Trends in exploration

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Overview

1. How much is spent on exploration?
2. Location of recent discoveries
3. Trends in the number and type of discoveries
4. Who made the discoveries?
5. Long term trends in the quality of discoveries
6. The value proposition for exploration
7. Summary / Conclusions
Industry spent $11.3 billion in 2019, down by 57% from the peak in 2012

1. HOW MUCH IS SPENT ON EXPLORATION
Historical and forecast exploration expenditures by Commodity


Exploration is very much a “boom-or-bust” business

Between 2012 and 2016 expenditures fell by 58%

Sources: MinEx Consulting estimates, based on data from ABS, NRCan, MNR (China) and S&P
Note: Includes expenditures on non-bulk and bulk mineral (i.e. bauxite, coal, and iron ore) exploration

Sources: MinEx Consulting estimates, based on data from ABS, NRCan, MNR (China) and S&P
China has severely cut back on exploration.
Over the last decade more than 1070 significant discoveries were made in the World

2. LOCATION OF RECENT DISCOVERIES
Significant discoveries in the world by Size: 2008-2017

846 known deposits, plus ~230 (as yet) unreported discoveries

Note: Bubble Size refers to Moderate / Major / Giant deposits

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

Source: MinEx Consulting © October 2019

MinEx Consulting

Strategic advice on mineral economics & exploration
Significant discoveries in the world by **Quality**: 2008-2017

![Map of global mineral discoveries](image)

- **GOLD**
- **PRECIOUS** (PGE+Ag+Diamonds)
- **BASE METAL** (Cu+Ni+Zn+Pb)
- **URANIUM**
- **MINERAL SANDS**
- **BULK** (Bauxite+Coal+Iron Ore+P₂O₅+K₂O)
- **OTHER**

<table>
<thead>
<tr>
<th>Tier 1</th>
<th>Tier 2</th>
<th>Tier 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>54</td>
<td>294</td>
</tr>
</tbody>
</table>

Note: Bubble Size refers to Tier 1 / Tier 2 / Tier 3

- "Tier 1" deposits are company-making mines and are large, long life and low cost with NPV at the Decision-to-Build stage of >$1000m (in 2013 US Dollars)
- "Tier 2" deposits are "significant" and have some of the elements of a Tier 1 but have an NPV of $200 to $1000m
- "Tier 3" deposits are modest or marginal deposits, with an NPV of $0 to $200m

367 Tier-1, -2 and -3 deposits found in the last decade

Source: MinEx Consulting © October 2019

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Tier 1 discoveries in the World: 2009-2018

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Only 1 in Latin America and No Tier-1 discoveries in Russia
4 in China, 4 in Australia, 3 in Africa and 2 in Canada

GOLD
- Red Hill Goldrush [2008: Gold]
- Taylor [2012: Zinc]
- Cascabel [2013: Copper]
- Arrow [2014: Uranium]

PRECIOUS (PGE+Ag+Diamonds)
- Timok [2012: Copper]
- Luaxe [2013: Diamonds]
- Red Hill/Goldrush [2008: Gold]
- Goat [2010: Gold]

BASE METAL (Cu+Ni+Zn+Pb)
- Hooke [2010: Gold]
- Haque [2016: Zinc]
- Huoshaoyun [2012: Zinc]
- Balama [2011: Graphite]
- Kakula [2014: Copper]

URANIUM
- Arrow [2014: Uranium]
- Timok [2012: Copper]
- Hu’u [2015: Copper]
- Huoshaoyun [2012: Zinc]

MINERAL SANDS
- Pilgangoora [2009: Lithium]
- Earl Grey [2016: Lithium]
- Wodgina [2016: Lithium]
- Swan [2016: Gold]

BULK (Bauxite+Coal+Iron Ore+P2O5+K2O)
- Earl Grey [2016: Lithium]
- Pilgangoora [2009: Lithium]
- Wodgina [2016: Lithium]
- Swan [2016: Gold]

OTHER
- Only 1 in Latin America and No Tier-1 discoveries in Russia
- 4 in China, 4 in Australia, 3 in Africa and 2 in Canada

Source: MinEx Consulting © October 2019
The number of discoveries made has steadily risen over time

3. LONG TERM TRENDS IN THE NUMBER AND TYPE OF DISCOVERIES
The number of discoveries made each year has been slowly rising over time. It's too early to tell whether the recent drop in the discovery rate is “real” or “apparent.”

Half of all known deposits in the World have been found since 1975.

Note: Based on deposits >=“Moderate” in-size, i.e., >100k oz Au, >10kt Ni, >100kt Cu, 300kt Zn+Pb, >5kt U3O8, >5 Mt Heavy Minerals, >20 Mt Fe, >20 Mt Thermal Coal, >10 Mt Met Coal, >3 Mt P2O5 and >3 Mt K2O.

Source: MinEx Consulting © October 2019
Number of discoveries by size
Significant mineral discoveries in the World: 1900-2017

In recent years, an increasing proportion of discoveries are "Moderate" in size
... though this may simply be an artefact of the time required to properly drill-out a discovery

Note:  “Moderate” >100k oz Au, >10kt Ni, >100k t Cu, >300k t Zn+Pb, >5k t U₃O₈, >20 Mt Fe, >20 Mt Thermal Coal
“Major” >1 Moz Au, >100kt Ni, >1 Mt Cu, >3 Mt Zn+Pb, >25 k t U₃O₈, >200 Mt Fe, >200 Mt Thermal Coal
“Giant” >6 Moz Au, >1 Mt Ni, >5 Mt Cu, >12 Mt Zn+Pb, >125 k t U₃O₈, >1000 Mt Fe, >1000 Mt Thermal Coal

Source: MinEx Consulting © October 2019
Number of discoveries by commodity type

Significant mineral discoveries in the World: 1900-2018

Note: Based on deposits >="Moderate" in-size, i.e., >100k oz Au, >10kt Ni, >100kt Cu, 300kt Zn+Pb, >5kt U3O8, >5 Mt Heavy Minerals, >20 Mt Fe, >20 Mt Thermal Coal, >3 Mt P2O5 and >3 Mt K2O

Source: MinEx Consulting © October 2019
**Number of discoveries by commodity type**

Significant mineral discoveries in the World: 1900-2018

- **Gold** remains the main target of interest.
- "Other" (which includes Li, Co, Graphite, REE etc) have grown in recent years.

**Note:** Based on deposits >"Moderate" in-size. i.e. >100koz Au, >10kt Ni, >100kt Cu, 300kt Zn+Pb, >5kt U\(_2\)O\(_8\), >5 Mt Heavy Minerals, >20 Mt Fe, >20 Mt Thermal Coal >10 Mt Met Coal, >3 Mt P\(_2\)O\(_5\) and >3 Mt K\(_2\)O

**Source:** MinEx Consulting © October 2019

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Note: Based on deposits >="Moderate" in-size. i.e. >100koz Au, >10kt Ni, >100kt Cu, 300kt Zn+Pb, >5kt U3O8
>5 Mt Heavy Minerals, >20 Mt Fe, >20 Mt Thermal Coal >10 Mt Met Coal, >3 Mt P2O5 and >3 Mt K2O

Source: MinEx Consulting © October 2019
Significant mineral discoveries in the World: 1900-2017

Number of discoveries by region

Significant mineral discoveries in the World: 1900-2017

The relative importance of each Region changes over time

... is driven by geological maturity, technology, infrastructure and Country Risk

Australia has grown ... but many of these discoveries are small in size

In the early 1900's USA was dominant ...

... followed by Canada

Russia dropped out following the collapse of the Soviet Union in 1991

Rest of World
China
FSU + E Europe
Western Europe
Africa
Pac / SE Asia
Latin America
United States
Canada
Australia

Source: MinEx Consulting © October 2019

MinEx Consulting Strategic advice on mineral economics & exploration
Junior explorers are now finding most of the deposits

4. LONG TERM TRENDS IN WHO MADE THE DISCOVERIES
Significant mineral discoveries in the Western World: 1900-2018

Prior to 1930
Prospectors accounted for 68% of all discoveries made

Between 1950-2000 Major Producers accounted for 31% of all discoveries made

In the last decade 63% of all discoveries in the WW were made by Junior Explorers

Note:  
* Junior Explorer” has no income  
* Small Producer” has a single small mine and <$50m pa sales revenue (in 2013 US Dollars)  
* Moderate Producer” has 1-3 mines and $50-500m pa sales revenue  
* Major Producer” has several large mines and >$500m pa revenue  
* “Other” includes industrial companies, major oil companies and private/unlisted companies

Source: MinEx Consulting © October 2019
In recent years the discoveries have been of lower quality

5. LONG TERM TRENDS IN THE QUALITY OF THE DISCOVERIES
Number of discoveries by quality
Tier 1, 2 & 3 mineral discoveries in the World: 1900-2017

Over time, Tier 1 discoveries have become less frequent

Note:  
* Tier 1 deposits are company-making mines and are large, long life and low cost with NPV at Decision-to-Build of >$1000m (in 2013 US Dollars)  
* Tier 2 deposits are ‘significant’ and have some of the elements of a Tier 1 but have an NPV of $200 to $1000m  
* Tier 3 deposits are modest or marginal deposits, with an NPV of $0 to $200m  
* Unclassified deposits are small deposits with an Expected Value of ~$10m

Source: MinEx Consulting © October 2019

Strategic advice on mineral economics & exploration
Number of discoveries by quality
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Source: MinEx Consulting © October 2019

MinEx Consulting  Strategic advice on mineral economics & exploration
Value of exploration: 1975-2018

Caution: Values are indicative/approximate only
Assumes that the average value of a Tier1/Tier2/Tier3/Unclassified discovery is $2000m / $500m / $80m / $10m in 2013 Dollars

Source: MinEx Consulting © October 2019
Does exploration create or destroy value?
What are the best commodities and places to explore?

6. VALUE-PROPOSITION FOR EXPLORATION
Cost and value of exploration: 1975-2018

Over the last decade, US$198 billion was spent on exploration, delivering US$109 billion of value... i.e., a "Bang per Buck" of 0.55.

Industry has gone from value creation to value destruction.

...the true situation is likely to be better, due to delays in reporting discoveries.

Caution: Values are indicative/approximate only.
Assumes that the average value of a Tier1/Tier2/Tier3/Unclassified discovery is $2000 million / $500 million / $80 million / $10 million in 2013 Dollars.

Source: MinEx Consulting © October 2019
## Discovery performance by Region: 2009-2018

<table>
<thead>
<tr>
<th>Region</th>
<th>Exploration Spend (2019 $b)</th>
<th>No of Discoveries</th>
<th>Tier 1+2 Discoveries</th>
<th>Estimated Value (2019 $b)</th>
<th>Value / Spend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>$23</td>
<td>185</td>
<td>14</td>
<td>$21</td>
<td>0.90</td>
</tr>
<tr>
<td>Canada</td>
<td>$25</td>
<td>87</td>
<td>11</td>
<td>$14</td>
<td>0.55</td>
</tr>
<tr>
<td>USA</td>
<td>$13</td>
<td>27</td>
<td>2</td>
<td>$6</td>
<td>0.44</td>
</tr>
<tr>
<td>Latin America</td>
<td>$39</td>
<td>110</td>
<td>11</td>
<td>$13</td>
<td>0.34</td>
</tr>
<tr>
<td>Pacific/SE Asia</td>
<td>$9</td>
<td>27</td>
<td>2</td>
<td>$6</td>
<td>0.63</td>
</tr>
<tr>
<td>Africa</td>
<td>$20</td>
<td>209</td>
<td>15</td>
<td>$23</td>
<td>1.11</td>
</tr>
<tr>
<td>W Europe</td>
<td>$4</td>
<td>29</td>
<td>1</td>
<td>$2</td>
<td>0.40</td>
</tr>
<tr>
<td>FSU+EE+China</td>
<td>$58</td>
<td>154</td>
<td>16</td>
<td>$25</td>
<td>0.42</td>
</tr>
<tr>
<td>Rest of World</td>
<td>$6</td>
<td>17</td>
<td>1</td>
<td>$1</td>
<td>0.21</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$198</strong></td>
<td><strong>846</strong></td>
<td><strong>73</strong></td>
<td><strong>$109</strong></td>
<td><strong>0.55</strong></td>
</tr>
</tbody>
</table>

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**Region**
- Australia and Africa performed well

**Note:**
- Analysis includes Bulk Minerals, but excludes satellite deposits found within existing camps.
- # No of Discoveries refer to Moderate-, Major- and Giant-sized deposits.

**Caution:** The Estimated Value is approximate only, and ignores the value of unreported discoveries.

**Source:** MinEx Consulting © October 2019
## Comparison between commodities: World: 2009-2018

**Best performer was “Other” Minerals** (ie Lithium, graphite, cobalt etc)

**Worst performers were Bulk Minerals** (ie Coal & Iron Ore)

<table>
<thead>
<tr>
<th></th>
<th>Exploration Spend (2019 $b)</th>
<th>No of Discoveries</th>
<th>Tier 1+2 Discoveries</th>
<th>Estimated Value (2014 $b)</th>
<th>Value / Spend</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gold</strong></td>
<td>$68</td>
<td>336</td>
<td>18</td>
<td>$34</td>
<td>31%</td>
</tr>
<tr>
<td><strong>Base Metals</strong></td>
<td>$51</td>
<td>176</td>
<td>22</td>
<td>$30</td>
<td>28%</td>
</tr>
<tr>
<td><strong>Uranium</strong></td>
<td>$9</td>
<td>18</td>
<td>5</td>
<td>$5</td>
<td>4%</td>
</tr>
<tr>
<td><strong>Diamonds</strong></td>
<td>$4</td>
<td>9</td>
<td>1</td>
<td>$3</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Iron Ore</strong></td>
<td>$19</td>
<td>96</td>
<td>0</td>
<td>$4</td>
<td>4%</td>
</tr>
<tr>
<td><strong>Coal</strong></td>
<td>$22</td>
<td>40</td>
<td>5</td>
<td>$5</td>
<td>4%</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>$25</td>
<td>171</td>
<td>22</td>
<td>$29</td>
<td>26%</td>
</tr>
<tr>
<td><strong>TOTAL inc Bulks</strong></td>
<td>$198</td>
<td>846</td>
<td>73</td>
<td>$109</td>
<td>100%</td>
</tr>
<tr>
<td><strong>TOTAL excl Bulks</strong></td>
<td>$157</td>
<td>710</td>
<td>68</td>
<td>$100</td>
<td>100%</td>
</tr>
</tbody>
</table>

Note: Analysis excludes satellite deposits found within existing camps.

# No of Discoveries refer to Moderate-, Major- and Giant-sized deposits.

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

Source: MinEx Consulting © October 2019
7. SUMMARY / CONCLUSIONS
Summary / Conclusions

1. **Location of recent discoveries** ~ 1070 discoveries have been made in the last decade … but only 19 of these were Tier 1 (or World Class). 4 each were found in China and Australia, 3 in Africa and 2 each in Canada, USA and Pacific / SE Asia.

2. **Trends in the number, size and quality of discoveries** – Gold still remains the main focus. Appears to be a drop in the size and quality of recent discoveries. It’s getting harder to find a Tier 1 deposit. The number of discoveries made each year has been slowly rising over time.

3. **Who made the discoveries?** – Used to be driven by the Majors. Junior explorers now account for 63% of all discoveries (by number).

4. **Value proposition for exploration** – 66% of the value is tied-up in the Tier 1 and 2 discoveries – but these account for less than 8% by number. The bang-per-buck is currently only 0.55 … which means that the industry is destroying value, not creating it.

The outlook is subdued / uncertain… **to meet our future needs we need to improve our performance**
Copies of this and other similar presentations can be downloaded from my website.

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