WHAT DO WE MEAN BY A WORLD-CLASS DEPOSIT? AND WHY ARE THEY SPECIAL?

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Overview

• What do we mean by “world-class”?
  – Current definitions and issues associated with them
  – Proposed definition – $250 million NPV threshold
    (based on an analysis of 143 significant mineral discoveries)

• How often are they found?
  – On average 2-4 are found each year in the Western World

• What makes them so “special”?
  – Special characteristics of world-class mines
  – Impact on investors, government and society
What do we mean by “world-class”?
There are wide range of definitions for world class

World-class means different things to different people … i.e. for:

- The general public … Something of outstanding quality
- Investors … They make lots of money for a long time!
- Geologists … A deposit with a very big mineral endowment
- Promoters … Something that might be big

The risk is that the term is being over-used by industry to the point of devaluing its meaning
Definitions commonly used by geologists

• Donald Singer (1995)
  Upper 10 percent of deposits in his database ordered in terms of contained metal. This equates to 3.2 Moz for gold, 77 Moz for silver, 2 Mt for copper, 1 Mt for lead and 1.7 Mt for zinc.

• Peter Laznicka (1999)
  “An informal term applied to ore deposits with an exceptionally large tonnage of economically recoverable metals”. … “The term attests to an exceptional economic benefit these deposits provide, or potentially provide, and consequently this class of deposits is eagerly sought by the industry”.
Major gold deposits discovered in the Western World between 1950 and 2003

Source: WMC June 2005

Million oz of Gold

N = 357

N_{>3.2} = 179

Singer's threshold for world-class gold deposits

World-Class Deposits
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Major base metal deposits discovered in the Western World between 1950 and 2003

Million Tonnes of Cu-equivalent Metal

BASE METALS

\[ N = 927 \]
\[ N_{>2} = 261 \]

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Assumes 1t Cu = 0.33t Ni = 2.91t Zn = 3.47t Pb

Source: WMC June 2005
Definitions commonly used by the industry

• Tom Albanese (2005)
  “Only the largest and highest grade deposits that would make a difference to the company’s bottom line”.

• Michael Doggett (2004)
  “World-class should be more than just big geologically [and that] there must be an economic consideration”....... “when economics are considered, there is no such thing as a world class mineral deposit. There are only big interesting mineral deposits or world-class mines”.
NPV approach
Analysis of the value created from potential world-class deposits

- Use WMC’s deposit database – contains information on 115,000 mineral deposits around the world, including discovery history data on 10,000 of these.

- Evaluated the NPV’s of 143 significant mineral discoveries made in low-risk western world countries between 1985-2003.
  - 63 gold (>1 Moz)
  - 6 diamond (>3 M carats)
  - 74 base metal (>0.5Mt Cu-equiv)

Returns achieved for major gold discoveries
Gold deposits found in low-risk WW countries 1985-2003

Some of the smaller gold discoveries generated exceptional returns

Constant US$400/oz REAL gold price

Deposit Size (moz Pre-Mined Resource)

Source: Schodde & Hronsky May 2006
Value of major gold discoveries
Gold deposits found in low-risk WW countries 1985-2003

NPV (US$m in 2004$)

$1000

$800

$600

$400

$200

$0

-$200

Deposit Size (moz Pre-Mined Resource)

GOLD

Bigger is better

Constant
US$400/oz REAL
gold price

Source: Schodde & Hronsky May 2006
Value of major base metal discoveries
Base metal deposits found in low-risk WW countries 1985-2003

**Deposit Size** (total mine site value US$b 2004 dollars)

**NPV (US$m in 2004$)**

- Copper
- Nickel Laterite
- Nickel Sulphide
- Lead-Zinc
- Other Base metals

Source: Schodde & Hronsky May 2006
Incremental NPV’s of all significant gold discoveries
Gold deposits found in low-risk WW countries 1985-2003

Caution: Assumes zero NPV for uneconomic deposits
Analysis excludes deposits < 1Moz

Incremental NPV (US$m)

Source: Schodde & Hronsky May 2006
Incremental NPV’s of all significant gold discoveries
Gold deposits found in low-risk WW countries 1985-2003

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Analysis excludes deposits < 1Moz

Incremental NPV (US$m)

Cumulative NPV (%)

Over half the value is captured in just 12% of the major (ie >1 Moz) discoveries

Source: Schodde & Hronsky May 2006
Incremental NPV’s of all significant gold discoveries
Gold deposits found in low-risk WW countries 1985-2003

Caution: Assumes zero NPV for uneconomic deposits
Analysis excludes deposits < 1Moz

Incremental NPV (US$m)

Cumulative Percent (Number)
Incremental NPV’s of all significant gold discoveries
Gold deposits found in low-risk WW countries 1985-2003

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Source: Schodde & Hronsky  May 2006
Incremental NPV’s of all significant gold discoveries
Gold deposits found in low-risk WW countries 1985-2003

Caution: Assumes zero NPV for uneconomic deposits
Analysis excludes deposits < 1Moz

The top 12% of the major gold deposits by value (i.e. >$250m) contain 30% of the metal tonnes and 53% of the total NPV

Source: Schodde & Hronsky  May 2006
Incremental NPV's of all significant base metal discoveries
Base metal deposits found in low-risk WW countries 1985-2003

Caution: Assumes zero NPV for uneconomic deposits
Analysis excludes deposits < 0.5mt Cu-equiv

Incremental NPV (US$m)

$2,000
$1,500
$1,000
$500
$250
$0

Cumulative Percent (Number)

$0  $250  $500  $1,000  $1,500  $2,000

0%  14%  20%  40%  60%  80%  100%

Source: Schodde & Hronsky May 2006
Incremental NPV’s of all significant base metal discoveries
Base metal deposits found in low-risk WW countries 1985-2003

Caution: Assumes zero NPV for uneconomic deposits
Analysis excludes deposits < 0.5mt Cu-equiv

Incremental NPV (US$m)

Source: Schodde & Hronsky May 2006
Incremental NPV’s of all significant base metal discoveries
Base metal deposits found in low-risk WW countries 1985-2003

Caution: Assumes zero NPV for uneconomic deposits
Analysis excludes deposits < 0.5mt Cu-equiv

Incremental NPV (US$m)

Cumulative Percent (Number, Tonnes, Tax)

Source: Schodde & Hronsky  May 2006
Incremental NPV’s of all significant base metal discoveries
Base metal deposits found in low-risk WW countries 1985-2003

The top 14% of the major BM deposits by value (i.e. >$250m) contain 32% of the metal tonnes and 67% of the total NPV.

Caution: Assumes zero NPV for uneconomic deposits
Analysis excludes deposits < 0.5mt Cu-equiv

Source: Schodde & Hronsky May 2006
Value of top 30 Discoveries
Deposits found in low-risk WW countries 1985-2003

NPV (US$m in 2004$ @ 7% discount rate)

Deposit

Source: Schodde & Hronsky  May 2006
Several commodities exhibit a step-change in value

$250m Threshold for World-Class Mines

Deposit Number (Ranked by NPV)

NPV (US$m in 2004 dollars)

$1,500

$1,000

$500

$0

$-500

1  5  10  15  20

Source: Schodde & Hronsky May 2006

World-Class Deposits
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Size-frequency distribution .. discontinuity above 6 Moz?
Gold deposits found in low-risk WW countries 1985-2003

Cumulative Frequency

Deposit size (Moz Pre-Mined Resource)

Source: Schodde & Hronsky  May 2006
Size-frequency distribution .. discontinuity above 6 Moz?
Gold deposits found in low-risk WW countries 1985-2003

Cumulative Frequency

Deposit size (Moz Pre-Mined Resource)

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Cumulative Frequency

Deposit size (Moz Pre-Mined Resource)

Source: Schodde & Hronsky  May 2006
Size-frequency distribution .. discontinuity above 4 Mt Cu?
Base Metal deposits found in low-risk WW countries 1985-2003

Cumulative Frequency

Deposit size (Mt Cu-equiv Pre-Mined Resource)

Assumes 1t Cu = 0.33t Ni = 2.91t Zn = 3.47t Pb

Source: Schodde & Hronsky May 2006
Size-frequency distribution .. discontinuity above 4 Mt Cu?
Base Metal deposits found in low-risk WW countries 1985-2003

Cumulative Frequency

Deposits size (Mt Cu-equiv Pre-Mined Resource)

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Size-frequency distribution .. discontinuity above 4 Mt Cu?
Base Metal deposits found in low-risk WW countries 1985-2003

Cumulative Frequency

 Deposit size (Mt Cu-equiv Pre-Mined Resource)

Assumes 1t Cu = 0.33t Ni = 2.91t Zn = 3.47t Pb

Source: Schodde & Hronsky May 2006
Highest value discoveries are in camps
Value of top 30 discoveries found in low-risk WW countries 1985-2003

NPV (US$m in 2004$ @ 7% discount rate)

Source: Schodde & Hronsky  May 2006
How many world-class discoveries are made each year?
Exploration expenditures and significant discoveries in the Western World: 1980-2005

2 to 4 world-class deposits are found each year in WW

Expenditures ($ Billion in 2005 dollars)

- Total Expenditures
- Tier 2 discoveries (NPV $50-250m)
- Tier 1 (i.e., World-Class) discoveries

Source: BHP Billiton May 2006
What are the special characteristics of a world-class mine?
Characteristics of world-class mines

• **Big** – often the largest in its class
• **Long life** – resulting in a lasting impact on the industry
• **High quality** – usually viewed in terms of ore grade, but more correctly in terms of low production cost
Size …. Tonnes-Grade distribution
Gold deposits found in low-risk WW countries 1985-2003

**Graph Details:**
- **Y-axis:** Grade (g/t Au-equiv)
- **X-axis:** Deposit size (Mt Pre-Mined Resource)

**Legend:**
- Note: Excludes deposits <100 koz

**Source:** BHP Billiton Sept 2005
Size .... NPV versus Tonnes-Grade
Gold deposits found in low-risk WW countries 1985-2003

Weighted Average NPV (Tier 1 gold deposit) = $477m

Bigger is better!

Notes:
- Excludes deposits <100 koz

Sources:
- BHP Billiton Sept 2005
- Schodde & Hronsky May 2006
Size .... Tonnes-Grade distribution
Copper deposits found in low-risk WW countries 1985-2003

Source: BHP Billiton Sept 2005
Size .... Tonnes-Grade distribution
Copper deposits found in low-risk WW countries 1985-2003

**Weighted Average NPV (Tier 1 copper deposit) = $692m**

- **NPV >$250m**
- **NPV $100m to $250m**
- **NPV $0 to $99m**
- **NPV negative**
- **Not modeled**

**Deposit size (Mt Pre-Mined Resource)**

**Grade (% Cu-equiv)**

- 0.1% Cu
- 1% Cu
- 10% Cu

**Need at least 0.8% Cu**

Sources: BHP Billiton Sept 2005
Schodde & Hronsky  May 2006
Size of footprint
Porphyry copper deposits

Footprint area (km²)

Copper metal (mt Cu-equiv)

Source: Donald Singer et al 2002
Size of footprint
Porphyry copper deposits

Footprint area (km²)

Copper metal (mt Cu-equiv)

Source: Donald Singer et al 2002
Size of footprint
Porphyry copper deposits

Footprint area (km²)

Copper metal (mt Cu-equiv)

Source: Donald Singer et al 2002
Giant orebodies have big footprints

Source: Donald Singer et al 2002
World-class deposits have a high “option” value

Their large size and long life creates the opportunity to:

• Achieve economies of scale in mining and processing. This lowers the cut-off grade & increases the overall resource – world-class deposits can “grow” significantly over time!

• Take advantage of market opportunities – by quickly expanding the mine during good times

• Invest in developing new technologies – which will lower costs and increase the economic resource base
Growth in Resources at Ertsberg-Grasberg Camp

Copper Metal (Mt Cu)

Resources can continue to grow long after the initial discovery. This is particularly true for world-class deposits.

Note: Resource data only available after 1996

Source: FCX
Copper Production From Grasberg Camp
Actual versus forecast

Annual Production (ktpa of Cu in concentrate)

Source: Brook Hunt & Associates 1980 to 2005
Copper Production From Grasberg Camp
Actual versus forecast

**Annual Production** (ktpa of Cu in concentrate)

- **Actual Production**
- **Brook Hunt forecasts**

Source: Brook Hunt & Associates 1980 to 2005
Copper Production From Grasberg Camp
Actual versus forecast

Annual Production (ktpa of Cu in concentrate)

- Actual Production
- Brook Hunt forecasts

1960: Ertsberg discovered

Source: Brook Hunt & Associates 1980 to 2005
Copper Production From Grasberg Camp
Actual versus forecast

**Annual Production** (ktpa of Cu in concentrate)

- **Actual Production**
- **Brook Hunt forecasts**

**Source:** Brook Hunt & Associates 1980 to 2005
Copper Production From Grasberg Camp
Actual versus forecast

Annual Production (ktpa of Cu in concentrate)

- Actual Production
- Brook Hunt forecasts

1960: Ertsberg discovered
1988: Grasberg discovered

Source: Brook Hunt & Associates 1980 to 2005
Copper Production From Grasberg Camp
Actual versus forecast

Annual Production (ktpa of Cu in concentrate)

Source: Brook Hunt & Associates 1980 to 2005
Copper Production From Grasberg Camp
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**Annual Production** (ktpa of Cu in concentrate)

- **Actual Production**
- **Brook Hunt forecasts**

Source: Brook Hunt & Associates 1980 to 2005

- 1960: Ertsberg discovered
- 1988: Grasberg discovered
Copper Production From Grasberg Camp
Actual versus forecast

**Annual Production** (ktpa of Cu in concentrate)

- **Actual Production**
- **Brook Hunt forecasts**

- 1960: Ertsberg discovered
- 1988: Grasberg discovered
- 1995
- 1999
- 2002
- 2005

Source: Brook Hunt & Associates 1980 to 2005
Summary: Ten benefits of world-class mines

1) They generate significant wealth over an extended period of time
2) Help launch major mining companies
3) Create new markets through lower prices \textit{(Climax mine for Molybdenum)}
4) Encourages further investment in exploration
5) Promotes innovation \textit{(flotation, autogenous smelting, synthetic rutile)}
6) Stimulates other mines to set up in the area
7) Encourages downstream processing
8) Encourages support industries \textit{(Sudbury, Johannesburg, Kalgoorlie/Perth)}
9) Assists in the social and political development of the region
10) Potentially lower environmental impact
Conclusions

• World-class mines by definition are “something special”. They produce major benefits to industry and society.

• Better to define them in terms of wealth creation than physical size.

• Deposits with NPV >$250m appear to have different size-frequency characteristics – an artefact of being part of a camp?

• To have a reasonable chance of being world-class the deposit needs to contain >6 Moz Au or >4-5 mt of Cu-equivalent ( = 1.0-1.3Mt Ni = 10-12 Mt Zn).

• On average 2-4 world-class deposits were found each year in the Western World.

• Economic analysis of 143 major deposits found between 1985-2003 showed that much of the industry’s wealth is captured in a handful of discoveries.
  
  – For gold: Of those >0.5 mt Cu-equiv, 12% by number had an NPV>$250m. These contained 30% of the metal and 53% of the total wealth.
  
  – For base metals: Of those >1 mos Au, 14% by number had an NPV>$250m. These contained 32% of the metal and 67% of the total wealth.
Closing note: The importance of world-class mines to society

Is mining a benefit to society?

“What matters is how the [mineral] wealth is transformed into other forms of wealth and income”.

Source: Stoekel (1999)

Since much of the minerals industry’s wealth is created by world-class mines, the discovery and management of these mines has a critical role in ensuring that the industry makes a positive and lasting impact on society.