buck” of 0.61. Over the same time period the World average was 0.56

**As more discoveries are drilled-out & reported, these returns will improve over time**

- “Bang per Buck” varied widely between Regions
  - Central Asia (0.06), Indian Sub-Continent (0.09), South East Asia (0.33), Middle East (0.39), North East Asia (0.40) and East Asia (0.82).
  - China (which is part of East Asia) achieved a “Bang per Buck” of 0.81

## Conclusions: [4/4]

Asia is an important contributor to the World's mineral endowment and new discoveries. 27% of the World's known deposits are in Asia.

China is central to all of this ... over the last decade it accounted for 16% of the total exploration expenditures, found 17% of the deposits and (more importantly) accounted for 5 of the 14 Tier-1 discoveries

**In short, the future of the mining industry depends greatly on continued exploration success in China**

The Great Wall, or  
the Golden Road?



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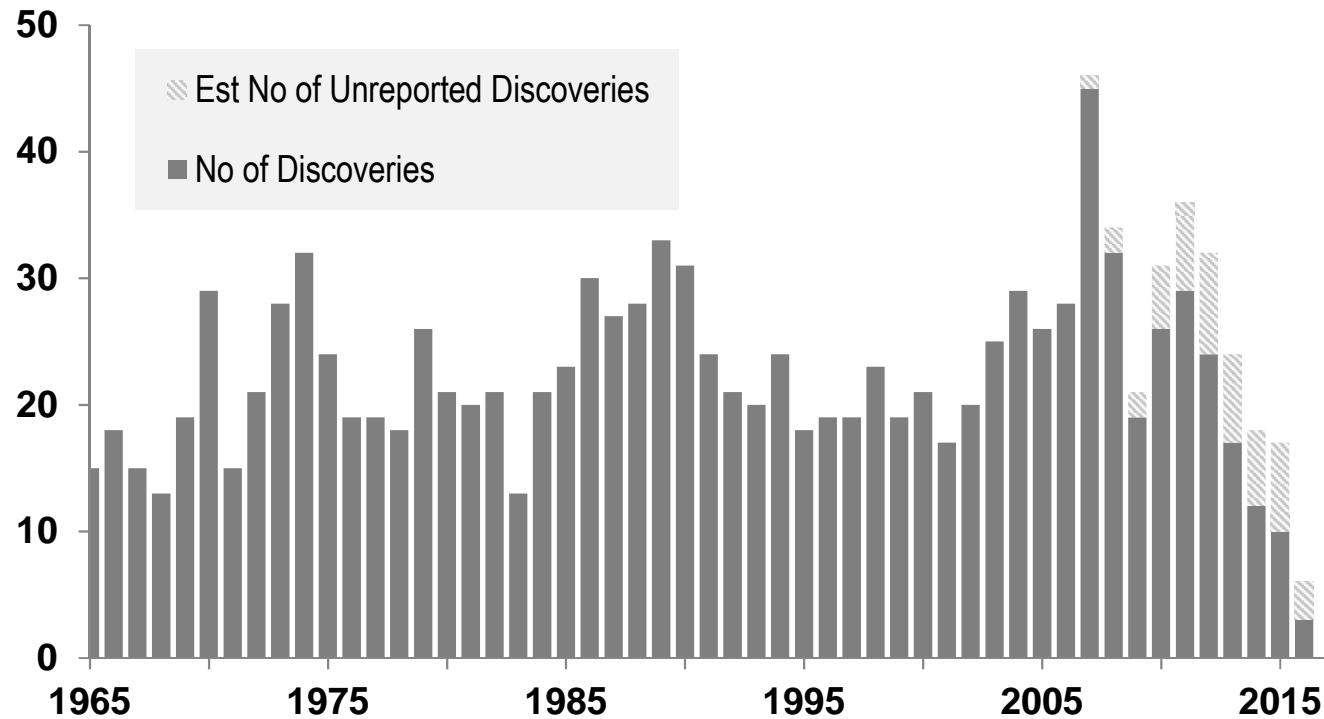
While costs have risen, Asia remains competitive

## TRENDS IN UNIT DISCOVERY COSTS

# Number of discoveries

Asia: 1965-2016

## Number of Discoveries

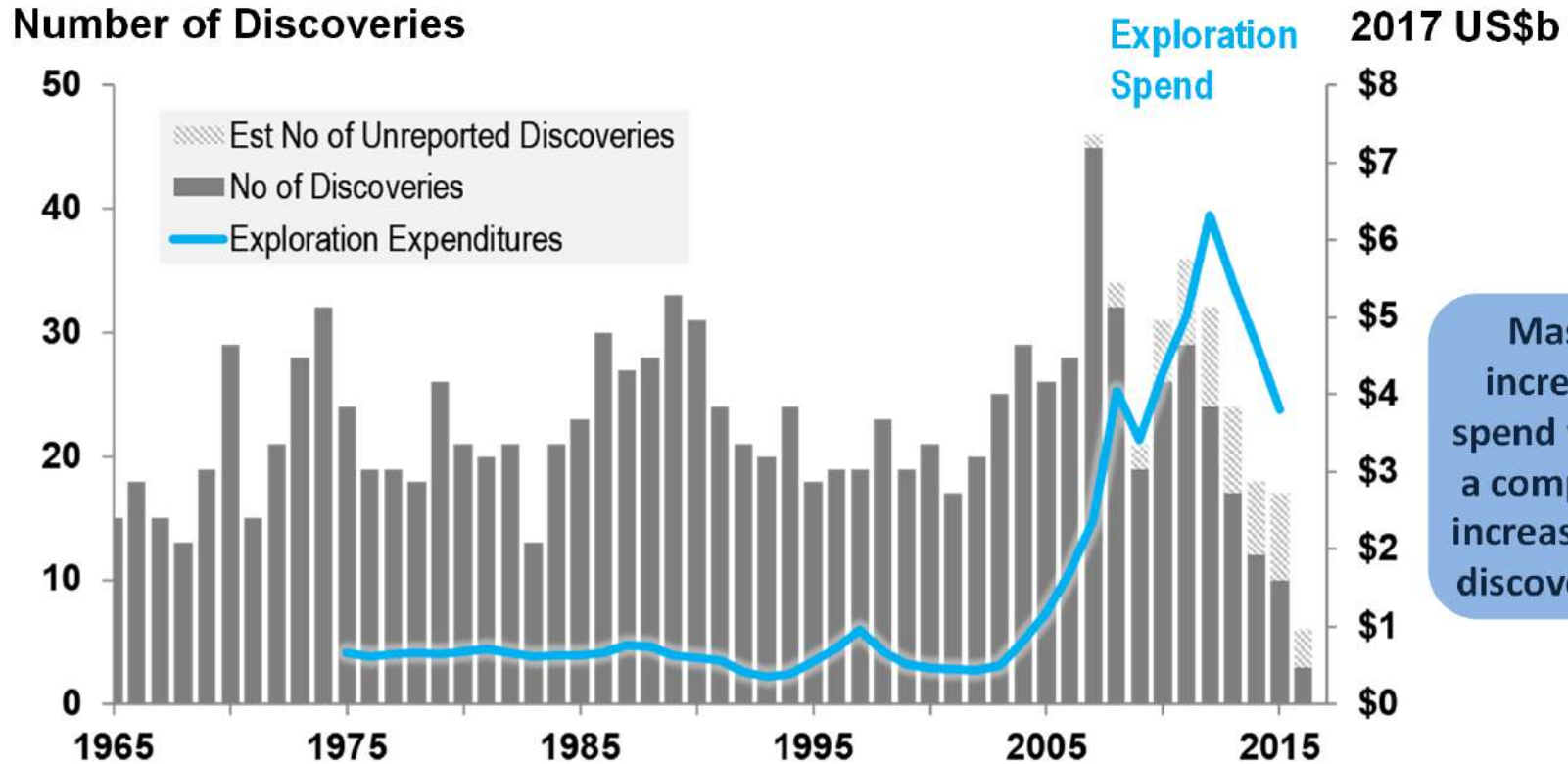


Note: Based on Moderate-, Major- and Giant-sized deposits  
Excludes Bulk Minerals (such as bauxite, coal and iron ore)  
Excludes satellite deposits in existing camps

Source: MinEx Consulting © September 2017

# Exploration spend and Number of discoveries

Asia: 1965-2016



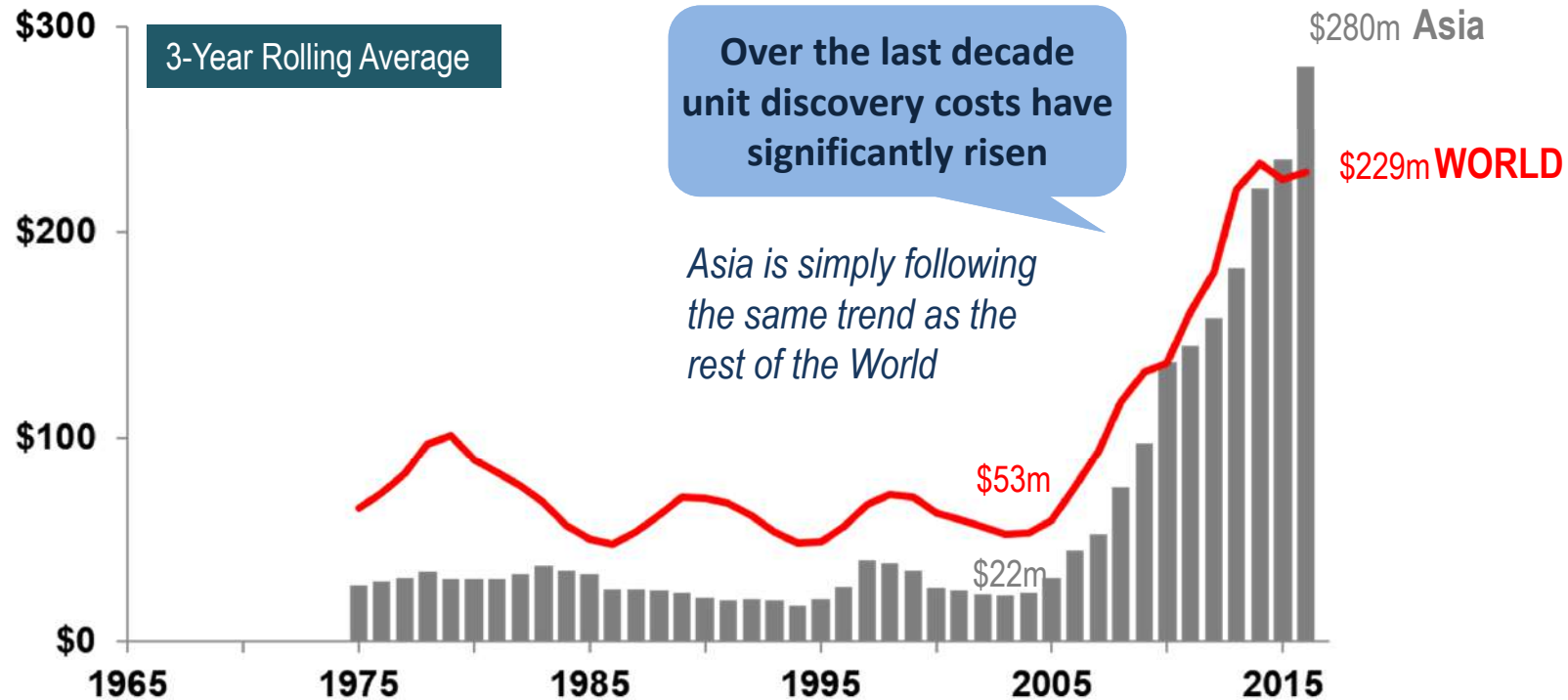
Note: Based on Moderate-, Major- and Giant-sized deposits  
Excludes Bulk Minerals (such as bauxite, coal and iron ore)  
Excludes satellite deposits in existing camps

Source: MinEx Consulting © September 2017

# Average cost per deposit found

Asia versus the World: 1975-2016

## 2017 US\$m per Discovery



Note: Based on a 3-year rolling Average  
 Based on Moderate-, Major- and Giant-sized deposits  
 Excludes Bulk Minerals (such as bauxite, coal and iron ore)  
 Includes an adjustment for the number of unreported discoveries in recent years

Source: MinEx Consulting © September 2017