Gold primer overview

This tome is intended as a desk reference for generalists or new analysts covering the precious metals space. This primer sheds light on the key long term themes driving supply and demand for bullion. In addition, we tackle subjects germane to gold including geology, exploration techniques for discovering gold deposits, types of deposits, reserve and resource classifications, and the mining and processing of gold deposits. And, we identify macroeconomic and industry-specific variables that drive gold stocks.

Global gold supply and demand fundamentals overview

We review the key drivers and characteristics of global gold supply and demand. The key components of gold supply are mine production and scrap disposals. The world's top three gold producing countries in 2011 were China at 371 tonnes, Australia at 258 tonnes, and the United States at 233 tonnes. Most recycled gold generated originates from jewelry. Over the past several years demand for gold fell into four categories. Jewelry accounts for the largest share of final demand at around 40-45%; industrial and dental uses account for approximately 13%; investment accounts for 30%; and, central bank purchases are 5% of demand.

Gold producer fundamentals

The total market capitalization of the global gold sector is $282 billion. The company with the largest market capitalization ($27 billion), gold output (7.2 million ounces) and gold reserves (140 million ounces) is Barrick Gold. The top 10 gold producers in the world control around 35% of global gold output. The global gold producers are facing continued pressures on cash costs due to rising labor rates, declining ore grades mined, and rising energy and consumable costs.

Conventional valuation approaches tend to work best

Metals and precious metal mining stocks are very volatile and require a great deal of savvy to trade on a short term basis. The group is sensitive to foreign exchange rates, macroeconomic factors, operating and capital cost pressures, and commodity price swings. In terms of valuation, we focus mostly on price to net asset value (P/NAV) and, to a lesser extent, price to cash flow (P/CF). We believe that P/NAV is very useful indicator of long term value of the underlying reserves.

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Refer to important disclosures on page 132 to 134. Link to Definitions on page 131.
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Introduction

Our gold primer is intended for use as a deep dive into key areas of our current coverage universe, in this case the global gold sector. We plan to build out into other areas over time in conjunction with our partners on the BoFA Merrill Lynch Global Metals Mining & Steels team. This primer sheds light on the key long term themes driving supply and demand for bullion. In addition, we tackle subjects germane to gold including geology, exploration techniques for discovering gold deposits, types of deposits, reserve and resource classifications, and the mining and processing of gold deposits. From a stock standpoint, we identify macroeconomic and industry-specific variables that drive gold stocks. In general, we approach supply-demand issues from a global perspective. This tome is intended as a desk reference for generalists or new analysts covering the precious metals space. More seasoned mining investors also may find this report useful in framing long term themes and company-specific drivers.

Gold through the ages

In his outstanding publication, *The Gold Book*, author Pierre Lassonde tells the fascinating history of bullion through the ages. Mr. Lassonde states that the oldest known gold objects are some 7,000 years old dating back to 5000 BC. The early Egyptians used gold for decoration, usually for the pharaohs. Eventually gold was recognized for its ductile qualities and was used by the Egyptians to replace rotted teeth (a practice that continues to this day, Mr. Lassonde notes). Gold was first used as money in 3000 BC, when the Pharaohs of Egypt introduced a half ounce gold wafer as a medium of payment. In the code of Menes, the founder of the first Egyptian dynasty, it is stated that "one part of gold is equal to two and one half parts of silver in value."

The use of gold as money dates back thousands of years; the first known gold coins were minted in the kingdom of Lydia in Asia Minor around 610 BC. The first coins minted in China are thought to date around 600 BC. The gold specie standard was not designed, but rather arose out of a general acceptance that gold was useful as a universal currency. When commodities compete for the role of money, the one that over time loses the least value takes on the role.

The *gold standard* is a monetary system in which the standard economic unit of account is a fixed weight of gold. There are distinct kinds of gold standard. The *gold specie standard* is a system in which the monetary unit is associated with circulating gold coins, or with the unit of value defined in terms of one particular circulating gold coin in conjunction with subsidiary coinage made from a less valuable metal.

Similarly, the *gold exchange standard* typically involves the circulation only of coins made of silver or other metals, but where the authorities guarantee a fixed exchange rate with another country that is on the gold standard. This creates a *de facto* gold standard, in that the value of the silver coins has a fixed external value in terms of gold that is independent of the inherent silver value. And, the *gold bullion standard* is a system where gold coins do not circulate, but in which the authorities have agreed to sell gold bullion on demand at a fixed price in exchange for the circulating currency.

Finally, a thank you is in order to George McIsaac, Boyd Davis and David Love, who taught the Spring 2012 edition of *The Basics of Mining Professional Development Seminar*, presented by the Robert M. Buchan Department of Mining at Queen’s University in Toronto, ON, as they provided inspiration for this report.
Section 2: Gold & silver basics

Gold

Gold is a chemical element with the symbol Au and atomic number 79. Gold is dense, soft, shiny and the most malleable and ductile substance known. Pure gold has a bright yellow color traditionally considered attractive. It is one of the coinage metals and formed the basis for the gold standard used before the collapse of the Bretton Woods system in 1971.

The metal occurs as nuggets or grains in rocks, in veins and in alluvial deposits. At the end of 2011, total above ground stocks of gold were estimated to be 171,300 tonnes (5.5 billion oz). Of this total the largest portion (84,300 tonnes or 49%) is estimated to be in the form of jewelry.

Jewelry accounts for about 40% of total gold demand. Around 13% of the gold is used for industrial purposes, including dentistry and electronics, where gold has traditionally found use because of its good resistance to oxidative corrosion. The rest of the gold is bought for investment, given its properties of being an inflation hedge and a monetary asset and by central banks for reserve diversification.

Gold supply consists of new gold from mining, and above ground stocks, which are recycled or sold out by the central banks.

The gold price is strongly correlated with the general price level (inflation) in the long run, but it fluctuates considerably in the short run due to political and financial turmoil as well as changes in exchange rates, real interest rates and the beta of gold.

Historically gold has displayed a strong correlation with oil prices. But since the onset of the global financial crisis, gold has significantly outperformed oil.

Silver

Silver is a chemical element with the chemical symbol Ag and atomic number 47. It is a soft, white, lustrous transition metal. It has the highest electrical conductivity of any element and the highest thermal conductivity of any metal. The metal naturally occurs in its pure, free form (native silver) and as an alloy with gold (electrum), as well as in various minerals, such as argentite and chlorargyrite. Most silver is produced as a byproduct of copper, gold, lead, and zinc refining.

Silver has been known since ancient times and has long been valued as a precious metal, used to make ornaments, jewelry, high-value tableware and utensils and currency coins. In modern life, silver metal is also used in electrical contacts and conductors, in mirrors and in catalysis of chemical reactions. Its compounds are used in photographic film and dilute solutions of silver nitrate, and other silver compounds are used as disinfectants. Although the antimicrobial uses of silver have largely been supplanted by the use of antibiotics, further research into its clinical potential is in progress.

Similarly to gold, silver supply is also derived from both mining and above ground stocks. Peru, Mexico and China are the top three silver producing countries in the world, accounting for about 48% of the total (based on 2011 production data).

Gold prices and pricing

Weight unit: troy ounces

The traditional unit of weight used for precious metals, including gold and silver, is the troy ounce (oz). The term derives from the French town of Troyes, where there was an annual trading fair in medieval days and where this was a unit of weight.
Conversions
1,000 grams = 32.1507465 troy ounces
1 troy ounce = 31.1034768 grams

Fine gold content
This is the actual quantity of pure gold in a bar and is expressed to three places of decimals. The fine gold content is thus calculated by multiplying the recorded gross weight by the fineness (to one place of decimals). Rounding of the third decimal in the resulting figure is allowed if the fourth decimal (prior to any rounding) is a 9.

For example, a Good Delivery bar with a gross weight of 404.075 ounces and a fineness of 995.8 would contain a net weight of gold or fine gold content of 402.377 fine ounces (404.075 x 0.9958 = 402.377885; no rounding up). On the other hand, if the same bar had a fineness of 999.5, the fine gold content would be 403.873 fine ounces (404.075 x 0.9995 = 403.8729625; rounding up the third decimal, as the fourth is a 9).

Spot price: London Gold Fixing
The London afternoon gold price fixing is used as the reference gold price around the world. There is also a morning fixing, but as the afternoon fixing takes place when both the US market and the European, Middle Eastern and African markets are still trading, it tends to be the most liquid period during the day.

On 12 September 1919 at 11:00am, the first Gold Fixing took place. The original five founding members were: N M Rothschild & Sons; Mocatta & Goldsmid; Samuel Montagu & Co.; Pixley & Abell; and Sharps & Wilkins.

The five members have changed and are now: The Bank of Nova Scotia - Scotia Mocatta, Deutsche Bank AG London, Societe Generale Corporate & Investment Banking, HSBC, and Barclays Capital. Any other market participant wishing to trade on the fix is required to do so through one of these five dealers. The fix is carried out twice a day by the five members via a dedicated conference call facility.

The fix mechanism
At the start of each fixing, the chairman announces an opening price to the other four members, who relay this price to their customers, and based on orders received from them, instruct their representatives to declare themselves as buyers or sellers at that price. Provided there are both buyers and sellers at that price, members are then asked to state the number of bars they wish to trade.

If at the opening price there are only buyers or only sellers, or if the numbers of bars to be bought or sold does not balance, the price is moved and the same procedure is followed until a balance is achieved. The chairman then announces that the price is fixed. It should be noted that the fix is said to balance if the buy amount and the sell amount are within 50 bars of each other. The Fixing will last as long as it is necessary to establish a price that satisfies both buyers and sellers.
Customers may leave orders in advance of the Fixings. Alternatively, they may choose to be kept advised of price changes throughout the Fixing and may alter their orders accordingly at any time until the price is fixed. To ensure that the price is not fixed before the member has had an opportunity to communicate any changes each member has a verbal flag. As long as any flag is raised, the chairman may not declare the price fixed. Occasionally, if it is impossible to strike a balance, the price will be fixed at the discretion of the chairman, an event known as fixing on discretion.

All fixing orders are transacted on the basis of this fixed price. These fixed prices are quoted immediately through the various wiring channels as well as numerous gold information websites. The fix is therefore a full and fair representation of all market interest at the time.

**Gold derivatives**

**Forwards and futures**

Gold trades in both forwards and futures markets as well as the physical market. The key futures exchanges are as listed in the table below.

<table>
<thead>
<tr>
<th>Exchange</th>
<th>Contract size</th>
<th>Price quotation</th>
<th>Nature of trading</th>
</tr>
</thead>
<tbody>
<tr>
<td>NYMEX (COMEX)</td>
<td>100 oz 99.5% purity</td>
<td>US$/oz</td>
<td>Continuous open outcry plus electronic trading via ACCESS</td>
</tr>
<tr>
<td>TOCOM</td>
<td>100g, 1 kilo, 99.99% purity</td>
<td>Yen/gram</td>
<td>Continuous computerized</td>
</tr>
<tr>
<td>MCX</td>
<td>100g, 1 kilo, 3 kg</td>
<td>Rp/10g</td>
<td>Continuous computerized</td>
</tr>
<tr>
<td>NCDEX</td>
<td>100g, 1 kilo, 99.99% purity</td>
<td>Rp/10g</td>
<td>Continuous computerized</td>
</tr>
<tr>
<td>CBOT</td>
<td>100 oz (full-sized), 33.2 oz (mini-sized), not less than 99.5% purity</td>
<td>US$/oz</td>
<td>Continuous computerized</td>
</tr>
<tr>
<td>TurkDEX</td>
<td>100g</td>
<td>Turkish Lira/gram</td>
<td>Continuous computerized ‘auction”</td>
</tr>
<tr>
<td>DGCX</td>
<td>1 kilo 99.5% purity</td>
<td>US$/oz</td>
<td>Continuous computerized</td>
</tr>
</tbody>
</table>

Source: World Gold Council

The difference between forwards and futures

A **futures contract** is an agreement to buy or sell a specific amount of a commodity or financial instrument at a particular price on a stipulated future date. The contract can be sold before the settlement date. Typically less than 1% of metals futures contracts on NYMEX ever come to delivery. Futures contracts have standardized unit size and delivery dates.

A **forward contract** is an Over the Counter, or principal’s contract which may be of any size or maturity date, subject to the agreement struck between the counterparties. It is therefore not standardized in terms of size or delivery date and is more flexible than outright exchange futures. The majority of physical business takes place on an Over the Counter basis.

**Options and spot-deferreds**

An **option** is a contract that gives the buyer of the option the right but not the obligation to buy (call option) or to sell (put option) a quantity of the underlying asset at a specified price (strike price) by or on a certain date. The seller of the option is the “writer” or “grantor”. An option writer holds a “naked” position when he has written an option without having the asset behind it.

European Options may only be exercised on the date of expiry and are the predominant option in the London bullion market. American Options may be exercised on any day up to and including the expiry date.
A spot deferred contract is a forward contract in which the contracts are rolled forward as they mature. There is thus no pre-specified delivery date, and as each contract comes to maturity it may be rolled forward with fresh interest rates applied. The facility is, however, set up such that it will to terminate within a pre-determined maximum period (eg, a client may roll forward every three months up to 10 years).

Gold exchange traded funds (ETFs)
In March 2003, the WGC launched the first ever gold ETF on the Australian Stock Exchange, giving investors a new, easy and cost-effective way to access the gold market. By design, this form of securitized gold investment, traded like any share, is expected to track the gold price almost perfectly. Unlike derivative products, the securities are 100% backed by physical gold held mainly in allocated form.

By the end of 2004, a similar product (Lyxor GBS) was also listed on the London Stock Exchange, sponsored by WGC and marketed by Societe Generale. This was quickly followed by a US product, streetTRACKS Gold Shares, which trades on the New York Stock Exchange.

Since then, the WGC has cross listed these products on stock exchanges around the world and WGC-supported gold ETFs now trade on the Australian Stock Exchange, London Stock Exchange, New York Stock Exchange, Johannesburg Securities Exchange, Euronext Paris, Mexican Bourse, Singapore, Deutsche Borse, and Borsa Italiana.

Gold ETFs have proved very successful in terms of the tonnage they have attracted. By the end of December 2012, gold ETFs had nearly 2,632 tonnes of gold of holdings, with a market value of $142 billion.
Section 3: Gold fundamentals

Gold supply

Slowly rising output and stable scrap

The key components of gold supply are global mine production (63%) and scrap (37%), with a tiny percentage for producer hedging. The latter is in stark contrast to 1995-1999, when nearly 20% of overall supply was derived from producer hedging and central bank sales. Gold hedging was very attractive due to the large returns that could be generated through the contango or forward premium (the difference between LIBOR and the prevailing borrowing rate for bullion). Producer enthusiasm for hedging disappeared when the forward premium contracted dramatically. Central banks, primarily European, were substantial sellers of gold under the European Central Bank sales agreement, but now are buyers. Table 2 and Chart 3 show annual gold supply for 1995-2012.

Table 2: Gold supply (1995-2012)

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<tbody>
<tr>
<td>Total Mine Production</td>
<td>2,285</td>
<td>2,291</td>
<td>2,375</td>
<td>2,493</td>
<td>2,574</td>
<td>2,602</td>
<td>2,618</td>
<td>2,646</td>
<td>2,619</td>
<td>2,624</td>
<td>2,496</td>
<td>2,550</td>
<td>2,482</td>
<td>2,476</td>
<td>2,408</td>
<td>2,589</td>
<td>2,689</td>
<td>2,836</td>
<td>2,842</td>
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<td>Central Bank Sales</td>
<td>130</td>
<td>167</td>
<td>279</td>
<td>326</td>
<td>363</td>
<td>477</td>
<td>479</td>
<td>520</td>
<td>547</td>
<td>620</td>
<td>479</td>
<td>663</td>
<td>365</td>
<td>484</td>
<td>235</td>
<td>34</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Gold Scrap</td>
<td>621</td>
<td>631</td>
<td>644</td>
<td>631</td>
<td>1,108</td>
<td>620</td>
<td>619</td>
<td>749</td>
<td>874</td>
<td>991</td>
<td>881</td>
<td>902</td>
<td>1,133</td>
<td>982</td>
<td>1,316</td>
<td>1,695</td>
<td>1,645</td>
<td>1,669</td>
<td>1,642</td>
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<td>Net Producer Hedging</td>
<td>105</td>
<td>475</td>
<td>142</td>
<td>504</td>
<td>97</td>
<td>506</td>
<td>0</td>
<td>0</td>
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<td>11</td>
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<td>Implied net disinvestment</td>
<td>203</td>
<td>93</td>
<td>83</td>
<td>256</td>
<td>0</td>
<td>0</td>
<td>300</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Total Supply</td>
<td>3,344</td>
<td>3,657</td>
<td>3,523</td>
<td>4,210</td>
<td>4,142</td>
<td>4,016</td>
<td>4,039</td>
<td>4,234</td>
<td>3,856</td>
<td>4,116</td>
<td>3,980</td>
<td>3,941</td>
<td>4,018</td>
<td>4,318</td>
<td>4,334</td>
<td>4,515</td>
<td>4,484</td>
<td></td>
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<tr>
<td>Gold Price (US$/oz)</td>
<td>384</td>
<td>384</td>
<td>388</td>
<td>331</td>
<td>294</td>
<td>266</td>
<td>279</td>
<td>271</td>
<td>310</td>
<td>363</td>
<td>409</td>
<td>436</td>
<td>604</td>
<td>690</td>
<td>872</td>
<td>974</td>
<td>1,227</td>
<td>1,572</td>
<td>1,669</td>
</tr>
</tbody>
</table>

Source: GFMS, BofA Merrill Lynch Global Research

Chart 3: Gold supply

Source: GFMS, BofA Merrill Lynch Global Research
World gold mine production by country

Gold is produced from mines on every continent with the exception of Antarctica (where mining is forbidden), in operations ranging from tiny to the enormous. The world’s top three gold producing countries in 2011 were China at 371 tonnes, Australia at 258 tonnes, and the United States at 233 tonnes. The dominant producing country for much of the 20th century was South Africa, which in the early 1970s was producing 1,000 tpa, or over 70% of the world total at that time. This position has been eroded in the past four decades, however, as South African production has dropped, due in part to ageing mines and reduced flexibility, while other nations have expanded their output considerably. Consequently South Africa is now the fifth largest producing country.

Table 3: World gold mine production by country (2001-2011)

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</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>193</td>
<td>202</td>
<td>211</td>
<td>217</td>
<td>230</td>
<td>247</td>
<td>281</td>
<td>292</td>
<td>324</td>
<td>351</td>
<td>371</td>
</tr>
<tr>
<td>Australia</td>
<td>285</td>
<td>266</td>
<td>283</td>
<td>258</td>
<td>262</td>
<td>247</td>
<td>247</td>
<td>215</td>
<td>224</td>
<td>261</td>
<td>258</td>
</tr>
<tr>
<td>United States</td>
<td>335</td>
<td>299</td>
<td>281</td>
<td>260</td>
<td>262</td>
<td>252</td>
<td>238</td>
<td>234</td>
<td>221</td>
<td>230</td>
<td>233</td>
</tr>
<tr>
<td>Russia</td>
<td>165</td>
<td>181</td>
<td>182</td>
<td>182</td>
<td>175</td>
<td>173</td>
<td>169</td>
<td>189</td>
<td>205</td>
<td>203</td>
<td>212</td>
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<tr>
<td>South Africa</td>
<td>417</td>
<td>419</td>
<td>398</td>
<td>363</td>
<td>315</td>
<td>296</td>
<td>270</td>
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<tr>
<td>Peru</td>
<td>134</td>
<td>163</td>
<td>178</td>
<td>181</td>
<td>218</td>
<td>214</td>
<td>184</td>
<td>196</td>
<td>201</td>
<td>185</td>
<td>188</td>
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<tr>
<td>Indonesia</td>
<td>183</td>
<td>158</td>
<td>164</td>
<td>114</td>
<td>167</td>
<td>114</td>
<td>150</td>
<td>96</td>
<td>161</td>
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<tr>
<td>Canada</td>
<td>157</td>
<td>153</td>
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<td>129</td>
<td>120</td>
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<td>102</td>
<td>95</td>
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<td>Ghana</td>
<td>72</td>
<td>70</td>
<td>69</td>
<td>58</td>
<td>63</td>
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<td>77</td>
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<td>92</td>
<td>91</td>
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<tr>
<td>Mexico</td>
<td>na</td>
<td>21</td>
<td>20</td>
<td>22</td>
<td>31</td>
<td>39</td>
<td>44</td>
<td>51</td>
<td>62</td>
<td>79</td>
<td>87</td>
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<tr>
<td>Other</td>
<td>705</td>
<td>687</td>
<td>697</td>
<td>712</td>
<td>713</td>
<td>728</td>
<td>714</td>
<td>727</td>
<td>785</td>
<td>841</td>
<td>962</td>
</tr>
<tr>
<td>Total</td>
<td>2,646</td>
<td>2,619</td>
<td>2,624</td>
<td>2,496</td>
<td>2,555</td>
<td>2,482</td>
<td>2,476</td>
<td>2,408</td>
<td>2,590</td>
<td>2,689</td>
<td>2,818</td>
</tr>
</tbody>
</table>

Source: GFMS

Chart 4: World gold mine production by country (2001-2011)
Scrap is an important part of the dynamics of the gold market. Scrap is defined as gold that has been sourced from old fabricated products, that has been recovered and refined back into bars. It does not include jewelry that has simply been traded in and resold without being re-refined, or resold investment bars and coins. Most recycled gold generated originates from jewelry. Smaller amounts come from recuperated electronics components and, at times, from investment bars and coins. The chart below shows how the supply of scrap has changed over the last 10 years. Scrap accounted for 34% of supply in 2011.

Table 4: World supply of gold from scrap by country (2002-2011)

<table>
<thead>
<tr>
<th></th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
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Source: GFMS
Global gold demand

Demand for gold falls into four categories. Jewelry accounts for the largest share of final demand at around 40-45%. Jewelry demand is seasonal. The fourth quarter is the strongest quarter due to Diwali, Christmas and other end of year festivals when jewelry gifts are common. Industrial demand is dominated by the electronics sector, but also includes dentistry and other industrial and decorative applications. Industrial and dental uses account for approximately 13% of gold demand; Investment demand is 30% of demand. The investment figure shown in the chart below includes bar hoarding, official coins, medals and imitation coins, other retail investment, and investment in exchange traded gold funds. Central bank purchases account for 5% of demand.

Table 5: Gold demand - by weight

| Jewelry | 2,640 | 2,809 | 2,830 | 3,287 | 3,169 | 3,139 | 3,204 | 3,009 | 2,662 | 2,484 | 2,616 | 2,719 | 2,300 | 2,423 | 2,304 | 1,814 | 2,017 | 1,972 | 1,885 |
| Other fabrication | 455 | 501 | 485 | 561 | 567 | 592 | 557 | 474 | 481 | 518 | 563 | 585 | 657 | 679 | 718 | 697 | 762 | 786 | 728 |
| Total Fabrication | 3,095 | 3,310 | 3,315 | 3,848 | 3,736 | 3,731 | 3,761 | 3,483 | 3,143 | 3,002 | 3,179 | 3,304 | 2,957 | 3,102 | 3,022 | 2,511 | 2,779 | 2,758 | 2,613 |
| Central Bank Purchases | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Physical bar investment | 249 | 347 | 208 | 362 | 208 | 208 | 208 | 208 | 208 | 208 | 208 | 208 | 208 | 208 | 208 | 208 | 208 | 208 | 208 | 208 |
| Net Producer De-Hedging | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Implied net investment | 0 | 0 | 0 | 0 | 233 | 265 | 0 | 22 | 277 | 761 | 17 | 461 | 353 | 155 | 0 | 1,040 | 499 | 103 | 354 |
| Total Demand | 3,344 | 3,657 | 3,523 | 4,210 | 4,143 | 4,265 | 4,018 | 3,915 | 4,039 | 4,234 | 3,856 | 4,116 | 3,980 | 3,941 | 4,018 | 4,318 | 4,334 | 4,515 | 4,484 |
| Gold Price (US$/oz) | 384 | 384 | 388 | 331 | 294 | 266 | 279 | 271 | 310 | 363 | 409 | 436 | 604 | 690 | 872 | 974 | 1,227 | 1,572 | 1,669 |

Source: GFMS, BofA Merrill Lynch Global Research

Chart 6: Global demand – by tonnes

Source: GFMS, BofA Merrill Lynch Global Research
Gold demand: In dollar terms, the chart is more bullish

While global gold demand in tonnes has been relatively constant (in the 4,000-4,500 tonne range) over the past 10 years, global gold demand in dollars more than quintupled over the same period. Table 6 (covering the 1995-2012 periods) and Chart 7 (2001-2012) show the dollar value of global gold demand by component.

### Table 6: Global - In US$ billions

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<td>388</td>
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</table>

Source: GFMS, BofA Merrill Lynch Global Research

### Chart 7: Gold demand – In US$ billions

Source: GFMS, BofA Merrill Lynch Global Research
Global jewelry demand by country

In 2000-2012, India has been the dominant jewelry buying country, with estimated jewelry demand of 612 tonnes in 2012 (accounting for 32% of total global jewelry demand). In recent years, China has emerged as the world’s second largest jewelry purchaser with 499 tonnes estimated for 2012. China and India alone accounted for an estimated 59% of global jewelry demand in 2012, compared to just 27% in 2000. Nations estimated to have substantial declines in jewelry demand through to 2012 included Italy (down by about 85% between 2000 and 2012), Turkey (off over 60%), the United States (down 69%) and Saudi Arabia (off 80%). Table 7 and Chart 8 show global jewelry demand by country for 2000-2012 in total tonnes.

Table 7: Global jewelry demand by country (2000-2012; tonnes)

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<td>1,885</td>
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</table>

Source: GFMS, BofA Merrill Lynch Global Research

Chart 8: Global jewelry demand by country (2000-2012; tonnes)

Source: GFMS, BofA Merrill Lynch Global Research
Global jewelry demand by country (US$ millions)

While global jewelry demand in tonnes has declined from 3,205 tonnes in 2000 to 1,885 tonnes for 2012, global jewelry demand in dollars has risen by some 250% to nearly $101 billion for 2012 over the same period. Table 8 and Chart 9 show the 2000-2012 dollar value of global gold jewelry demand by country.

Table 8: Jewelry demand (including scrap; 2000-2012) (US$ millions)

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<td>288</td>
<td>360</td>
<td>451</td>
<td>695</td>
<td>799</td>
<td>981</td>
<td>628</td>
<td>832</td>
<td>1,485</td>
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</tr>
<tr>
<td>Other</td>
<td>10,544</td>
<td>9,182</td>
<td>8,899</td>
<td>9,353</td>
<td>10,671</td>
<td>11,558</td>
<td>13,428</td>
<td>15,183</td>
<td>17,614</td>
<td>15,043</td>
<td>17,997</td>
<td>19,947</td>
<td>20,763</td>
</tr>
<tr>
<td>Total</td>
<td>28,747</td>
<td>26,218</td>
<td>26,527</td>
<td>28,995</td>
<td>34,405</td>
<td>38,113</td>
<td>44,660</td>
<td>53,763</td>
<td>64,594</td>
<td>56,696</td>
<td>79,557</td>
<td>99,636</td>
<td>101,133</td>
</tr>
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</table>

Source: GFMS, BofA Merrill Lynch Global Research

Chart 9: Jewelry demand (including scrap; 2000-2012)
Global physical bar investment demand by country (tonnes)

Historically India has been the region with the largest bar investment. But in 2012 it was supplanted by China with 256 tonnes of bar investment as a result of widespread concern over the emerging European debt crisis. Next up were Europe and India with 244 tonnes and 215 tonnes of physical bar investment demand, respectively. These three regions accounted for some 70% of total physical bar investment demand in 2012. Reflecting the impact of the global financial crisis, which started in 2008, global physical bar investment demand grew by 404% in 2007-2011 from 240 tonnes to 1,197 tonnes, and is estimated by GFMS to have remained strong in 2012 with 961 tonnes of demand estimated on a preliminary basis. Table 9 and Chart 10 show 2001-2012 global physical bar investment by country in tonnage.

Table 9: Physical bar investment - tonnes

<table>
<thead>
<tr>
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<tr>
<td>Europe</td>
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<td>-35</td>
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<td>India</td>
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<td>67</td>
<td>66</td>
<td>76</td>
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<td>9</td>
<td>10</td>
<td>21</td>
<td>61</td>
<td>102</td>
<td>179</td>
<td>250</td>
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<tr>
<td>Thailand</td>
<td>12</td>
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<td>1</td>
<td>12</td>
<td>28</td>
<td>16</td>
<td>5</td>
<td>43</td>
<td>-10</td>
<td>63</td>
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</tr>
<tr>
<td>Vietnam</td>
<td>34</td>
<td>35</td>
<td>36</td>
<td>39</td>
<td>34</td>
<td>70</td>
<td>56</td>
<td>96</td>
<td>58</td>
<td>67</td>
<td>88</td>
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<td>3</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>31</td>
<td>38</td>
<td>22</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Saudi Arabia &amp; Yemen</td>
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<td>4</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>14</td>
<td>11</td>
<td>15</td>
<td>17</td>
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<td>15</td>
<td>14</td>
</tr>
<tr>
<td>Other</td>
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<td>110</td>
<td>78</td>
<td>-9</td>
<td>-2</td>
<td>27</td>
<td>-5</td>
<td>33</td>
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<tr>
<td>Total</td>
<td>259</td>
<td>232</td>
<td>177</td>
<td>215</td>
<td>251</td>
<td>233</td>
<td>240</td>
<td>621</td>
<td>498</td>
<td>882</td>
<td>1,197</td>
<td>961</td>
</tr>
</tbody>
</table>

Source: GFMS

Chart 10: Physical bar investment - tonnes

Source: GFMS
Physical bar investment demand by country (US$ millions)

Gold’s use as an investment is rooted in history and results from its role as a safe haven, a store of value and a monetary asset. Because gold is not a liability of any government or corporation, unlike currencies, bonds and equities, it does not run any risk of becoming worthless through the default of the issuer. Its role has been recognized as an effective portfolio diversifier due to the lack of correlation of the gold price with mainstream investments and as a currency and inflation hedge. The renewal of investment demand in gold is rooted in a range of factors: concerns about dollar volatility and inflationary expectations, continued high geopolitical uncertainty and increased acceptance of the role gold can play as a portfolio diversifier. Table 10 and Chart 11 show the 2001-2012 dollar value of global physical bar investment by country.

### Table 10: Physical bar investment - US$ millions

<table>
<thead>
<tr>
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<th></th>
<th></th>
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<td>766</td>
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<td>3,297</td>
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<td>3,673</td>
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<td>477</td>
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<td>1,245</td>
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<td>1,819</td>
<td>2,643</td>
<td>4,418</td>
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<td>Indonesia</td>
<td>74</td>
<td>100</td>
<td>19</td>
<td>66</td>
<td>42</td>
<td>-19</td>
<td>7</td>
<td>81</td>
<td>-188</td>
<td>592</td>
<td>1,107</td>
<td>966</td>
</tr>
<tr>
<td>North America</td>
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<td>36</td>
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<td>80</td>
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<td>863</td>
<td>1,185</td>
<td>884</td>
<td>891</td>
<td>644</td>
</tr>
<tr>
<td>Saudi Arabia &amp; Yemen</td>
<td>21</td>
<td>37</td>
<td>57</td>
<td>68</td>
<td>102</td>
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<td>200</td>
<td>378</td>
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<td>41</td>
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<td>-47</td>
<td>743</td>
<td>-141</td>
<td>1,318</td>
<td>3,688</td>
<td>542</td>
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<tr>
<td>Total</td>
<td>2,253</td>
<td>2,316</td>
<td>2,068</td>
<td>2,827</td>
<td>4,525</td>
<td>5,320</td>
<td>17,409</td>
<td>15,568</td>
<td>34,810</td>
<td>60,228</td>
<td>51,559</td>
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</tr>
</tbody>
</table>

Source: GFMS

### Chart 11: Physical bar investment - US$ millions

Source: GFMS
Central bank activity

Prior to 2010, central banks on the whole (led by those in Europe) were a source of supply of gold, until in 2011 when a large pullback in selling from euro area central banks coincided with a significant increase in emerging market central bank buying (Table 11 and Chart 12). In 2012, the 536 tonnes of net demand was the highest level in more than four decades according to GFMS. One caveat is that China (which last reported its gold holdings in 2009) is quite likely accumulating gold at its central bank, yet this is not being regularly reported, so it is difficult to determine its contribution to demand.

<table>
<thead>
<tr>
<th>Table 11: Central banking buying and selling of gold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other</td>
</tr>
<tr>
<td>China</td>
</tr>
<tr>
<td>Russia</td>
</tr>
<tr>
<td>India</td>
</tr>
<tr>
<td>Mexico</td>
</tr>
<tr>
<td>Thailand</td>
</tr>
<tr>
<td>Turkey</td>
</tr>
<tr>
<td>Argentina</td>
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<tr>
<td>Korea</td>
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<td>Philippines</td>
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<tr>
<td>Euro Area</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Source: IMF, GFMS, BofA Merrill Lynch Global Research

Chart 12: Central banking buying and selling of gold

Source: IMF, GFMS
Chart 13: Top 25 central bank holdings of gold globally, year end 2012 or most recent (tonnes)

Source: IMF, GFMS
Global hedging: Producers a small supplier of gold

In the 1990s gold supply from gold producer hedging remained steady as producers concerned about the potential for a falling gold price helped further lower the gold price through efforts to lock in future gold prices. From 1991-1999 producer hedging average 9% of total gold supply. With a switch in the early 2000s to expectations for higher gold prices, gold producers began to unwind the hedges they had put in place throughout the 1990s. This provided a steady source of gold demand, with gold producer dehedging average 12% of total demand for gold. With substantial hedge books now unwound, we do not expect gold producer hedging activity to contribute substantially to supply or demand in the near to medium term.

Chart 14: Global gold producer hedging

Chart 15: The contango spread
Global gold ETF holdings

A major source of global gold demand in recent years has been gold-backed ETFs, the largest and most liquid being State Street’s SPDR gold ETF, which accounts for 41 million oz or 51% of the total gold held in ETFs globally. Other gold-backed ETFs include Gold Bullion Securities offered on several exchanges by ETF Securities Ltd and the ZKB by Swiss-based Zuercher Kantonalbank.

Chart 16: Gold ETF holdings (oz)

Aggregate Statistics:
- Current Total Ounces: 79,250,720 ounces as of 18-Mar-13
- Month over month change: -4,416,304, down 5.9%
- Year over year change: 1,762,064, up 2.3%
- Year-to-date: -5,009,600, down 5.9%

Components:
- SPDR: 39,642,064 ounces as of 18-Mar-13
- All Others: 39,608,656 ounces as of 18-Mar-13

Source: Bloomberg, BofA Merrill Lynch Global Research

Chart 17: Value of global ETF holdings (US$ billions)

Source: Bloomberg, BofA Merrill Lynch Global Research
Above ground gold stocks as a source of supply

At year-end 2011, total above ground stocks of gold amounted to 171,300 tonnes, nearly half of which consists of jewelry, some 20% held in private investments, 16% plus in official central bank holdings, 12% in other fabrication, and 2% unaccounted for. Around 1% of the total above ground gold stocks is re-mobilized back to supply as scrap, which accounts for 34% of annual supply (the balance being new mine production). At current rates, above ground stocks alone could satisfy annual gold demand for nearly 40 years. Exhibit 1 shows the sources of gold supply and how they are mobilized for the demand items.

Exhibit 1: Life cycle of above ground gold stocks

**Note: Diagram not to scale**

Source: GFMS
Gold macroeconomic charts

Gold price vs. trade-weighted USD
The USD price gold has a strong correlation to the USD. This is true in both the long and short term.

**Chart 18: Gold price vs. the trade-weighted USD**

[Graph showing the correlation between Gold price and Trade-weighted USD from 1997 to 2013]

Source: Bloomberg

**Chart 19: Gold price vs. US short real rates**

[Graph showing the correlation between 90 Day T-Bill in Real Terms and Monthly Average Gold Price from 1997 to 2013]

Source: Bloomberg
Historical gold prices in local currency

In most developed nations’ currencies, the gold price has long surpassed previous highs. The exception to this is Japan, whose currency is still well off the high set in the early 1980s.

Chart 20: Gold price in USD

Source: Bloomberg

Chart 21: Gold price in YEN

Source: Bloomberg

Chart 22: Gold price in EUR

Source: Bloomberg

Chart 23: Gold price in AUD

Source: Bloomberg
Relative gold price movements in various currencies

Since the recent secular bull market in gold bullion prices began around early 2002, the price in US dollar terms has far outpaced the price in other major currencies. The price of gold bullion in AUD, on the other hand has underperformed the price in many other major currencies on the back of that currencies strength relative to the others (see Chart 24).

Chart 24: Relative gold price movements in various currencies

Source: Bloomberg
Section 4: Geology

Geology, the study of the Earth, consists of branches specializing in the Earth’s physical materials, the structure of those materials, and the processes acting upon them. An important part of geology is investigating how Earth’s materials, structures, processes and organisms have evolved over time. For the mining industry, physical and chemical processes that influence the creation of various rock structures have a direct bearing on discovery and processing.

While the oldest surviving rocks are dated by the uranium-lead method as 3.96 billion years old, it is theorized that the true age of the Earth is about the same as the solar system, approximately 4.6 billion years old. The planet began as a body of molten rock – a magma ocean. Over time, the surface cooled to form a crust of solid rock while the interior continues to be heated by radioactive decay of various elements.

Ore formation

In the eons that followed the appearance of the Earth, plate tectonic forces formed new mountains, wore old ones down and melted volcanoes. When any weaknesses developed in the crust, the release of pressure caused the superheated rock to erupt onto the surface. During the cooling process, mineral constituents of molten lava tended to concentrate and often formed ore bodies – zones where minerals occur in the Earth’s crust in sufficient quantity and quality to be economically mined. Ore bodies can form as a result of:

- **Magmatic processes.** Ores can be formed by fractional crystallization, where minerals crystallize over a range of temperatures and crystals become segregated by gravity or differential flow. Magmatic segregation could also occur through liquid immiscibility, where two liquid fractions (a silicate melt and a sulphide melt) form and the heavier droplets of sulphide melt sink.

- **Hydrothermal processes.** Minerals are dissolved in circulating waters within a crust, typically between 50 and 650 degrees Celsius. Sources of hydrothermal fluids include surface water, sea water, connate water and magmatic water. The mineral is redeposited at a point where chemical and physical conditions prevail (sulfide deposition).

- **Metamorphic processes.** Heat from igneous intrusions or pressure due to deformation may result in dehydration and liberation of water. Consequently, the minerals are recrystallized, often increasing in grain size.

- **Surficial processes.** Minerals can be mechanically concentrated in moving water and form placer deposits (pale placer, conglomerate) or be chemically precipitated from sea-water (Banded Iron Formation, evaporites). Due to weathering, some elements are leached out of the host rock or from upper horizon with concentration beneath (nickel laterites, bauxite).

Factors like the tonnage, form, grade and depth of burial determine whether the ore can be recovered profitably.
In Exhibit 2, the geologic time scale is depicted in its traditional form with the oldest at the bottom and the more recent at the top – the present day is at the zero mark. Geologic time is finely subdivided through most of the Phanerozoic (see Harland et al., 1990 for details), but most of the finer subdivisions (e.g., epochs) are commonly referred to by non-specialists only in the Tertiary. Because of the vast difference in scale, the younger intervals have been successively expanded to the right to show some of these finer subdivisions.
Main rock types

There are 118 known chemical elements on Earth today, but only five: oxygen, silicon, aluminum, hydrogen, and sodium, comprise over 90% of all substances on the planet. If elements cluster and form solid crystalline structures, their compounds are referred to as minerals, and aggregations of minerals are called rocks. Exhibit 3 shows the periodic table of elements.

Exhibit 3: Periodic Table of Elements

<table>
<thead>
<tr>
<th>Element</th>
<th>Symbol</th>
</tr>
</thead>
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<td>Hydrogen</td>
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<tr>
<td>Helium</td>
<td>He</td>
</tr>
<tr>
<td>Lithium</td>
<td>Li</td>
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<td>Beryllium</td>
<td>Be</td>
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<tr>
<td>Boron</td>
<td>B</td>
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<tr>
<td>Carbon</td>
<td>C</td>
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<tr>
<td>Nitrogen</td>
<td>N</td>
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<td>Ne</td>
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<tr>
<td>Sodium</td>
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<tr>
<td>Magnesium</td>
<td>Mg</td>
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<tr>
<td>Aluminum</td>
<td>Al</td>
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<tr>
<td>Silicon</td>
<td>Si</td>
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<td>Phosphorus</td>
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<td>Sulfur</td>
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<td>Arsenic</td>
<td>As</td>
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<tr>
<td>Antimony</td>
<td>Sb</td>
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<tr>
<td>Bismuth</td>
<td>Bi</td>
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<td>Iodine</td>
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<td>Promethium</td>
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<tr>
<td>Thorium</td>
<td>Th</td>
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<tr>
<td>Protactinium</td>
<td>Pa</td>
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<td>Plutonium</td>
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<td>Ununoctium</td>
<td>Uuo</td>
</tr>
<tr>
<td>Ununennium</td>
<td>Uun</td>
</tr>
</tbody>
</table>

Earth’s crust is composed of myriad rocks which are distinguished using various classifications. The most common classifications are based on chemical composition and grain size. In terms of chemical composition, the most abundant groups of minerals are feldspar, quartz, amphibole and pyroxenes as well as olivine and mica, all of which contain silicon bonded with some other element(s). With regard to grain size, minerals are divided into three large categories: igneous, sedimentary, and metamorphic.

Igneous

As the name igneous (from Latin fire) suggests, rocks of this class are formed by the cooling and solidification of magma. In terms of composition, igneous rocks are either mafic, rich in magnesium and iron, or felsic, rich in feldspar and silicon. Based on solidification conditions, predominantly depth and duration, igneous rocks are split into three subdivisions:

- **Extrusive** (volcanic). Magma forming the extrusive rock cools down quite close to the surface and therefore the process is relatively quick, spanning the course of several years on average. Because crystals do not have sufficient time to grow, the grains are invisible to the eye or very small, and the rocks are aphanitic in texture.

- **Intrusive**. Intrusive rocks solidify deeper and for a longer period of time than their extrusive brethren, which results small to medium-sized grains. This type of texture, when grains can be differentiated, is called phanitic.

- **Plutonic**. Commonly located well below the surface, plutonic rocks take several millions of years to cool. Accordingly, plutonic rocks are characterized as having the biggest mineral grains, displaying a phanetic texture.
Sedimentary
Formed at the Earth’s surface, primarily under water, sedimentary rocks are further divided into three subgroups based on structure:

- Clastic. Clastic rocks are composed mainly of broken pieces, or clasts, of eroded stones occurring in sediment, which could be mud, sand, gravel, clay or a mixture of the above. Provided that sediment is exposed to conditions such as high pressure or heat for a sufficient length of time, it commences to cement and turn into a rock. For instance, sand becomes sandstone, while clay would transform into shale.

- Biologic. Biologic rocks are so named for their organic origin, composed of material such as dead plankton. The two most abundant organic sediment rocks are limestone and chert. Another important mineral that belongs to this group is coal, which is made of compressed dead plant material.

- Chemical. Chemical rocks are the result of minerals precipitating in ancient shallow sea areas that are isolated from the ocean. Examples of minerals that formed from this process are dolomites, gypsum rock and rock salt.

Metamorphic rocks
Metaphoric rocks are igneous or sedimentary (or older metamorphic) rocks that underwent severe external conditions, which caused the mass to change (or metamorphose). Most common sources of metamorphism are heat, pressure, strain and fluids. Metamorphic rocks are easy to detect due to their characteristic laminated or banded texture. Among the most common minerals in this group is Gneiss (pronounced “nice”), which is composed of metamorphosed quartz, feldspar, and mica. Metamorphic rocks can be further classified into three subgroups by formation process:

- Contact. Contact metamorphism describes changes caused when high temperature magma is injected into the existing rock (country rock), typically at low pressure. The zone surrounding the igneous intrusive rock (formed through cooling of the injected magma) is referred to as a contact metamorphism aureole. The width and nature of an aureole depends on the temperature of the magma injected and on the depth at which this occurred (pressure). The largest originate near surface (low pressure so the country rock tends to be a much lower relative temperature vs. the magma) and at higher temperatures (~1000°C). Skarn deposits are formed from the contact metamorphism of limestones and dolomites.

- Cataclastic. Cataclastic metamorphic rocks are those formed through changes to an existing rock type in a high pressure (but typically low temperature) environment. Tectonic events that lead to the environment necessary to form this rock type include folding, faulting and shearing. Unlike many rocks formed through contact metamorphism, the mineralogy of cataclastic metamorphics is often unaltered by the process.

- Regional. Regional metamorphism describes changes caused to a country rock when it is exposed to both higher temperature and higher pressure. These changes occur over large regions (huge masses of rock) as opposed to the more localized changes in contact metamorphism. The great pressure and temperature that creates regionally metamorphosed rock leads to the destruction of the original rock and the creation of new minerals.
Section 5: Deposit types

A zone, or body with an ample aggregation of minerals, is referred to as a deposit. In addition to the mineral that carries valuable metal, a deposit also contains gangue mineral, material that does not make any contribution to the deposit, but helps to store the desired content.

Gold is usually refined from ores made up of rock with microscopic or very small particles of the precious metal. Gold ore is most often combined with quartz, sulfide minerals, or tellurium. Silver, in contrast, can be found in its native form or in electrum, an alloy with gold. On average, the shallower the gold deposit, the higher the concentration of silver. White metal can also be found in ores containing sulfur, arsenic, antimony or chlorine.

Placer deposits

Placer gold deposits are sourced from pre-existing gold deposits, dominated by surficial erosion and stream depositional processes. In the stream environment, gold is relatively inert, forming deposits where the water velocity drops. The density of the mineral causes gold to sink into trap sites within the river bed, such as bends in rivers, behind boulders or intrusions in the river floor or in depressions in the river floor. In some instances these deposits can be irregular and discontinuous due to the randomness of the flowing river that created them, making economic extraction especially challenging.

Deposits of this kind were among the first to be mined, the Klondike being a prominent example. While Placer deposits represent only 3% of the major gold discoveries (>2 million oz) in the past 15 years, The Witwatersrand placer goldfield in South Africa is estimated to account for almost 40% of gold mined throughout human history.

The Witwatersrand gold deposits are a unique form of placer deposit, called Paleoplacer deposits, where the deposited gold accumulations and the surrounding gravel and sand have been lithified, basically turned into rock (fossilized). The Witwatersrand basin measures approximately 160 km in width and 350 km in length and more than 4 km in depth based on maximum known depths of drilling intercepts. Goldfield’s Tarkwa mine in Ghana, West Africa is also considered to be paleoplacer deposit.
Orogenic

Orogenic gold deposits are shear-hosted, structurally controlled and dominated by quartz veins (and sometimes stockwork breccia zones). They feature extensive vein arrays or replacement zones in weakly metamorphosed volcanic rocks. Formation of these deposits is generally thought to be the result of hydrothermal fluids from deep within the earth’s crust that carry dissolved metals (like gold) toward the surface along permeable pathways such as faults, shear zones and folds. As these fluids reach areas closer to the surface (areas with physical and chemical characteristics needed to cause gold and quartz to precipitate out of solution) gold is deposited in the form of quartz veins. These deposits are formed long after the host rock and hence are termed epigenetic.

Orogenic deposits can host free gold, which is easier to extract, or refractory gold (gold in arsenopyrite, gold in pyrite), which are more difficult to extract. These deposits tend to contain gold exclusively or gold with small traces of metals such as silver, lead, copper, and zinc that are usually not in sufficient quantities for economic extraction.

Exhibit 5: Clustering of Greenstone hosted gold deposits in the Abitibi region of Canada

Greenstone hosted. Greenstone belts are areas of fine-grained metamorphosed volcanic rocks with a green tinge, typically consisting of highly altered andesite, dacite, or basalt. Zones where igneous rocks intrude into greenstone belts, referred to as plugs or batholiths, tend to be worthy of further exploration. Given the brittleness of the host Greenstone rock, compressional and extension forces tend to form faults, secondary splays and shear zones; gold mineralization is associated with these major structural breaks. Greenstone hosted gold deposits tend to occur in clusters along and near major faults. Exhibit 5 demonstrates this phenomenon as it...
occurs in the Abitibi Greenstone belt in Ontario and Quebec, Canada. These veins tend to be sheet like, or tabular due to the fault controlled formation.

- **Slate hosted.** Given the ductility of slate, the host rock will fold as opposed to fault or shear when subjected to compressional and extensional forces. In these folds, particularly at fold hinges in the slate, “saddle reefs” of quartz veining can form. These veins tend to be tube like due to the hinge controlled formation. Reefs contain native gold or gold sulfides and tellurides. Slate hosted orogenic gold deposits are dominated by quartz veins, but also contain stockwork and disseminated zones. Examples of this type of gold deposit include Centerra’s Kumtor mine, Golden Star’s Prestea/Bogoso mine and Anglogold Ashanti’s Obuasi mine.

- **Iron-formation hosted.** Banded iron-formation (BIF) hosted gold deposits occur mostly in quartz veins that cross-cut layering and replacements along layering. These deposits occur mainly in Archean-aged Greenstone belts such as the shield areas of northern Ontario and Quebec and the Northwest Territories, Canada. BIF’s have a unique appearance with alternating very thin layers (measured in centimeters) of iron-rich and cherty (silicious) layers. This type of gold deposit is relatively small in number, accounting for less than 5% of the area of greenstone belts. Examples of the type of deposit include Goldcorp’s Musselwhite in northern Ontario, Agnico-Eagle’s Meadowbank and Meliadine in the Northwest Territories, and the famous (but now closed) Homestake mine in South Dakota (currently owned by Barrick).

**Practical considerations in structurally controlled quartz vein deposits**

In structurally controlled quartz veins, the concentration of gold mineralization tends to vary throughout. This can lead to misinterpretation of drill results in terms of grade continuity throughout a vein. Further, systems of structurally controlled veins often have great length and depth but are very narrow such that underground mining is the only feasible option. In some instances though, veins are situated so that economic bulk mining is feasible.

**Epithermal**

Epithermal deposits are formed within one to two kilometers of the earth’s surface, beneath geothermal systems or geysers. They will sometimes occur even closer to the surface as a result of erosion. These deposits are mostly formed in areas of active volcanism near the margins of continents. Epithermal gold mineralization is formed from one of two distinct fluids, low sulphidation (near-neutral pH) or high sulphidation (acidic and oxidized) fluids. These fluids travel to the surface through fractures in the rock, which is where mineralization occurs. Because epithermal deposits are located close to surface they are usually amenable to lower-cost open pit mining extraction. A large majority of these deposits are located in land areas that circle the Pacific Ocean including the Western United Stated, Chile, Indonesia, and Japan.

- **Low sulphidation.** This style of epithermal gold deposit will occur either as large veins or a series of finer veins called stockworks. Low sulphidation deposits often contain economic quantities of silver as well as zinc and lead. These deposits tend to be higher grade and lower tonnage than the high-sulphidation variety. Examples include Round Mountain in Nevada (owned 50% by Kinross and 50% by Barrick), Newmont’s Waihi in New Zealand, and Goldcorp’s Cerro Negro project.
- **High sulphidation.** Due to the higher acidity of the formation fluids that allow for farther penetration into the host rock, this style of epithermal gold deposit will include veins but is mostly well disseminated in the host rock. High sulphidation deposits often contain economic quantities of copper and sometimes silver. These deposits tend to be lower grade and higher tonnage than the low-sulphidation variety. Examples include Newmont’s Yanacocha in Peru, and several of Barrick’s deposits including Veladero in Argentina, Pueblo Viejo in Dominican Republic, Pierina in Peru and Pascua-Lama on the Chilean/Argentinean border.

**Exhibit 6: Grade and tonnage characteristics of low and high sulphidation gold deposits**

[Graph showing grade and tonnage characteristics of low and high sulphidation gold deposits]

**Carlin-type (disseminated sediment hosted)**

Carlin-type deposits are usually disseminated, with very fine grained gold. Silver content is usually very low. Host rocks are carbonates or carbonaceous sediments that have been strongly altered by the hydrothermal solutions that deposited the gold. Formation of these deposits is associated with major tectonic events that forced gold bearing hydrothermal fluid along major faults until encountering porous carbonaceous sedimentary rocks or breccia zones. Hydrothermal fluids then reacted with these rocks and the gold contained within was deposited. The gold occurs in arsenic bearing pyrite and quartz.

Carlin-type deposits are generally exposed near surface, making them amenable to extraction by open pit mining. The operations tend to be lower grade and larger tonnage. While this type of deposit is found in China and Peru, only those found in the western United States (primarily the Great Basin in Nevada) have produced quantities of gold. Examples of such deposits include Barrick’s Goldstrike and Pipeline/Cortez deposits, and Newmont’s Twin Creeks and Gold Quarry deposits.
Intrusion hosted

Mineral deposits frequently appear alongside felsic igneous intrusions. Intrusions can sometimes appear in the form of veins – discrete sheet-like bodies of rock. If those “sheets” are vertically positioned in a somewhat parallel manner, they are called dykes. In case they are lying somewhat horizontally, they are referred to as sills. Kinross Gold’s Fort Knox open pit mine in Alaska is an example of this type of gold deposit.

Porphyry

Porphyry deposits are typically associated with base metals; however, gold is a very important byproduct of this type of deposit. Of all copper deposits developed globally between 1988 and 2008 (100 in total), 41% were of the porphyry type (which is more than any other type of copper deposit). As shown in Chart 25 porphyry deposits account for 42% of large gold deposits (>2 million oz) discovered in the past 15 years. Porphyries are also the most important source globally of molybdenum and rhenium (a platinum group metals (PGM)). Copper is always present in porphyries, while gold and molybdenum can occur alongside copper either together or exclusive of each other, but never as together without copper. Silver is also recovered from porphyry deposits.

These deposits occur in similar geological settings to epithermal style gold deposits, and in fact tend to be located in the same land areas that circle the Pacific Ocean where epithermal deposits are often found. Porphyry deposits are particularly common in the Canadian Cordillera (British Columbia and the Yukon), the Andes Mountains of Chile and Peru, the Philippines, Indonesia, and Papua New Guinea, and eastern Australia.

Formation of porphyry deposits is theorized to occur in a two step process in which the only requirement of the host rock is that it is rigid or brittle. First, water contained in magma (that rises toward the earth’s surface as a result of tectonic plate collisions) boils off as the magma approaches the earth’s surface. Sometimes this water will contain metals such as copper, gold and molybdenum. The pressure from the boiling water will cause the near surface rock (can be several kilometers from surface) to brecciate and fracture creating a pathway for the aqueous solution to travel and deposit minerals. Second, the continued cooling of the intrusive magma causes ground water to circulate, effectively upgrading the metal concentration of the existing sulphide. Intense alteration of the host intrusive and country rock is always a feature.

As a result of this emplacement process, porphyries tend to be much larger and of much lower grades in comparison to other deposit, in particularly, the closely related epithermal gold deposits. Grade distributions tend to be uniform, with high continuity, reducing upfront drilling costs. Since grades also tend to be relatively low (0.2%-1%+ copper and 0.3-1.0+ g/t gold) and the overall deposit size very large, open pit mining is generally the only feasible method of extraction. This makes overall profitability highly dependent on economies of scale, operational efficiency, and strip ratio, which is the tonnage of waste rock required to be mined for each tonne of ore extracted – this is largely determined by deposit depth. Examples of this type of deposit are Newmont’s Batu Hijau and Freeport McMoran’s Grasberg, both in Indonesia, Newcrest Mining’s Cadia Complex (Cadia Hill and Cadia East) in Australia, and Yamana Gold’s Chapada.
Other base metal deposits containing gold

Iron oxide copper gold (IOCG)
Iron oxide copper gold (IOCG) deposits are not a major source of global gold production, accounting for only 2% of major gold deposits (>2 million oz) discovered in the last 15 years. There is no consensus as to the origin and formation of this style of deposit, so they are named mostly for the component minerals (iron, copper, and gold); the iron tends to be in the form of magnetite and/or hematite. Another distinguishing factor is that these deposits tend to have prominent structural controls and associations such as fault and breccia zones. These deposits also tend to have a distinctive suite of minor elements, including rare earth elements (REE), cobalt, silver, and sometimes uranium. A limited number of these deposits have been discovered to date, but two prominent examples are Freeport McMoran’s Candelaria in Chile and BHP Billiton’s Olympic Dam in Australia.

Skarn
Skarn deposits can be a source of a wide range of metals including tungsten, copper, iron, molybdenum, lead, zinc, tin and gold. These deposits often have minor amounts of silver. They account for approximately only 1% of large (>2 million oz) deposits discovered in the last 15 years. Skarn deposits are classified as calcic if they form in limestone and magnesian if they form in dolomitic rock. Gold occurs in calcic skarns, usually as a byproduct of base metals such as copper, lead and zinc, but some are mined principally for gold and silver. Examples of this type of deposit include Barrick’s Bald Mountain and Ruby Hill in Nevada, Yamana’s Gualcamayo and Polyus Gold’s Aksue deposit in Kazakhstan.

Volcanic-associated massive sulphides (VMS)
VMS deposits are typically mined for zinc, copper and lead with gold and silver as a common byproduct. These deposits can occur as various combinations of the primary metals zinc, copper and lead, but not as copper and lead only or lead only. These deposits often occur multiple times along one stratigraphic horizon (clustering) and may be stacked at multiple depths along one structure. Some deposits such as those in the Flin Flon region in Canada have produced notable quantities of gold, not because they are gold rich but because they are large. In 1996, Hannington and Poulsen estimated that the Flin Flon region had produced 170 tonnes of gold over its long history. Other examples include Agnico-Eagle’s LaRonde mine, Barrick’s Jabal Sayid.
Section 6: Mining project life cycle
Exploration and discovery
The mining life cycle begins with the exploration and discovery stage, during which the aim is to find and attempt to quantify the minerals contained in the deposit.

- **Project generation:** The life cycle begins when prospecting yields a promising area for exploration.

- **Exploration:** Factors important to successful exploration include skillfully handling claim staking and negotiations as well as geologic testing and sampling.

**Appraisal: Mining project economics**
If exploration and discovery are successful, a series of investigations are conducted to assess the economic value of the asset. These investigations are iterative, increasing in breadth and depth of detail.

- **Scoping:** the first step bring a project to production where basic assumptions are used to put economic value on the project.

- **Preliminary Economic Assessment (PEA):** initial estimates of the costs, expenditures and revenue from the project.

- **Pre-feasibility:** analysis of alternatives and identification of the optimum project configuration.

- **Feasibility:** final discussion of the risks and rewards of the project and sensitivity analysis prior to the commencement of project development.

**Development**
During the development stage of the life cycle, work is done to prepare the site for excavation. This section is not discussed below as it is a fairly generic process that follows from the decisions made in the above steps, and is carried out by contractors.

- Engineering.

- Construction.

- Commissioning.

**Production**
After the preparation work is completed, excavation of the site begins and steps are undertaken to extract the ore from the ground to produce the desired mineral.

- **Mining:** Extraction methods vary depending on the ore type and regional geologic conditions with safety, cost effectiveness and efficiency being key considerations.

- **Processing:** The ore is then processed to separate and concentrate the desired minerals.
Closure
As the ore becomes depleted over the time, steps are undertaken to scale down operations and eventually close the mine, bringing the project to a conclusion.

The corporate point of view
Corporate risks
We think risks from the corporate perspective include the effects of the financing strategy. Management must be conscious of dilution and funding. When investing in a new project, the financial resources required can have significant ramifications on profitability. Decisions when raising capital through debt or equity include sources, pricing and market perception.

Management team experience and skills contribute to the success of project management. Project managers are as important to the success of operations as the geology of the mine. Management must use discretion to choose individuals with relevant mining experience and capabilities. Community and labor relations, or health, safety, and environmental (HSE) affairs, if not properly addressed by management, are potential source for disruption.

Aside from appropriately addressing interest rate and foreign exchange fluctuations, companies must also be able to negotiate the contingencies that may arise from economic and political instability in the regions where their operations are located. This is an aspect that is especially important to consider as most companies own assets outside of the region where they are headquartered.

As stated by the Fraser Institute, “While geologic and economic evaluations are always requirements for exploration, in today’s globally competitive economy where mining companies may be examining properties located on different continents, a region’s policy climate has taken on increased importance in attracting and winning investment.” The Institute’s Policy Potential Index, shown below in Chart 26, rates various governments on the attractiveness of their policies are from the perspective of exploration managers.
Chart 26: Policy Potential Index

Source: Fraser Institute, BofA Merrill Lynch Global Research
Section 7: Exploration

Project generation
Projects begin with the selection of an area of manageable size for exploration. This may come as the result of regional reconnaissance, a spot check of promising geologic situations described in publications, a proposal submitted by a prospector or independent geologist, or the decision to restudy an old mine or mining district. While prospectors need considerable geologic knowledge, many are amateurs or “rogues” without formal training. Although some have attempted to equip and train themselves, many lack a rudimentary understanding of geology as well as an appreciation of local mining regulations, so may create difficulties.

Claim staking
Once the results of prospecting or reconnaissance work are submitted, management will decide whether to proceed with property acquisition, where it is necessary to move quickly and stake all open ground.

A mining claim grants the discoverer the right to mine on public land, allowing for some security of tenure for the owner. Mining claim laws vary by jurisdiction. In the United States, for instance, federal minerals are regulated by the U.S. Bureau of Land Management. The holder of a claim is granted preferential right to extract the mineral within the claim as well as for incidental uses such as exploration and development. However, the holder does not own the surface, water, rocks or gravel.

Negotiations
Mineral rights are secured as soon as the area has been deemed to have exploration potential, but the details of property acquisition may continue during the initial physical exploration work. While completing the location requirements on staked ground, the company usually undertakes negotiations with private land owners and prior claimants. The area selected for exploration work usually includes additional ground outside the area of actual interest. For example, a certain area may be the only suitable site for mill tailings, and planning should take this into consideration.

Before discovering the ore, negotiation is usually straightforward; while after the discovery of ore this becomes more complex. A minor overlap with prior claims may be resolved by an agreement to share a royalty on production that may one day come from the disputed area. After sufficient land is acquired, detailed explorations plans are made.

Regional geography
The geography of the region is vital to exploration when applying the theories behind ore genesis. With knowledge of known ore occurrences and the process of their formation, geologists may hypothesize where similar deposits would occur. The Cerro Negro mine, for instance, was discovered along a well established mineral trend. Disciplines such as basin modeling, structural geology, geochronology and petrology help to draw parallels between know deposits and potential “lookalikes.” Various mines in Manitoba were discovered through this process.
Geological exploration
Knowledge of company assets and their characteristics are prerequisites to strong production over the entire life of the mine. Understanding the regional geography of properties is a critical starting point, and this information is usually portrayed on geologic maps and cross sections. Important factors to consider include the chemical composition of the igneous rock, host rock, wall rock, gangue mineral and secondary (gangue) mineral, the age of mineralization, structural controls, physiographic expression, weathering effects and ore mineralogy.

Geophysical exploration
Employing basic principles of physics, geophysical exploration relies on properties such as magnetic behavior, radioactivity and electrical conductivity to locate minerals. A well-designed exploration project usually applies a combination of techniques, depending on geographical and geological factors of the area under investigation. Technological innovations are making exploration more precise and reliable, but there remain many uncertainties when it comes to mineral discovery.

Six of the most commonly used exploration methods
- **Magnetic.** Aeromagnetic surveys and other methods based on the same principle measure distortions in the earth’s magnetic fields caused by ferromagnetic minerals. Historically, this method was used for magnetic copper skarn, nickel ore, and asbestos-bearing serpentine, but has since been adopted for gold and silver deposits.

- **Resistivity.** Electric currents are run through the earth between widely spaced electrodes, and voltmeters read the resistivity and current flowing through the circuit. Resistivity is a characteristic dependent on specific rock types, so the underlying rock can be inferred from the readings.

- **Induced polarization (IP).** Induced polarization is usually conducted with resistivity analysis. Certain materials can store electric charge, and the time it takes for the charge to decay depends on the unique properties of the sample. Resistivity and induced polarization techniques are mostly used to look for sulphide deposits. Their extraordinarily low resistivity renders them easy to detect.

- **Electromagnetic (EM).** When area is investigated for mineral content using electromagnetic methods, a transmitter sends a signal to the ground, receives a message back, and then analyzes the response characteristics. EMs do not require electrical contact with the ground. Therefore, they are considered to be among the most effective airborne exploration techniques.

- **Gravity.** These methods involve evaluating the gravitational field at different points in an area in order to detect differences in the distribution of rock densities and infer the rock types responsible for the difference. Due the highly sensitive nature of this method, it is primarily used for quick reconnaissance survey of the area to indicate specific zones that should be further explored using other techniques.

- **Seismic.** This method relies on determining velocities of acoustical energy in the material – how long it takes a shock or sound wave to go through the matter. Seismic methods are not widely used in exploration because the intricate structure of mineral deposits complicates the process significantly and consequently increases the costs.
Geochemical exploration

The principal role of geochemical analysis is to determine whether any of the samples collected from a certain area contain unusual elements, which would in turn indicate that the sample was in touch with an ore deposit. Methods of geochemical exploration include reconnaissance geochemistry and vegetation:

- **Reconnaissance geochemistry.** This is a rapid, inexpensive technique, and observations can be made from the air, from aerial photographs or in person for unusual rock, soil and vegetative effects. Air “sniffing” devices, mounted on airplanes, vehicles or observation stations have been designed to measure indicators such as mercury vapor or sulfur dioxide. These initial observations narrow interest to smaller areas, where analysis can be done on rock chips, soils, surface and underground water.

- **Vegetation.** Geobotanical methods involve visual observation of changes in appearance or distribution of certain vegetation and biogeochemical method involves examining samples for trace metal content. The vegetation in an area may show visible toxic effects or in other cases, the conspicuous presence or absence of a certain kind of plant may indicate unusual soil conditions. Needles of pinyon have been shown to have the capacity to selectively absorb an element and concentrate it within the plant, effectively acting as a much larger sampling system.

Trenching

After interpreting the results of trace studies, trenches are made to establish the trend, width and mineral character of the ore in cases where it is protruding from the soil. The face of the trench is used for geologic exploration, because it is clean of broken material. Trenches are frequently oriented at high angles, perpendicular to the elongated mineral trends.

Bulldozers are often used in trenching as are mechanical or hydraulic rippers on tough ground. Drilling and blasting are rarely resorted to because adequate samples can usually be collected before the point where the ground is too hard to be moved by blades or rippers. On terrain where bulldozers would not perform well, backhoe trenching is often done to cleanly and quickly expose wall faces. Backhoe trenching is possible in a variety of topographic conditions, even on steep hillsides.

Target selection

The pattern and spacing of exploratory drill targets depend largely on the size, geometric orientation and internal distribution of mineral values of the ore target determined from reconnaissance, trace analysis and trenching. Possessing a clear conceptual model of the ore deposit is vital when planning an efficient and economic drill-hole pattern. Early drilling emphasizes speed and cost, and a more accurate and expensive drilling method is used once preliminary results show promise.

Initial drill testing

The next stage of exploration is to conduct initial drilling in the targeted area. Taking a representative sample of a large mass still appears to be the most accurate way to approximate the value of a deposit. There are two main types: drills which produce rock chips and drills which produce core samples.
- **Reverse Circulation (RC) drilling:** RC drills, under ideal conditions, produce dry rock chips. Reverse circulation is achieved by the hammer, a pneumatic piston, pushing air down the rods and lifting cuttings up the inner tube through differential pressure. The drill cuttings are returned to the surface, reaching the bell at the top of the hole, travelling around the inside of the cyclone before falling out through an opening at the bottom. RC drilling is slower and costlier, but achieves better penetration than percussion reverse air blast (RAB) or air core drilling. Compared to diamond coring, it is less expensive and thus preferred for most exploration work.

- **Diamond drilling:** Among the most prominent types of drills for extracting core samples are diamond drills. A circular cut is made in the ground using a drill with diamonds at the end of the core barrel, diameters ranging from 48mm to 96mm depending on nature of the deposit. As the drill travels deeper down, core sample is gradually extracted from the ground for storage and further examination.

  Up to 100,000 meters of drilling may be needed before the feasibility study, averaging at over $200/m. Diamond rigs can also be part of a multi-combination rig, dual setups rig capable of operating in either a reverse circulation (RC) or diamond drilling role. This is a commonly done where exploration is being performed in a very isolated location. The rig is first set up to drill as an RC rig and once the desired meters are drilled, the rig is set up for diamond drilling.
Section 8: Mineral reserve & resource evaluation
NI 43-101

National Instrument 43-101 (NI 43-101) is the standard for mineral project resource classification used in Canada. An instrument for the “Standards of Disclosure for Mineral Projects,” the NI 43-101 strictly regulates how companies can disclose scientific and technical information. Specifically, the standard defines the content and level of detail allowed in reports, press releases or any other form of public disclosure for each stage of the project lifecycle. Also outlined are the personnel who are qualified to write these reports.

It is comparable to other standards such as the Joint Ore Reserves Committee Code (JORC Code) in Australia and the South African Code for the Reporting of Mineral Resources and Mineral Reserves (SAMREC). In the United States, there is no specific standard, however, the SEC Industry Guide 7, Description of Property by Issuers Engaged or to Be Engaged in Significant Mining Operations, contains regulations on the publication of mineral reserves.

Definitions

The Canadian Institute of Mining Metallurgy and Petroleum (CIM) adopted standard definitions of terms relating to mineral resources and mineral reserves in 2005. These definitions have since been incorporated into the NI 43-101. A series of modifying factors can allow mineral deposits to be upgraded from resources to reserves. Within the broad categories of resources and reserves, deposits are broken down further into subcategories based on the level of geological knowledge and confidence. The CIM Definition standards on mineral resources and mineral reserves are provided as follows in order of geological confidence.

- **Mineralized material** is the projection of mineralization in rock based on geological evidence and assumed continuity. It may or may not be supported by sampling but is supported by geological, geochemical, geophysical or other data. This material may or may not have economically recoverable mineralization.

- **Mineral resource** is a concentration or occurrence of diamonds, natural solid inorganic material, or natural solid fossilized organic material including base and precious metals, coal, and industrial minerals in or on the earth’s crust in such form and quantity and of such a grade or quality that it has reasonable prospects for economic extraction. The location, quantity, grade, geological characteristics and continuity of a mineral resource are known, estimated or interpreted from specific geological evidence and knowledge.

- **Inferred mineral resource** is the part of a mineral resource for which quantity and grade or quality can be estimated on the basis of geological evidence and limited sampling and reasonably assumed, but not verified, geological and grade continuity. The estimate is based on limited information and sampling gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes.

- **Indicated mineral resource** is the part of a mineral resource for which quantity, grade or quality, densities, shape and physical characteristics can be estimated with a level of confidence sufficient to allow the appropriate application of technical and economic parameters, to support mine planning.
and evaluation of the economic viability of the deposit. The estimate is based on detailed and reliable exploration and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes that are spaced closely enough for geological and grade continuity to be reasonably assumed.

- **Measured mineral resource**: is the part of a mineral resource for which quantity, grade or quality, densities, shape, and physical characteristics are so well established that they can be estimated with confidence sufficient to allow the appropriate application of technical and economic parameters, to support production planning and evaluation of the economic viability of the deposit. The estimate is based on detailed and reliable exploration, sampling and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes that are spaced closely enough to confirm both geological and grade continuity.

**Mineral reserves**

Mineral reserves are the economically mineable part of a measured or indicated mineral resource demonstrated by at least a preliminary economic assessment (PEA). This study must include adequate information on mining, processing, metallurgical and other relevant factors that demonstrate, at the time of reporting, that economic extraction can be justified. A mineral reserve includes diluting materials and allowances for losses that may occur when the material is mined.

- **Probable mineral reserve**: is the economically mineable part of an Indicated and, in some circumstances, a measured mineral resource demonstrated by at least a preliminary feasibility study (PFS). This study must include adequate information on mining, processing, metallurgical, economic, and other relevant factors that demonstrate, at the time of reporting, that economic extraction can be justified.

- **Proven mineral reserve**: is the economically mineable part of a measured mineral resource demonstrated by at least a PFS. This study must include adequate information on mining, processing, metallurgical, economic, and other relevant factors that demonstrate, at the time of reporting, that economic extraction is justified.

**SEC Industry Guide 7**

In the United States, the SEC Industry Guide 7 provides guidelines on the content of mining operations disclosure, defining the terms for reserves and the classifications of mining operators. Companies are required to disclose for each of their properties the location and means of access, previous operations, condition of plant and equipment, rock formations and mineralization.

A major difference between NI 43-101 and Industry Guide 7 is the disclosure of reserves and resources. Companies reporting in the United States report proven (measured) and probable (indicated) reserves, defined as the parts of a mineral deposit that could be economically and legally extracted or produced. The SEC requires reserves to be estimated using appropriate cut-off grades based on a maximum of three-year trailing average price. The process of commodity price determination is not specified in Canada. While the terms "mineral resource", "measured mineral resource", "indicated mineral resource" and "inferred mineral resource" are defined in and required to be disclosed by NI 43-101, they are not defined terms under SEC Industry Guide 7 and are normally not permitted to be used in reports.
The practice of estimating “contained ounces” in mineral resources using cut-off grades and gold price assumptions determined by the company, permitted in Canada, is not allowed in the United States. Resources, or other mineralization that does not constitute “reserves”, can only be described by in place tonnage and grade without reference to unit measures. Due to differences in the standards, U.S. investors are cautioned not to assume that all or any part of the mineral reserves in these categories will ever be converted into mineral reserves, nor that any part of an inferred mineral resource ever be upgraded to a higher category.

**Other standards**

The JORC (Australia) and SAMREC (South Africa), CIM (Canada), National Committee (Chile), National Committee PERC (Europe) and SME (USA) are represented at the Combined Reserves International Reporting Standards Committee (CRIRSCO). The organization is part of an international initiative to standardize market related reporting definitions for mineral reserves and resources. The Denver Accord of 1997 saw the participants reach an agreement on the definitions of the two major categories mineral resources and mineral reserves, as well as their respective subcategories measured, indicated and inferred mineral resources, and proved and probable reserves. The JORC Code has since been updated and the various national reporting codes are now very similar.

### Table 12: Comparisons between reporting standards

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<thead>
<tr>
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</tr>
</tbody>
</table>

(1) Allowed in certain restricted circumstances
(2) Pre-feasibility study expected (The Reporting Code) or required (NI 43-101)
(3) Feasibility study for new projects

Source: Stephenson and Weatherstone, CRIRSCO, BoA Merrill Lynch Global Research

The JORC Code, which is widely accepted as a standard for professional reporting purposes for companies listed in the Australian and New Zealand Stock Exchanges. Compared to the NI and Industry Guide 7, the JORC Code requires less technical disclosure to the market, as it was derived from an independent mineral industry body as opposed to securities regulators. While the NI requires technical reports to be published in full, a summary of key points in commonly published in place of the report on the Australian Stock Exchange, often preserving commercially sensitive information.
Another commonly used standard is South African Code for the Reporting of Mineral Resources and Mineral Reserves (SAMREC). The code is very similar to standards like the NI 43-101 in terms of the content of the technical reports, the mineral resource classifications, but is less prescriptive in the manner of mineral exploration reporting. Other codes used internationally include The Reporting Code used in Europe, Code for Mineral Resources and Reserves in Peru and Chile, SME guide for Reporting Exploration Info, Resources and Reserves in the US.

Where can estimates go wrong?

Reported ore resources and reserves must always be treated with caution because they never exactly describe the ore body. Limited geological observations, sampling and testing can form estimates, but they are not calculations. The minerals contained are not known for certain until mining development takes place. Ore bodies can range from simple to complex in terms of their shape, grade distributions, deleterious elements, specific gravities, rock mechanics and so forth. All of these factors can affect the accuracy of the estimate. Errors can arise from a variety of sources:

- **Amount sampled.** Physical sampling of the deposit is 1 part in 100,000 and laboratory analysis done on sub-samples equal to 1 part in 40,000,000. To place this into perspective, imagine knitting needles penetrating the room depicted in Exhibit 8, how much would need to be sampled in order to accurately report the volume of the needles? There is great room for error when detecting for minerals.

- **Interpretation error.** Interpretation error can occur in instances where the test results are extrapolated based on incorrect assumptions. For instance, the assumed ore shape in Figure 4 is vastly different from the actual illustrated in Figure 5.

- **Instrument error.** Faulty calibration can sometimes cause inaccurate resource measurements, one instance being when magnetite in the ore caused the instruments to provide the wrong location for the drill holes. The deposit was much smaller than they thought when they sunk the shaft.

- **Bulk density.** Is a measure of the weight of rock or soil per volume. Errors in reporting bulk density can be very costly, causing the loss of up to one gram per tonne in grade. The clod and core method of bulk density determination is particular prone to errors because it does not take interclodal space into account, typically reporting a higher density than methods like radiation.
■ **Grade estimation.** When the measured grade is higher than the true grade, a material error is made and extra cost is incurred in operating a mine relative to forecasted estimates. When the measured grade is lower than the actual grade, a material error is made such that potential revenue is lost. The nugget effect in measuring homogeneity of the deposit needs to be properly accounted for. When selecting an estimation method, factors to be considered include minimizing costs, ore boundaries, deposit geometry and grade variability. There is no single method that is considered to be superior to all others, so usually a combination is used and the results from various methods are compared to arrive at the final resource estimate.

■ **Human error.** Mistakes can be made by individuals during processes such as inputting values when constructing databases. To prevent human error, reporting guidelines in all of the CRIRSCO jurisdictions have a competent (qualified) person requirement for the individual responsible for reserve and resource estimation reports. Under the NI 43-101, for example, a qualified person must be an engineer or geologist with a minimum of five years of related field experience, a member of a recognized professional organization and must have knowledge specific to the geological environment, type of mining operation, metallurgical process and/or part of the world.

■ **Mining dilution.** Failure to properly consider the correct mining method and its effectiveness for a particular ore body can lead to underestimating the amount of rock that has to be removed along with the ore. As a result, the effective grade of the ore processed is lower than anticipated. Including mining dilution in estimates is required under the NI 43-101 for reserve estimates, but it is not a requirement for resource estimates.
Geological confidence and share price

During the course of a typical gold asset lifecycle, share price fluctuations can be approximated by the pattern shown in Chart 27. Mineral projects begin at the discovery stage, which is typically one to two years on average. Investors begin to speculate on the stock and when exploration confirms the deposit, there is typically a sharp increase in share price, a highly risky time to invest. The project then segues into the build stage, which lasts for two to three years on average. Most of the investment analysis is performed on the company during this period. The ideal entry point is generally when the production decision is made as the asset transitions from development into the production stage. The next catalyst for the stock is production start-up, when the share price will generally react positively.

Chart 27: Life cycle of a mining share

Source: Exploration Insights
Section 9: Mining project economics

At each stage of asset development, various studies are conducted on mining projects to provide information technical information as well as economic assessments. Since the study process is a function of uncertainty, a phased and iterative process has emerged under most regulations. As the studies progress from one level to the next, the option will either be deemed uneconomical and abandoned, or promising results at each level and more studies will be conducted leading to results with a greater level of confidence. The main types of studies, by chronological sequence, generally are:

- Scoping study
- Preliminary Economic Assessment (PEA)
- Preliminary Feasibility Study (PFS)
- Defined Feasibility Study (FS)

These studies generally accompany specific stages in the mining lifecycle, and the permitted disclosure and relevant documents vary depending on the type. An example is the timeline for NI 43-101, shown below in Exhibit 9.

Exhibit 9: Defined Stages in NI 43-101

Source: Pat Stevenson, AMC Mining Consultants (Canada)
**Scoping study**

Scoping studies and resource statements are completed in order to determine whether it is worth to invest in further exploration program and more thorough engineering work at the given asset. General features of the opportunity, key business drivers, potential flaws, cost and time required to undertake further development work to advance to the next stage, technical issues needing further investigation are among the subjects discussed. First estimates of the mineral resource are released together with initial financial appraisal.

Typically based on early resource estimates, it is unlikely for the study to include sufficient measured and indicated material available to be converted to a reserve. Although the scoping study usually includes a mining plan, it is only necessary to prove one likely method as economical in order to advance to a prefeasibility study. Referred to as order of magnitude feasibility studies, a tolerance of +/- 30% is generally considered appropriate capital and operating cost estimates.

**Preliminary economic assessment (PEA)**

Latest update of the NI 43-101 in 2011 allows PEAs to be done at any stage in a project life to explore alternatives based on new information or developments. It is permissible for PEAs to include inferred resources, but there must be disclaimers about uncertainty and note that it is not a valid economic study. Over the past few years, several prospectuses to raise funds were rejected by securities commissions because of confusion around PEA disclosures. In one case, the engineering inputs were to the confidence level of a PFS but a portion of the study is based on inferred mineral resources.

**Preliminary feasibility study (PFS)**

Preliminary feasibility studies are generally undertaken after the delineation of mineral resources. Items like detailed description of the project, ore resource estimate, pre-production construction and production schedules, capital and operating cost estimates, preliminary financial evaluation are typically contained in the report. Different mining, processing, location and project configuration cases are considered as well as different capacities.

The study will conclude with a recommendation for the optimum case to be examined during the feasibility study. The accuracy of estimates generally improves to the +/-20% range. PFS are usually carried out in the anticipation of a feasibility study and usually follow a very similar template. However the depth of analysis and accuracy of the result are different. The key distinction between a PFS and a detailed feasibility study is that details are not yet sufficient to provide basis for an investment decision.

**Feasibility study**

Detailed feasibility study is meant to provide a well-supported conclusion on whether the project should be pursued or not and what the economic consequences of it will be. It must include a number of macroeconomic projections, such as commodity prices and sales volumes, future costs, exchange and interest rates. Plans for the implementation phase are outlined to provide a basis for control and monitoring and a management plan for the production phase is established. In addition, it should incorporate a good risk analysis and determination of production capacity for the specific asset. It would usually include a NAV and IRR valuation in it. The feasibility study is the most expensive, but also the most accurate and comprehensive type of feasibility study.
Section 10: Mining

Mining cycle

1. **Development drilling.** The first phase of the mining cycle is development drilling, which entails drilling holes in the ground, filling them in with dynamite and then exploding it to break the rock. Most commonly used equipment for this type of work is an electric-hydraulic drill jumbo that has booms and drifters (or drills) built into it. Those vehicles are used for initial development drilling to indicate where development is heading. Once development is completed, drill jumbos can also be used for production mining.

2. **Development raises.** This step involves removing drills, bits, traces of explosives, timber, and so on from the holes after every successive blast. This procedure is considered to be among the most challenging and physically demanding in the whole mining cycle.

3. **Production drilling.** Depending on the mining method (discussed later), there are a lot of options to select from in terms of equipment. Production drills available range all the way from small-diameter longhole to large-diameter blasthole drills.

4. **Loading and blasting.** Once some of production holes have been drilled, blasting crew starts to fill those in with explosives. The most common substance used for blasting is abbreviated ANFO which stands for ammonium nitrate and fuel oil. Explosions are carried out in a special sequence to accommodate further steps of exploration cycle and make sure that the rock breaks in the predetermined manner. Blasts are always performed after the work hours in order to avoid life-threatening accidents as well as to let dust and fumes brought about by the explosion settle down before workers come into the mine next morning.

5. **Mucking.** Mineral ore that has been broken up as a result of explosion is called muck. The mucking step of mining cycle simply involves loading muck on trucks, rail cars, or a conveyor belt and sending it to either underground processing center, or to the surface. One of the most popular machines, used in the mucking step, is called load-haul-dump (or LHD). This is a vehicle with rubber tires that is very commonly used, especially in mines where distances are quite long. LHD’s load with muck trucks or rail cars, which later take the rock to the established destination.

6. **Backfilling.** As soon as a stope (a production center in the mine) is cleaned from the muck, it is often necessary to bring back some of the waste material (sometimes mixed with cement) to fix the underground structures. This will ensure that work done on the ores abutting to the stope, does not do any damage to the architecture of the entire underground network.

7. **Ore haulage.** For transporting ore within the mine, truck and train are the two options. Statistically, companies with longer hauls and narrower openings prefer to use rail cars, while those with shorter travel distances and larger workings usually choose trucks or LHD’s. In the mines operating track haulage, ore is dropped down the chutes on different levels of the mine and gradually fills the rail cars. Once full, those cars are taken to the station and dumped there. Prior to travelling through the finger pass from the station to the main ore pass, ore will be sent to grizzly (a machine for crushing rocks) to make sure that there are no oversized chunks found in the main ore pass.
8. **Skipping ore to surface.** The most conventional way of moving ore to the surface is through skipping. A skip is a lightweight alloy self-dumping basket that can carry anywhere from 3 to over 20 tonnes of ore. Those baskets get filled in at the base of the ore pass and then get sent to the surface either by truck or rail car. Once the ore is above the ground, it goes to the mill where it will undergo crushing, grinding, beneficiation, and finally refining to become a commercial product.

**Selecting a mining method**
Choosing a mining method is probably the most important decision that a mining company has to make. When deciding, the company should aim for maximizing cost recovery and profitability of operations, minimizing dilution and permitting the most efficient removal of ore. Main factors to consider should be the following:

**Dip size**
Dip of an orebody measures the vertical inclination of the deposit and identifies whether the broken ore will, without difficulty, fall to lower mining levels to be loaded on trucks and taken to the processing facility. If dip is found to be larger than 50°, then traditional blasthole, vertical retreat mining, shrinkage stopping, sublevel mining or block caving techniques are to be used. If dip is lower than 50°, geologists should prefer room-and-pillar method. Cut-and-fill method can be used for deposits of any dip.

**Shape of the ore body**
On average, ore bodies can be of three distinct kinds: vein-type, massive or tubular.

- **Vein-type.** Since vein-type deposits almost always have a dip at an angle greater than 50°, blasthole mining, shrinkage stoping and cut-and-fill techniques are recommended.

- **Massive.** The most applicable methods for massive ore bodies that spread over hundreds of meters, are blasthole mining with deferred fill, vertical retreat mining, sublevel caving, and mechanized cut-and-fill.

- **Tubular.** For tubular deposits, which are relatively flat, one should use a room-and-pillar method.

**Strength of the ore body**
Strength of the ore body is heavily dependent on natural conditions such as jointing and faulting of the deposit. However, artificially created mine support is also an extremely important factor. There are essentially three levels of mine support: self-supporting, supported, and openings that are allowed to cave.

- **Self-supporting deposits.** When walls and pillars within the mine are sufficiently strong, external support is not necessary. Blasthole stoping, vertical retreat mining shrinkage stoping and room-and-pillar mining methods should be considered.

- **Supported deposits.** On the other side, there exist mines that would require artificial support to ensure that working conditions there are relatively safe. Cut-and-fill is the best fit in this case.

- **Openings that are allowed to cave.** For this kind of support, caving should be used.
Cut-and-fill stoping

This method is preferred for comparatively high grade ore bodies of irregular shapes or vein structures with very steep incline. Providing high ore recovery, it is a versatile method suitable for mines that require the capability of mining selected ore pockets and the adaptability to variations in the rock structure. Cut-and-fill is often used in deposits with weak wall rock, since the fill acts to support slope walls, in addition to providing a working platform for subsequent cuts.

The operating cost for cut-and-fill stoping is high with a relatively low productivity. Typical direct mine operating costs for cut-and-fill range from $75-$250/tonne (for example, Goldcorp’s Red Lake mine, which uses underhand cut and fill to mine parts of the ore body, is at the high end of the range though due to its high ore grades is a low cost per ounce mine). Costs generally increase with decreasing ground quality and increasing irregularity of the shape of the ore body.

As shown in Figure 7, the stope is mined in horizontal slices, often from the bottom up. After a single excavation pass has been completed, the entire slice is backfilled before the next slice can be cut. This process is reiterated multiple times till the whole deposit is depleted. The process begins with a haulage drive along the footwall of the orebody at the main level. Once this is completed, the stope area is undercut with drains for water. A spiral ramp is then built in the footwall with access drive to the undercut. For ventilation and filling material, a raise is made to connect to levels above.

After drilling the stope surface, the face appears to be a wall across the stope with an open slot below the fill. When the face charged and blasted, the slot provides space into which the blasted rock can expand. This controlled fragmentation and smooth fill surface are ideal for implementing LHDs to move the ore from chutes to ore storage pockets. Hydraulic sandfills are often used with cut-and-fill to fill slopes.

With overhand cut-and-fill (discussed above), operators typically mine upwards until only a small pillar is left overhead. At depth, this (roof) pillar becomes overly stressed and may burst, collapsing on workers below. Underhand cut-and-fill eliminates the need for such a pillar as it removes a cut of ore, fills the space left

Table 13: Mine dilution and recovery factors

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<th>Mining method</th>
<th>Dilution factor, %</th>
<th>Recovery factor, %</th>
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<td>Open pit</td>
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<tr>
<td>Block caving</td>
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<td>95</td>
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<td>Cut-and-fill</td>
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</tr>
<tr>
<td>Room-and-pillar</td>
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<td>185</td>
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<td>Shrinkage</td>
<td>10</td>
<td>90</td>
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<tr>
<td>Sublevel longhole</td>
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<td>85</td>
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<tr>
<td>Vertical crater retreat</td>
<td>10</td>
<td>90</td>
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</table>

Source: U.S. Bureau of Mines

Figure 6: Cut-and-fill cross section

Source: U.S. Bureau of Mines

Figure 7: Cut-and-fill stoping

Source: BofA Merrill Lynch Global Research
by the ore with very high-quality backfill and then take the next cut underneath. This method is by far the most expensive form of mining with direct mine operating costs as high as the $250/tonne range. It is only used in cases where grades are very high. Instances where the underhand variation is used include Goldcorp’s Red Lake and Hecla’s Lucky Friday.

**Long-hole sublevel stoping**

Long-hole sublevel stoping is sometimes referred to as sublevel open stoping or blast hole stoping. It is common when mining big underground ore bodies. This method is used where the ore body is vertical or steeply dipping, very tall, with a medium to narrow width (6-30 meters). Both the hanging wall and the footwall must be strong, since there is no support in the stopes. The ore must be competent with regular boundaries and good continuity. This method is best suited for large ore bodies, where the ore can be multiple times larger than the stope size.

Ore recovery in long-hole stoping tends to be excellent and dilution control very good. Direct mining costs are much lower as compared to cut-and-fill methods and fall in a fairly wide range of approximately $20-$60/tonne, but potentially higher in some instances. Costs tend to vary with drilling and blasting design with the more costly methods exhibiting higher ore recovery than less costly methods. Long-hole sublevel stoping (and its variations) is a very common form of mining, accounting for approximately 75% of the mining methods used in mines across Canada.

Development includes a haulage drift, raises for access to sublevels, sublevels for access to ore body, an undercut below the stope, drawpoints, and a slot raise at the end of the stope (Figure 8 and Figure 9). To begin, the ore body is divided
into parallel sublevels approximately 20 meters away from one another. Then, a slot raise is developed and subsequently increased by blasting. Drilling accesses are developed into the ore from which multiple holes are drilled across the whole area of the orebody and filled in with explosives and blasted in sequence. The following detonation turns the targeted portion of the deposit across the entire stope into muck. Broken ore is recovered at the bottom of the stope and once completely removed the stope is backfilled with either cemented or unconsolidated waste rock or paste fill.

**Longitudinal stoping**

One variation of the long-hole method is longitudinal stoping, sometimes referred to as bench stoping or sublevel benching. In longitudinal stoping, mining is conducted along or parallel to the strike of the orebody (Figure 10). Longitudinal stoping is a preferred method in instances where the orebody is thin or narrow veins are present and when the orebody is steeply dipping and sheet-like. As in Figure 10: Longitudinal retreat long-hole stoping longitudinal mining is well suited to the retreat style of mining, with most development occurring in the orebody, reducing development costs. The disadvantage of this method is the inability to part from one sequence of mining, starting at one end of a mining block and mining to the other. There are three main methods of longitudinal stoping used, Avoca, Eureka, and Creeping Cone, the use of which depends on the geotechnical conditions and operational requirements.

**Transverse long-hole stoping**

Transverse long-hole stoping, also known as primary-secondary sequence mining is a subset of long-hole stoping where the long access of the stope and access drifts are perpendicular to the strike of the orebody (Figure 11: Transverse long-hole stoping). This method is useful in cases were the rock quality of the hanging wall limits the length of the open mining span. As compared to longitudinal, transverse has the disadvantage of requiring more development in waste rock for drawpoints and footwall drifts. The advantage is that it is more flexible in terms of sequencing and scheduling. The orebody must be of sufficient width (thickness) to justify the waste rock development costs. In Canada transverse mining is utilized for orebodies with widths no less than 15 meters.
**Vertical crater retreat**

Vertical crater retreat (VCR) is another long-hole stoping method used on vertical or steeply dipping ore bodies under similar conditions for sublevel stoping (and shrinkage stoping). Development includes a haulage drift, raises for access to drill overcuts, undercut of the complete area below the slope, drawpoints, and overcut of the complete slope area along the top of the slope. The VCR stopes are excavated in horizontal slices starting from the bottom, and the broken ore can remain in the slope for support similar to shrinkage stoping. It is this bottom-up approach that differentiates VCR from other open stoping methods that generally mine ore from left to right (or vice versa). Further, it does not require sublevel drifts to be excavated before blasting and mucking to proceed.

Vertical crater retreat, also referred to as Vertical Retreat Mining (VRM), is a modification of long-hole (blasthole) stoping. It is different from the blasthole stoping in two ways though. Firstly, it does not require any slot raises. Secondly, instead of drilling small-diameter longholes, VCR involves drilling large-diameter blastholes. Once muck from the previous explosion is removed, the mine is ready for a new blast. VCR was developed by Inco to improve worker safety by ensuring miners are not required to work inside the stope, preventing exposure to open holes. The drawbacks of this method is the need for a large upfront capital investment to develop drift infrastructure and the potential for subsidence of overlying stope zones, only avoided by using backfill at an additional cost.

**Room-and-pillar mining**

Room-and-pillar mining is usually applied to ore bodies that are horizontal with dips less than 30 degrees and thickness limited to no more than about 30 meters (determined by the stability of the ore forming the pillars). With a number of work faces, this method is highly productive, but only feasible when the ore, hanging wall and footwall are of good quality.

Compared to other underground methods, room-and-pillar is low cost with a low ore recovery rate (since ore must be left behind in pillars that sustain the mines structure), yet very little dilution as the contact between ore and waste is normally well defined (waste at top and bottom of ore body). Direct mine operating costs for room-and-pillar mining typically range from $5-$20/tonne.

Since ore is often left behind as pillars, this mining method is most useful for lower grade ore bodies. However, if the pillars are of sufficient grade, the remaining cavern can be filled and the pillars mined during retreat. This would increase the mining cost on a per tonne basis but may not impact mining cost on a per ounce produced basis if the grade is sufficiently high.

With room-and-pillar mining, the ore is mined from large empty stopes or rooms with the pillars of ore left in place to support the hanging wall (Figure 13). The minerals contained in the pillars are usually not recovered but can be if the grade is sufficiently high to justify the additional expense. Pillars are generally 11 to 15 meters in diameter and are offset to maintain an acceptable distribution of stresses from overburden. On average, pillars are spaced 11 meters apart with a pillar to ore ratio of about 1:5.
Depending on the thickness of the ore body, a series of passes (cuts) are carried out, with horizontal slices starting at the top and benching down in steps. A typical sequence consists of an initial cutting-in pass, followed by overhand stoping of ore in the back and horizontal benching of ore in the floor. Mining the ore body creates large open stopes where machinery can travel on the flat floor.

The initial pass is usually initiated toward the top of the ore body below the hanging wall to help define the lateral extent of the ore body. Rock bolts are installed to reinforce the rock strata at this stage. Additional mining is carried out by horizontally drilling and blasting the brow with standard crawler rigs until the lateral boundaries of the ore body are reached for this particular pass. Provided the stopes are sufficiently large, big drill jumbos can be used for mechanized drilling. The overhand stoping passes of ore body will continue upward until the top of the ore body is reached.

Variations to the classic room and pillar include post room-and-pillar mining, where mined-out space is backfilled to keep the rock mass stable and serve as a work platform for the next ore slice. Another variation is step room-and-pillar mining, adapted for trackless mining to ore bodies where the dip is too steep.
Shrinkage stoping

Shrinkage stoping is an overhand mining method that is suited to vertical ore bodies that do not require any external support for the walls or the ore (they are self-supporting). Since the ore will often sit broken in moist environments and for long periods, high sulphide content in the ore is not amenable to shrinkage stoping extreme heating and possible spontaneous combustion are serious risks.

This method has a high recovery, but requires steeply dipping, narrower ore bodies. Shrinkage stoping is not as popular as it once was. Sublevel stoping, vertical crater retreat (VCR), sublevel caving, cut-and-fill are all methods that can be applied to ore bodies where shrinkage stoping is feasible. With a relatively better safety record and increased mechanization in the last several decades leading to reduced costs these other mining methods have been increasingly used in place of shrinkage stoping, and its use (at least in North America) has declined. The key safety concern is that ore extraction can cause sudden shifting of the broken ore while miners are working on the broken ore.

The principal idea behind this method is that muck takes up a greater volume than in-situ rock. In practice, blasted rock fills in almost 50% more space than it used to as a solid mass (the swell factor). Once a horizontal slice of the stope is blasted and drops on the mine floor as muck, some of it is removed for processing (approximately 30%-35% during a blasting cycle) but most of it is left in place to serve as the floor for the next cut to happen. As soon as the stope is exhausted, all blasted rock is cleaned out from the mine.

Only enough ore is removed after each blast to provide a working platform for the next drill round; the remaining ore in the stope helps to support the wall rock during blasting. The remaining ore is removed from the slope at the end of the mining cycle, when support is no longer necessary. It is usually not necessary to fill the resulting void after mining this is often done in practice, using waste rock. Required equipment include jackleg drills and stopers for production and drift development, rock bolts for wall support, LHDs to move the ore.

Sublevel caving

In sublevel caving the setup is similar to long-hole open (blasthole) stoping, except loft raises are not required and more importantly, drilling actually starts from the top rather than the bottom, and the ore is effectively mine as one large stope. As compared to long-hole open stoping, this top-down approach allows for a quicker and less costly initial setup prior to commencement of mining. However, sublevel caving tends to result in greater dilution and so is used on lower value ore bodies. Another advantage vs. long-hole open stoping is that it is better in instances when rock quality is quite low. This technique is relatively inexpensive (in the $5-$8/tonne range typically) and results in a large amount of muck, which makes it attractive for producers for its efficiency.

Figure 15 and Figure 16 demonstrate the implementation sublevel caving. The name is derived from the use of underground development that is carried out on intermediate levels (sublevels) combined with the resultant surface and hanging wall subsidence (caving). Due to the surface subsidence, these are used more often in underground mining beneath existing open pits as opposed to beneath undisturbed earth.
Block caving is the logical scale-up of sublevel caving. The ore is mined effectively as one large stope (as with sublevel caving) but instead of mining from the top down, ore is extracted from draw points at the bottom of the ore body. As a result of this bottom up approach upfront capital costs tend to be quite large. Ore is initially blasted in its lower portion but after that rock is mostly broken under the stresses of its own mass causing it to fail. Because of the minimal blasting required after initial production has started, operating costs are generally lower than other mining methods (in the $2.50-$5/tonne range). In fact, some block caving operations have mining costs that are less than those of open pit mines, generally considered to be the lowest cost form of mining.

Block caving ideally suited to large, deep, steeply dipping and low grade ore bodies. This is due to the high dilution and low recovery inherent in under bulk underground mining. Due to the low selectivity of this mining method it is very well suited to ore where the grade distribution is quite uniform. High quality ore that does not cave well sometimes requires fracturing with explosives or hydraulic in order to pre-condition the ore for caving and maintain production. This can increase development costs significantly. The danger inherent in poorly caving ore is that a large cavity can form that can result in sudden collapse of the rock mass. Such an event would create a potentially fatal and destructive wind blast.

Panel caving
Panel caving is very similar to block caving with the key difference being that only a portion of the ore body is undercut and blasted at start-up, such that caving propagates horizontally, as well as vertically (similar to sublevel caving). This method has the advantage of requiring less initial capital investment prior to the commencement of production. Figure 17 demonstrates the general set up of what could be either a block or panel caving operation depending on the initial configuration prior to start-up. New Gold’s New Afton mine in British Columbia started up in 2012 and is the only operating block caving mine in Canada.
Open pit mining

Open pit mines, at the extreme, are by far the largest mining operations globally, with operations such as Goldcorp’s Penasquito gold-silver-lead-zinc in Mexico processing approximately 110,000 tonnes of ore per day (tpd) or Freeport’s Grasberg copper-gold mine in Indonesia extracting more than 200,000 tpd. That said many open pit mines are very small, producing less than 1,000 tpd, such as the open pits at Pan American Silver’s Manantial Espejo in Argentina. (At Manantial Espejo the mill processes approximately 2,000 tpd consisting of ore combined from multiple open pit and underground mines). When deciding to operate using open pit mining the key factor to consider is the proximity of the deposit to the surface; those near the surface can generally be mined more economically with an open pit as opposed to an underground operation.

Major cost savings are achieved through economies of scale because much larger equipment can be used in an open pit operation. Given the huge range in the size of open pit operations the costs can vary significantly, with the largest experiencing costs less than $1/tonne, and smaller operations in the $10/tonne range. The greatest variability in the total cost across open pit mines is in the strip ratio.

The strip ratio is the ratio of the mass of waste required to be moved to the mass of the ore moved. The higher the strip ratio the higher the total cost of the operation. Often a very high strip ratio (>10x) will require high grades in order for an operation to be economical. It should be noted that under IFRS, the accounting standard adopted by Canadian domiciled gold producers, waste stripping costs can be capitalized. This is not the case under United Stated GAAP. This means that open pit operations with high strip ratios will appear more costly in expense terms, under United States GAAP vs. IFRS. This stripping cost will be equivalent as included in the statement of cash flows.

There are other important risks that need to be taken into consideration in this case. Most importantly, strong and secure walls must be maintained in order to ensure uninterrupted production (and to guarantee maximum possible workplace safety). Pit wall stability is determined through a combination of the rock quality...
and the pit wall slope. The lower the pit wall slope the more stable the pit but this will cause more waste rock to be removed, increasing the strip ratio and thus, costs. In designing an open pit the correct balance must be achieve between stability, the costs of achieving this, and the costs of increased spending on rock engineering and safety down the road.

**Exhibit 10: Partial view of Tasiast open pit – late March 2011**

**Exhibit 11: Open pit showing a moderate strip ratio**
Section 11: Gold processing

The last step in creating a commercial product out of ore is processing. Just as important and challenging as exploration or mining, it takes place in the processing plant either on the surface or under the ground. Once ore goes through a series of transformations in crushers, mills, thickeners, etc., it becomes a product ready for sale. In the case of gold and silver, it usually comes out as a doré bar.

Processing cycle

Primary crushing

Even if an operation's main processing plant is located above the ground, primary crushing usually happens before ore leaves the mine. The goal of this process is to make pieces of blasted rock smaller so that it is easier to haul them to the surface. Two types of crushers, primarily used for this purpose, are jaw and gyratory crusher. A jaw crusher, as suggested by the name, works in a similar manner to animal jaws: the ore goes between a pair of metal jaws, one of which is fixed, while the other one is moving. Operation of a gyratory crusher follows a somewhat similar logic with one part moving while the other one is standing still. Ore falls into a fixed cylinder that has a rotating cone in it. Fragments of blasted rock are compressed between the walls of a crushing bowl and moving gyratory head, fall into smaller pieces under the strain.

Secondary crushing

A secondary crusher is only used if primary crushing did not give small enough pieces of rock as a result. The most commonly used crusher in this case is a cone crusher. In terms of architecture, it is very similar to a gyratory crusher but designed for smaller rocks.

The size of rocks that come out after the secondary crushing is controlled by vibrating screens. If pieces of ore fall through the openings in those screens, they are ready for the next processing step. If not, they get sent back to the crusher on a special conveyor belt.
Grinding circuit
The size of crushed rocks is even further reduced through the milling process. A mill is just a cylinder that is partially filled with steel balls (if it is a ball mill) or rods (if it is a rod mill) that rotates and by doing so, grinds the material within it. If milling is based solely on rock-against-rock friction and is done without adding any steel scraps, the process is referred to as autogenous grinding. It is the most economical but it is also the least effective. Semi-autogenous grinding lies somewhere in between and involves adding some steel fragments to the cylinder but not as many as for ordinary grinding.

Concentration
- **Gravity separation.** Sometimes crushing and grinding will be sufficient to release a portion of the gold from its host minerals. Gold is then separated (or concentrated) from the host minerals with most often either a cyclone or a knelson/falcon concentrator (or both) by taking advantage of gold’s greater relative density. This method often yields only a portion of the total gold contained in the ore. The remaining gold must be extracted using cyanidation (or sometimes a more complex process in the case of refractory ore).
- **Floatation.** Ore delivered to mill often contains minerals that do not bear gold. Concentration circuits can be built that will reduce the ore to only metal-bearing minerals, allowing for further processing that is more efficient. To separate gold-bearing minerals from those that don’t bear gold is most often accomplished through the floatation process.

Cyanidation
Chemical properties of gold are used to liberate (ore leach) the metal from gangue material. Cyanide (a chemical compound that contains the cyano group, CN-) is one of a few compounds in the world that is able to dissolve gold. At the same time it cannot dissolve minerals that bear gold. Therefore when cyanide is added to the drum containing gold-rich minerals, it reacts with the gold and dissolves it while leaving the rest of material untouched. Because cyanide cannot dissolve anything other than gold, the rock should be finely crushed when the solvent is added so that surface area for the reaction and therefore the recovery rate are maximized.

In addition to cyanide, lime is added to the pulp ore (finely crushed rock in water) in the grinding circuit. It protects cyanide from being neutralized by other naturally occurring minerals as well as improves the efficiency of thickening stage in the future.

Taking gold out of solution
Once hard rock has been turned into pulp and the gold is dissolved in the cyanide solution, processing techniques that use either zinc powder or activated carbon can be applied to separate worthless material from the gold.

Refining
A mixture of silica, borax and soda (or steel wool in the case of CIP) is added to the gold precipitate and heated in the furnace in the refinery process. As a result of this procedure, the molten material splits into two parts with liquefied gold at the bottom and all impurities on the top. The liquid is then poured into a conic shape where it cools down. When melted content solidifies, impurities and refined gold are still distinctly separated, so impurities can be easily broken from the pure precious metal. Once it is done, gold is melted again and poured into bar moulds.
Processing methods - the details

Concentration: gravity separation

Gravity concentration methods take advantage of the fact that gold, once in water, settles faster than other minerals. Different types of equipment, such as jigs, spirals, pans, cones, and sluices can be used for gravity concentration, but the essence of the method is the same regardless of instruments: as water flows through, heavier mineral, in this case gold, sinks to the bottom of the vessel while lighter gangue material is washed off the top.

This model is designed for evaluating deposits where a gravity mill will be used to process ore that can be separated by gravity. Typical deposits where gravity mills are used include free milling gold, some tungsten, and other heavy mineral deposits. The model is valid for feed rates of 100 to 1,000 tons/day. Recovery is assumed to be 93%.

Mine-run ore is initially crushed by a jaw crusher. The discharge is sent to a double-deck screen, where the plus 3/4 inch fraction discharges onto a conveyor and is fed to a cone crusher. The minus 3/4 inch fraction from the jaw and cone crusher is conveyed to vibrating screens. Oversize from the screens is returned to the cone crusher, and the undersize is slurried and fed to the jig.

Tails from the jig go to the rod mill, where grinding occurs in closed circuit with a cyclone classifier. Overflow from the cyclone is pumped to a spiral classifier. Size fractions from the classifier are sent to a series of tables to produce a high-grade concentrate, a middling product, and tailings. The middlings are combined and recycled through the rod mill.

Table concentrates are sent to a flotation cell where any sulfides present are floated off. Underflow from the float cell is combined with the concentrates from the jig and then thickened and dried. Tailings are thickened and sent to the tailings pond.

Concentration: floatation

Gold bearing sulphides can be very efficiently recovered using floatation techniques. In the processing plant, oils and synthetic chemicals are added to the ore in the grinding stage, instead of cyanide and lime. The pulp is then poured into floatation cells (cylindrical reservoirs) where it circulates while more floatation reagents are added. Due to the swirl, air bubbles form in the pulp. After some time, floatation reagents start covering the sulphides and make them adhere to the bubbles, which in turn, carry sulphides to the top of the reservoir, where they are mechanically collected. In the meantime, impurities that sink to the bottom of the tank are gathered and later discarded.
Cyanidation/extraction: CIP - electrowinning
Carbon-in-pulp (CIP) - electrowinning is an economical way of extracting gold from the pulp that involves adding activated carbon granules (usually ground and burnt coconut shells) to the cyanide solution. Gold is adsorbed onto the granules that are then easily sifted from the pulp cue to there relatively large size. The gold is later stripped from the activated carbon through a process called elution or desorption. Both CIP and CIL processes are most often used for processing gold ores with little or no byproducts (for example, silver or copper).

In Figure 21, mine-run ore is initially crushed with a jaw then a cone crusher. Crushed ore is then ground in a rod mill and sent through cyclones. The oversize is sent to a ball mill, while the undersize is sent to a thickener. The overflow from the thickener is sent to a series of carbon adsorption columns, while the underflow goes through a series of agitated leach tanks.

After leaching, the slurry is fed to the CIP circuit, which consists of a series of tanks with high efficiency agitators. Carbon is moved countercurrent to the slurry, which moves by gravity from the first to the last tank. Barren slurry from the last tank of the CIP circuit is sent to the tailings pond. The loaded carbon from the CIP circuit and the carbon columns is sent to the stripping tanks. Pregnant strip solution is sent to the electrowinning circuit, where the electrowinning cells are used to plate gold onto steel wool cathodes. Loaded cathodes are removed, treated with dilute sulfuric acid, and sent to the refining furnace, where a doré is produced for shipment. Stripped carbon is regenerated in a kiln and returned to the circuit.
Cyanidation/extraction: CIL - electrowinning

The Carbon-in-leach (CIL) - electrowinning processes are often used where the ore contains preg-robbing characteristics, such as fine clays or naturally occurring carbon within the ore. This method is also used where short leach times are feasible. If a longer leach time is required, and no preg-robbing characteristics are present in the ore, carbon-in-pulp (CIP) would probably be applied. The key difference between CIL and CIP processing is that in a CIL process, carbon is present while gold is being leached by cyanidation. In the CIP process cyanidation and carbon adsorption of the gold are performed separately.

In the flowchart in Figure 22, mine-run ore is initially crushed with a jaw and cone crusher circuit. Crushed ore is then ground in a semi-autogenous grinding (SAG) mill and sent through cyclones. The oversize is sent to a ball mill, while the undersize is sent to the CIL circuit.

Carbon is added in the CIL circuit, which consists of a series of tanks with high efficiency agitators. Carbon is moved countercurrent to the slurry, which moves by gravity from the first to the last tank. Barren slurry from the last tank of the CIL circuit is sent to the tailings pond. The loaded carbon from the CIL circuit is sent to the stripping tanks. Pregnant strip solution is sent to the electrowinning circuit, where the electrowinning cells are used to plate gold onto steel wool cathodes. Loaded cathodes are removed, treated with dilute sulfuric acid, and sent to the refining furnace, where a dore is produced for shipment. Stripped carbon is regenerated with acid in a kiln and returned to the circuit.

Cyanidation/extraction: CCD-Merrill Crowe

The Countercurrent decantation (CCD) - Merrill Crowe approach to extracting gold from cyanide solution (post-cyanidation) starts with placing the pulp into wide but shallow tanks called thickeners. When pulp is being slowly poured into the tank, all hard particles sink to the bottom, while purified gold-laden solution is collected in the launder around the tank’s perimeter. Although most of the gold is contained in the solution, there is still some amount in the hard particiles separated in the thickener. The second stage of the CCD - Merrill Crowe method involves filtering this material to recover the rest of gold.

Filtering is done by pouring the pulp from the bottom of the thickener into a steel tank that also contains a large porous rotating drum in it. Once a vacuum is applied to the system, hard particles stick to the rapidly revolving drum while cyanide solution is sucked out. Spraying some water on the top of the drum helps to wash out the remnants of the cyanide solution from the pulp.

At this point, all gold is contained in two solutions collected during either thickening or filtering stage. These two solutions are combined in a tank, to which zinc powder is also added. When zinc (which has a higher affinity for the cyanide ion than gold) is introduced to the solution, a gold precipitate of a dark color is formed. If present, silver and copper will also precipitate. The mixture is then pumped through layers of canvas sheets to separate solids from the liquid. The solids containing gold, zinc, and sometimes other elements will be further processed in the refining stage to obtain nearly pure gold.

The vat leach-countercurrent decantation (CCD)-Merrill Crowe process is most often used for processing gold ores with high silver content relative to the gold.
In Figure 23, ore is initially crushed with a jaw, then a cone crusher. Crushed ore is then ground in a ball mill and sent through cyclones. The oversize is returned to the ball mill, while the undersize is sent to a grinding thickener. The overflow from the thickener is also returned to the ball mill, while the underflow goes through a series of agitated leach tanks, where cyanide is added to the slurry.

After leaching, the slurry is fed to the CCD circuit, which consists of a series of thickener tanks. The pregnant solution overflows from the first tank to the pregnant solution tank. Barren solution is added to the last tank and flows countercurrent to the solids. The underflow solids from the last tank of the CCD circuit are sent to the tailings pond. The pregnant solution is pumped through clarifying filters and the solution sent to a clarified solution tank. The clarified solution is then deoxygenated in a vacuum tower and pumped to the precipitate filters. Barren solution from the filters is pumped to the last tank in the CCD circuit. The precipitate is sent to the refining furnace, where a doré is produced for Cyanidation/extraction: heap leaching

Typical deposits where heap leaching is used are low-grade gold and silver oxide deposits as it is relatively quite low cost vs. milling. The flowchart in Figure 24 describes the typical processing of gold bearing ore via heap leaching. A variation of heap leaching, known as dump leaching, involves placing ore on the leach pad without prior crushing. As compared to milling methods, heap and dump leaching tend to have greatly extended ramp-up times as the cyanides solution slowly percolate the ore, and lower recoveries.

In Figure 24, mine-run ore is crushed in a jaw and cone crushe in series, screened, and stored in a fine ore bin. Trucks haul the ore to the heap leach pads, where bulldozers are occasionally used to contour or level the pile. A cyanide leach solution is sprayed on the leach pads, which percolates through the ore and is collected in a pregnant solution pond. Leached ore is washed and then moved to waste dumps. The pregnant solution is pumped to a series of carbon adsorption columns. Barren solution from the columns is returned to the leach pads. The loaded carbon is sent to stripping tanks. Pregnant strip solution from the tanks is sent to the electrowinning cells, where the gold is plated onto steel wool cathodes. Loaded cathodes are removed, treated with dilute sulfuric acid and sent to the refining furnace, where a doré is produced for shipment. Stripped carbon is regenerated in a kiln and returned to the circuit. An alternative would be to use the CCD - Merrill Crowe process to extract gold from the pregnant solution.

Processing of refractory ore material

Refractory gold ore is simply ore that is resistant to being recovered using standard cyanidation. Methods of pre-treating such ore have been developed to render it amenable to cyanidation. Table 14 shows several types of refractory ore and the processes that can be used in order to pre-treat the ore such that cyanidation can be performed.

### Table 14: Types of refractory gold ore and pre-cyanidation treatment options

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Problem</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrrhotite</td>
<td>Lower recovery with higher reagent use</td>
<td>Pre-aeration</td>
</tr>
<tr>
<td>Arsenopyrite and Pyrite</td>
<td>Gold too fine to liberate by grinding</td>
<td>Pressure Oxidation and Roasting</td>
</tr>
<tr>
<td>Carbonaceous Ore</td>
<td>Preg. robbing (gold associated with or absorbed by carbon in ore</td>
<td>Blanking, CIL, and Roasting</td>
</tr>
<tr>
<td>Tellurides</td>
<td>Gold present as a component of a telluride compound</td>
<td>Roasting</td>
</tr>
<tr>
<td>Occluded</td>
<td>Fine gold with host rock (silica)</td>
<td>Fine Grinding</td>
</tr>
</tbody>
</table>

Source: BofA Merrill Lynch Global Research
Pre-aeration (ore washing)
Aeration or washing of ore (notably those that are partially sulphidized) prior to cyanidation, will cause the sulphides to oxidize. An example of this is copper sulphide, which is preg-robbing curing cyanidation, but can be oxidized to form a copper oxide that will cause much less interference during cyanidation. Pyrrhotite is another sulphide that can disrupt cyanidation when present during the process.

Pressure oxidation (POX)
Pressure oxidation is often used to treat arsenopyrite and pyrite ores where gold particles are too fine to liberate through grinding. Autoclaves treat the ore by pressure oxidation, by subjecting ore to elevated temperatures and pressures in an oxygen-rich aqueous environment. This process removes sulphur from the ore making it amenable to cyanidation. Key parameters impacting the effectiveness of pressure oxidation are fineness of grinding, pressure, temperature, density, pH of the slurry and total retention time. Roasting can also be used to treat arsenopyrite and pyrite ores but pressure oxidation may be preferred when treating the whole ore (ore that is not previously concentrated) as gas emission treatment is reduced. Autoclaves represent the most expensive type of leaching related processing with large units costs hundreds of millions of dollars each.

Figure 25 shows a standard autoclave flowchart where ore from the thickener is sent to the autoclave circuit. The thickened slurry is sent to a surge tank, and through a series of splash heating towers. It is then sent to the autoclaves. From the autoclaves, the slurry goes to flash cooling towers, a surge tank, cooling vessels, and on to the CIL circuit where the ore is processed as described earlier.

Roasting
Roasting can be used to treat arsenopyrite and pyrite ores, carbonaceous ores (those with free carbon compounds that are preg-robbing), and tellurides (a rarer naturally occurring gold compound often in the form of calaverite or sylvanite).

With arsenopyrite and pyrite ores, pressure oxidation presents an often more economic alternate while a standard CIL circuit or blanking (using kerosene to coat carbon) can also be used to treat carbonaceous ores. In the case of tellurides, roasting is the pre-eminent alternative. In roasting, the sulphur, sulphides (arsenic, antimony, lead, etc), and/or carbon is burned off, with the process ultimately emitting these unwanted materials as gas.

The flowchart in Figure 26 depicts modifications to a standard gold processing flowchart to incorporate a roaster. Floatation concentrate is thickened and dried in a disk filter. This dried sulfide concentrate is then delivered to the fluid-bed roaster. The resulting sulfide matte is then sent to a carbon column circuit, from
which the loaded carbon is sent to stripping tanks and the standard process is used to create gold doré. Note that flotation is required in the roaster flowchart while it is not in the pressure oxidation flowchart.

**Fine grinding**

This method will sometimes achieve liberation of gold particles but will at other times not as gold may be too fine to release it from the host mineral. This method also suffers from high energy costs which rise dramatically the finer the grind (Chart 29).

**Other methods: bio-oxidation**

Bio-oxidation is a process that uses bacteria microbes to breakdown sulphide minerals in refractory ores, leaving them more amenable to cyanidation. This has the advantage of being relatively inexpensive as the bacteria self replicate as they feed from the ore. The disadvantage of this method is that the bacteria, which are sensitive to environment parameters such as temperature and pH, can die easily. The re-inoculation period can then require several months.

**Tailings ponds**

Tailings ponds are required for most milling facilities. For the mill cost models, the cost of a tailings pond is required for all models except heap leach and solvent extraction-electrowinning. The size of tailings ponds and their containment dams varies widely from one operation to another. This variability is dependent to a great extent on topography. For this reason, it is usually advisable to determine the specific areal requirements for tailings ponds for each individual project as it is evaluated.

In instances where this is not feasible, the following rough guidelines may be followed: for a 5-yr mine life; 17 acres per 1,000 st/d mill capacity, for a 10-yr mine life; 32 acres per 1,000 st/d mill capacity, and for a 20-yr mine life; 62 acres per 1,000 st/d capacity. It should be emphasized that these are guidelines to be followed only in the absence of specific data. It is much more accurate to study the topography of the area, choose the pond site, calculate the total tonnage and volume to be contained, and calculate the area requirements and amount of impoundment dam required for the site.
Section 12: Gold producer fundamentals

Global market capitalization

The total market capitalization of the global gold sector is just under $300 billion. Barrick is the world’s largest precious metals producer by market capitalization, followed by Goldcorp. Both are Canadian based and trade predominantly on the Toronto Stock Exchange and the New York Stock Exchange. Among the top 10 (excluding platinum and palladium producers) are four Canadian based gold producers, two silver companies (one producer and one silver streaming company), one South African gold producer, one US based gold producer, one Australian gold producer and one Russia based gold producers. Below is a chart of the market capitalizations of all the precious metals companies covered by BoA Merrill Lynch, ranked by market capitalization as of the date of this report.

Table 15: Global precious metal market capitalization (for companies under coverage)

<table>
<thead>
<tr>
<th>Company name</th>
<th>Mkt Cap (US$ mn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrick Gold</td>
<td>28,939</td>
</tr>
<tr>
<td>Goldcorp</td>
<td>26,471</td>
</tr>
<tr>
<td>Newmont Mining</td>
<td>19,468</td>
</tr>
<tr>
<td>Newcrest Mining</td>
<td>17,281</td>
</tr>
<tr>
<td>Yamana Gold</td>
<td>10,742</td>
</tr>
<tr>
<td>Polyus Gold</td>
<td>9,625</td>
</tr>
<tr>
<td>AngloGold Ashanti</td>
<td>9,409</td>
</tr>
<tr>
<td>Kinross Gold</td>
<td>9,029</td>
</tr>
<tr>
<td>Randgold Resources</td>
<td>7,450</td>
</tr>
<tr>
<td>Zijn Mining Group</td>
<td>7,339</td>
</tr>
</tbody>
</table>

Source: Bloomberg, BoA Merrill Lynch Global Research

Chart 30: Global precious metal company market capitalizations

Source: Bloomberg, Company reports, BoA Merrill Lynch Global Research
Gold output - 2012

Barrick leads the gold industry in output producing 7.4 million oz in 2012. Newmont was the next largest producer globally in 2012 at 4.98 million oz. Among the top 10 producers globally four are Canadian based, three South African, one Australian, one Russian, and one based in the United States. The top 10 global primary gold producers yielded 30 million ounces of gold output in 2012, accounting for around 35% of total global gold output that year. The global gold sector is highly fragmented with over 100 publicly traded gold producers around the world.

Table 16: Top 10 global gold producers

<table>
<thead>
<tr>
<th>Company name</th>
<th>Gold output (koz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrick Gold</td>
<td>7,410</td>
</tr>
<tr>
<td>Newmont Mining</td>
<td>4,977</td>
</tr>
<tr>
<td>AngloGold Ashanti</td>
<td>3,950</td>
</tr>
<tr>
<td>Kinross Gold</td>
<td>2,649</td>
</tr>
<tr>
<td>Goldcorp</td>
<td>2,396</td>
</tr>
<tr>
<td>Newcrest Mining</td>
<td>2,286</td>
</tr>
<tr>
<td>Gold Fields</td>
<td>2,124</td>
</tr>
<tr>
<td>Polys Gold</td>
<td>1,675</td>
</tr>
<tr>
<td>Harmony Gold</td>
<td>1,275</td>
</tr>
<tr>
<td>Yamana Gold</td>
<td>1,201</td>
</tr>
</tbody>
</table>

Source: Company reports

Chart 31: Gold producer gold output for 2012

Source: Bloomberg, BofA Merrill Lynch Global Research
In our coverage universe, Koza Gold had the lowest gold cash costs in 2012. Although we point out that this cash cost is presented net of byproduct credits (silver in this case) while the majority of the other names are represented on a coproduct basis. Although, Koza also uses a hub processing approach which helps to minimize costs. Zhaojin Mining, the gold producer with the second lowest cash costs in 2012 benefitted from a byproduct as well. The gold producer under coverage with the highest cash costs in 2012 was DRD Gold.

**Table 17: Top 10 low-cost gold producers globally**

<table>
<thead>
<tr>
<th>Company name</th>
<th>Cash costs (US$/oz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koza Gold</td>
<td>375</td>
</tr>
<tr>
<td>Zhaojin Mining Industry</td>
<td>406</td>
</tr>
<tr>
<td>Yamana Gold</td>
<td>525</td>
</tr>
<tr>
<td>Eldorado Gold</td>
<td>558</td>
</tr>
<tr>
<td>Regis Resources</td>
<td>583</td>
</tr>
<tr>
<td>Barrick Gold</td>
<td>584</td>
</tr>
<tr>
<td>Newcrest Mining</td>
<td>618</td>
</tr>
<tr>
<td>Randgold Resources</td>
<td>649</td>
</tr>
<tr>
<td>Goldcorp</td>
<td>650</td>
</tr>
<tr>
<td>Centerra Gold</td>
<td>663</td>
</tr>
</tbody>
</table>

Source: Company reports

**Chart 32: 2012 global gold producer gold cash costs (US$/oz)**

Source: BofA Merrill Lynch Global Research
Gold reserves - Year-end 2012

Based on year 2012 reserve updates, Barrick has the largest gold reserves of all gold producers globally with 140 million oz. Newmont follows well behind with 99 million total reserve ounces of gold then Russia’s Polyus Gold with 91 million oz.

For Barrick and Newmont, gold reserves are concentrated across several continents including North America, South America, Australia and Africa, while Polyus Gold’s gold reserves are concentrated in Russia.

Table 18: Top 10 gold reserves globally

<table>
<thead>
<tr>
<th>Company</th>
<th>YE 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrick Gold</td>
<td>140</td>
</tr>
<tr>
<td>Newmont Mining</td>
<td>99</td>
</tr>
<tr>
<td>Polyus Gold</td>
<td>91</td>
</tr>
<tr>
<td>Newcrest Mining</td>
<td>79</td>
</tr>
<tr>
<td>Gold Fields</td>
<td>78</td>
</tr>
<tr>
<td>AngloGold Ashanti</td>
<td>76</td>
</tr>
<tr>
<td>Goldcorp</td>
<td>67</td>
</tr>
<tr>
<td>Kenross Gold</td>
<td>60</td>
</tr>
<tr>
<td>Harmony Gold</td>
<td>42</td>
</tr>
<tr>
<td>Eldorado Gold</td>
<td>25</td>
</tr>
</tbody>
</table>

Source: Company reports

Chart 33: Gold reserves for global gold producers under coverage

Source: Company reports
Not surprisingly, Barrick has the largest gold resources of all gold producers globally. While Newmont was the second largest in terms of gold reserves, it is seventh largest in terms of gold resources (likely a function of having to be more conservative when publishing its year-end resource position). Also, this is a reflection of the South African companies having enormous gold resources at great depths at their respective mines in South Africa, where the costs of drilling associated with upgrading these to reserves is very cost prohibitive.
Industry cost trend

After flat to down industry cash costs from 1988-2001, the year 2002 saw the beginning of a now 11-year run of increasing gold industry cash costs, driven by higher gold prices that allowed miners to extract gold from increasingly lower grade ores. In addition, overall commodity price increases led to accelerated increases for many of the inputs required for mining gold, such as oil and steel. Massive shortages of skilled labor also emerged as a strong inflationary force on gold industry cash costs.

Table 20: Gold industry cash cost trend

<table>
<thead>
<tr>
<th>(US$/oz)</th>
<th>2010A</th>
<th>2011A</th>
<th>2012A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash Costs</td>
<td>462</td>
<td>550</td>
<td>600</td>
</tr>
<tr>
<td>Depreciation</td>
<td>164</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>G&amp;A, exploration, taxes</td>
<td>250</td>
<td>325</td>
<td>375</td>
</tr>
<tr>
<td>Total</td>
<td>876</td>
<td>1,025</td>
<td>1,125</td>
</tr>
<tr>
<td>Realized Gold Price</td>
<td>1,669</td>
<td>1,669</td>
<td>1,669</td>
</tr>
</tbody>
</table>

Source: Company reports, BofA Merrill Lynch Global Research

All-in cash costs

A more realistic methodology to portray costs

Working with the World Gold Council, key global gold producers have begun adopting an “all-in sustaining cash cost” measure that the industry believes more fully defines the total costs associated with producing gold. All-in sustaining cash costs include byproduct cash costs, sustaining capital, general & administrative expenses and exploration expense. This new measure seeks to reflect the full cost of gold production from current operations. This methodology has been already adopted by Goldcorp and Yamana. In 2008, Gold Fields introduced the Notional Cash Expenditure (NCE) margin to better reflect all-in-cash costs.

On pages 76-78 we show the 2010-2012 World Gold Council view of all-in-sustaining cash costs. The new measure excludes several key cost items including interest expense, cash taxes (the latter generated by operating mines), and growth capex (some of which is actually capital spent to expand processing capacity to offset declining grades). On pages 79-81 we show the BofAML all-in-cash cost (including interest expense, cash taxes and growth capital spending).
Chart 36: All-in sustaining cash costs for 2010-2012 based on World Gold Council industry definition

Source: BofA Merrill Lynch Global Research, Company reports
Chart 37: All-in sustaining cash costs for 2010 based on World Gold Council industry definition

Average spot gold price for 2010: $1,227/oz

Source: BofA Merrill Lynch Global Research, Company reports

Chart 38: All-in sustaining cash costs for 2011 based on World Gold Council industry definition

Average spot gold price for 2011: $1,573/oz

Source: BofA Merrill Lynch Global Research, Company reports
Chart 39: All-in sustaining cash costs for 2012 based on World Gold Council industry definition

Average spot gold price for 2012: $1,669/oz

Source: BofA Merrill Lynch Global Research, Company reports
Chart 40: All-in cash costs for 2010-2012 based on BofA Merrill Lynch definition of all-in cash costs (including interest expense, cash taxes and growth capex)

Source: BofA Merrill Lynch Global Research, Company reports
Chart 41: All-in cash costs for 2010 based on BofA Merrill Lynch definition (including interest expense, cash taxes and growth capex)

Average spot gold price for 2010: $1,227/oz

Source: BofA Merrill Lynch Global Research, Company reports

Chart 42: All-in cash costs for 2011 based on BofA Merrill Lynch definition (including interest expense, cash taxes and growth capex)

Average spot gold price for 2011: $1,573/oz

Source: BofA Merrill Lynch Global Research, Company reports
Chart 43: All-in cash costs for 2012 based on BofA Merrill Lynch definition (including interest expense, cash taxes and growth capex)

Average spot gold price for 2012: $1,669/oz

Source: BofA Merrill Lynch Global Research, Company reports
Section 13: 2012 global gold M&A

2012 global gold M&A driven by junior miners

Due to the global gold industry’s insatiable appetite to add new reserves and resources, activity in the global gold M&A arena remained buoyant in 2012. On a global basis, there were a record 61 gold transactions above $20 million in size during 2012, including 29 for companies, 9 for mines and 23 for development projects. This compared to 51 gold acquisitions in 2011 for 25 companies, 10 mines and 16 development projects. Reflecting the lack of mega deals, the total value of all transactions in 2012 was $13.7 billion, similar to $13.6 billion in 2011, but well below the record $29.0 billion of acquisitions in 2010.

Common themes in the 2012 transactions

- **And the meek shall inherit the sector.** Global gold M&A activity in 2012 was dominated by junior/intermediate gold companies acting as the acquirer for virtually every company transaction.

- **Focus on companies with development assets.** Interestingly, less than 25% of the company targets had assets in production, no doubt reflecting the relative expensive of operating assets.

- **What happened to the global senior producers?** The global senior gold producers were involved in just 5% of the acquisitions announced in 2012. We attribute this to the fact that the average reserve per asset acquired was just 1.39 million ounces of gold, too small to make an impact on a senior.

- **Rationalizing non core assets.** In order to reduce cash costs and/or streamline asset bases, Kinross sold its stake in the Serra Grande mine, IAMGOLD disposed of its Quimsacocha project in Ecuador, AuRico sold its high cost Australian mines and its El Cubo and Ocampo mines in Mexico, and Newmont Mining announced the planned disposal of Hope Bay. In South Africa, Harmony sold its Evander mine which was considered noncore and DRD Gold sold its high cost Blyvoor mine.

- **Bolt-on deals becoming more prevalent.** We define bolt-on deals as smaller transactions that are strategically logical moves from the buyer’s point of view. Examples included Yamana purchasing Extorre Gold (Yamana has a substantial presence in Argentina), IAMGOLD buying Trelawney (IAMGOLD has operations in eastern Canada), and Pan American Silver purchasing Minefinders (which augments Pan American’s Mexican asset base).

- **Cash over shares.** In 2012, cash payments of $7.6 billion comprised 55% of the total transaction value (with stock at $6.1 billion and 45%). Pure cash transactions accounted for 52% of the aggregate transactions in 2012, with the balance being stock (31%) and cash and stock (17%) deals.

- **Friendly transactions becoming the norm.** The vast majority of the company transactions announced in 2012 were considered friendly.

- **Absolute company transaction prices at 15 year highs.** Due to a 6.6% increase in the yoy average gold price ($1,669 in 2012 vs. $1,573/oz a year ago), the average transaction price for companies rose by 21.6% from $1,016/oz in 2011 to $1,235/oz during 2012, the highest annual average price in the 15 years we have been compiling this survey.
■ **But transaction discounts versus the gold price remain depressed.** For 2012, we have calculated that company, mine and development project transactions were priced at discounts of 26%, 38% and 33% to the prevailing gold price at time of announcement, respectively. Acquisition discounts (based on a discount to gold price at the time of the transaction) in 2012 were at near record lows over the 15-year history of the survey.

■ **Potentially the start of the exit from South Africa for the majors.** Late in 2012, Gold Fields announced the unbundling (and separate listing) of its South African legacy assets. Successful implementation of the transaction is likely to lead to other companies exploring similar routes.

**Geographic breakdown of 2012 transactions**

Chart 44 shows the corporate buyers based on where they are domiciled. By far the most aggressive country/region for buying assets was Canada (acting as buyers for 35% of all transactions in 2012). We attribute this to Canadian companies generally trading at premium valuation multiples to other global regions, ease of capital raising in Canada and the significant amount of gold mining companies domiciled in Canada.

![Chart 44: 2012 buyers by region – Canadian companies leading the charge as acquirers](source)

Perhaps a function of low valuations and a safe geopolitical environment, Australia was the country/region that was most coveted by buyers of gold assets. Chart 45 shows the location (country or region) of the underlying target assets.

![Chart 45: 2012 take-over targets by region – Australian assets most coveted](source)
### Table 21: Global gold M&A transactions in 2012

<table>
<thead>
<tr>
<th>Company transactions</th>
<th>Acquirer</th>
<th>Target</th>
<th>Asset location</th>
<th>Payment type</th>
<th>Deal value (US$M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>23-Jan-12</td>
<td>Pan American Silver</td>
<td>Minefinders</td>
<td>Mexico</td>
<td>Cash or stock</td>
<td>1,500</td>
</tr>
<tr>
<td>1-Feb-12</td>
<td>Ergin Mining</td>
<td>Gold-Ore Resources</td>
<td>Sweden</td>
<td>Stock</td>
<td>110</td>
</tr>
<tr>
<td>7-Feb-12</td>
<td>Eurasian Minerals</td>
<td>Bilion Monarch Mining</td>
<td>USA</td>
<td>Cash and stock</td>
<td>46</td>
</tr>
<tr>
<td>9-Mar-12</td>
<td>Shandong Gold Mining</td>
<td>Zhongbao Mining</td>
<td>China</td>
<td>Cash</td>
<td>115</td>
</tr>
<tr>
<td>23-Mar-12</td>
<td>Zhaojin Mining</td>
<td>Jin Han Jun Mining</td>
<td>China</td>
<td>Stock</td>
<td>56</td>
</tr>
<tr>
<td>3-Apr-12</td>
<td>Zijin Mining Group</td>
<td>Norton Gold Fields</td>
<td>Australia</td>
<td>Cash</td>
<td>186</td>
</tr>
<tr>
<td>16-Apr-12</td>
<td>LionGold Corp</td>
<td>Castlemaine Goldfields</td>
<td>Australia</td>
<td>Stock</td>
<td>29</td>
</tr>
<tr>
<td>27-Apr-12</td>
<td>IAMGOLD</td>
<td>Treilawney Mining and Exploration</td>
<td>Canada</td>
<td>Cash</td>
<td>607</td>
</tr>
<tr>
<td>14-May-12</td>
<td>Metals X</td>
<td>Westgold Resources</td>
<td>Australia</td>
<td>Stock</td>
<td>63</td>
</tr>
<tr>
<td>18-Jun-12</td>
<td>Yamana Gold</td>
<td>Exotore</td>
<td>Argentina</td>
<td>Cash and stock</td>
<td>438</td>
</tr>
<tr>
<td>29-Jun-12</td>
<td>St Barbara</td>
<td>Allied Gold Mining</td>
<td>PNG/ Solomon Islands</td>
<td>Cash and stock</td>
<td>559</td>
</tr>
<tr>
<td>5-Jul-12</td>
<td>Lupaka Gold</td>
<td>Andean American(2)</td>
<td>Peru</td>
<td>Stock</td>
<td>31</td>
</tr>
<tr>
<td>10-Jul-12</td>
<td>Sovereign Gold</td>
<td>Previous Metal Resources</td>
<td>Australia</td>
<td>Stock</td>
<td>22</td>
</tr>
<tr>
<td>13-Jul-12</td>
<td>Weather Investments II</td>
<td>La Mandia Resources</td>
<td>Australia</td>
<td>Cash</td>
<td>490</td>
</tr>
<tr>
<td>18-Jul-12</td>
<td>Nord Gold</td>
<td>High River Gold Mines</td>
<td>Russia</td>
<td>Cash or stock</td>
<td>290</td>
</tr>
<tr>
<td>8-Aug-12</td>
<td>Silver Lake Resources</td>
<td>Integra Mining</td>
<td>Australia</td>
<td>Stock</td>
<td>447</td>
</tr>
<tr>
<td>8-Aug-12</td>
<td>Endeavour Mining</td>
<td>Avion Gold</td>
<td>Mal</td>
<td>Stock</td>
<td>389</td>
</tr>
<tr>
<td>27-Aug-12</td>
<td>Western Mining Group</td>
<td>Inter-Clic Minerals</td>
<td>China</td>
<td>Cash</td>
<td>252</td>
</tr>
<tr>
<td>19-Sep-12</td>
<td>BZ Gold</td>
<td>CGA Mining</td>
<td>Philippines</td>
<td>Stock</td>
<td>1,213</td>
</tr>
<tr>
<td>20-Sep-12</td>
<td>Shandong Gold International</td>
<td>Focus Minerals</td>
<td>Australia</td>
<td>Cash</td>
<td>238</td>
</tr>
<tr>
<td>27-Sep-12</td>
<td>Shandong Zhongrun Property</td>
<td>Noble Mineral Resources</td>
<td>Ghana</td>
<td>Cash</td>
<td>88</td>
</tr>
<tr>
<td>28-Sep-12</td>
<td>Unity Mining</td>
<td>Cortona Resources</td>
<td>Australia</td>
<td>Stock</td>
<td>26</td>
</tr>
<tr>
<td>15-Oct-12</td>
<td>Argonaut Gold</td>
<td>Prodigy</td>
<td>Canada</td>
<td>Stock</td>
<td>348</td>
</tr>
<tr>
<td>18-Oct-12</td>
<td>Riverstone Resources</td>
<td>Blue Gold Mining</td>
<td>Burkina Faso</td>
<td>Stock</td>
<td>28</td>
</tr>
<tr>
<td>8-Nov-12</td>
<td>Hochschild Mining</td>
<td>Andina Minerals</td>
<td>Chile</td>
<td>Cash</td>
<td>103</td>
</tr>
<tr>
<td>12-Nov-12</td>
<td>Osisko Mining</td>
<td>Queenston Mining</td>
<td>Canada</td>
<td>Stock</td>
<td>550</td>
</tr>
<tr>
<td>5-Dec-12</td>
<td>Keegan Resources</td>
<td>PM Gold</td>
<td>Ghana</td>
<td>Stock</td>
<td>340</td>
</tr>
<tr>
<td>13-Dec-12</td>
<td>Primero Mining</td>
<td>Cerro Resources</td>
<td>Mexico</td>
<td>Stock</td>
<td>121</td>
</tr>
<tr>
<td>17-Dec-12</td>
<td>Canaco Resources</td>
<td>Shark Minerals</td>
<td>Sudan</td>
<td>Stock</td>
<td>35</td>
</tr>
</tbody>
</table>

**2012 sub-total** $8,719

### Development transactions

| 3-Jan-12 | Longyu Mining (Guizhou Guanshan) | Sino Prosper assets | China | Cash and debt | 87 |
| 25-Jan-12 | Erlilean National Mining Corp | Zara Gold Project | Erlilea | Cash | 34 |
| 3-Feb-12 | Cliff Gold (now Amara) | Sega Gold Project | Burkina Faso | Cash and stock | 29 |
| 8-Feb-12 | Polymetal International | Veduga gold deposit (Amkan Holding) | Russia | Cash | 20 |
| 23-Mar-12 | Zhaojin Mining | Hou Cang Exploration Right | China | Stock | 39 |
| 28-Mar-12 | Kirkland Lake Gold | South Claims (Kirkland Lake Camp) | Canada | Cash | 60 |
| 10-Apr-12 | Premier Gold Mines | Cove McCoy Property | Canada | Cash | 48 |
| 20-Apr-12 | SAT & Co | Romatyn Mining | Romania | Cash | 20 |
| 25-May-12 | Barrick Gold | MiI Canyon | USA | Cash | 24 |
| 29-May-12 | Valeo Gold | Red Rock/North Battle Mountain | USA | Cash and stock | 27 |
| 30-May-12 | Yamana Gold | American Copper Mining | Mexico | Cash | 22 |
| 1-Jun-12 | Highland Gold | Ken deposit | Russia | Cash | 69 |
| 21-Jun-12 | INV Metals | Quimsacocha | Ecuador | Stock | 30 |
| 6-Jul-12 | China Precious Metal Resources | Sinowise Century Ltd | China | Cash and stock | 312 |
| 23-Jul-12 | African Barrick Gold | Aivina Mining (Kenya) | Kenya | Cash | 21 |
| 9-Aug-12 | Regis Resources | McPhyllings Gold | Australia | Stock | 159 |
| 9-Aug-12 | Royal Gold | Mt. Milian | Canada | Cash | 200 |
| 20-Aug-12 | Franco-Nevada | Cobre Panama | Panama | Cash | 1,000 |
| 9-Oct-12 | Montague International | El Rihon Prohibido | Peru | Cash | 54 |
| 19-Oct-12 | AUX Acquisition 3 (EBX) | California Valley assets (Columbia) | Colombia | Cash | 69 |
| 19-Oct-12 | AUX Acquisition 2 (EBX) | California Valley assets (Columbia) | Colombia | Cash | 304 |
| 5-Dec-12 | Sandstorm Gold | Deflector | Australia | Cash | 38 |
| 12-Dec-12 | Centerra Gold | Oksut | Turkey | Cash | 20 |

**2012 sub-total** $2,688

### Mine transactions

| 2-Mar-12 | Gold One International | Ezulwini Mine | South Africa | Cash | 70 |
| 2-Mar-12 | AngloGold Ashanti | Mine Waste Solutions | South Africa | Cash | 335 |
| 23-Mar-12 | Crocodile Gold | Aussie assets (Stawell/Fosterville) | Australia | Cash | 105 |
| 29-May-12 | AngloGold Ashanti | Crixus (Sierra Grande) - 50% | Brazil | Cash | 220 |
| 30-May-12 | Pan African | Evander Gold Mines | South Africa | Cash | 176 |
| 15-Apr-12 | Endeavour Silver | El Cubo | Mexico | Cash and stock | 200 |
| 8-Jun-12 | Ahtygrou | Kazakhaltyn / Norc Mining | Kazakhstan / Kyrgyz Rep. | Cash | 385 |
| 9-Oct-12 | Minera Frisco | Ocampo / Orion | Mexico | Cash | 750 |
| 18-Oct-12 | Yifufu Gold | Dayu | China | Cash | 24 |

**2012 sub-total** $2,265

### Overall 2012 total deal value

$13,070

Source: BofA Merrill Lynch Global Research, Company reports, Bloomberg
Table 22: Top transactions by year

<table>
<thead>
<tr>
<th>Date</th>
<th>Acquirer / Target</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>RU</td>
<td>Glamis Gold / Rayrock</td>
<td>Company</td>
</tr>
<tr>
<td>1999</td>
<td>Repadre Capital / Golden Knight</td>
<td>Company</td>
</tr>
<tr>
<td>RU</td>
<td>Homestake / Amable</td>
<td>Dev. Proj.</td>
</tr>
<tr>
<td>2000</td>
<td>AngloGold / Morila</td>
<td>Mine</td>
</tr>
<tr>
<td>2002</td>
<td>Glamis Gold / Francisco Gold</td>
<td>Company</td>
</tr>
<tr>
<td>RU</td>
<td>Wheaton River / Luisman</td>
<td>Mine</td>
</tr>
<tr>
<td>2003</td>
<td>Wheaton River / Alumbrera</td>
<td>Mine</td>
</tr>
<tr>
<td>2004</td>
<td>Kinross Gold / Paracatu</td>
<td>Mine</td>
</tr>
<tr>
<td>2005</td>
<td>Barrick Gold / Placer Dome</td>
<td>Company</td>
</tr>
<tr>
<td>RU</td>
<td>Eldorado Gold / Alcan Mining</td>
<td>Company</td>
</tr>
<tr>
<td>2006</td>
<td>Glamis Gold / Western Silver</td>
<td>Company</td>
</tr>
<tr>
<td>RU</td>
<td>Yamana / Viceroy</td>
<td>Company</td>
</tr>
<tr>
<td>RU</td>
<td>Agnico-Eagle / Pinos Altos</td>
<td>Dev. Proj.</td>
</tr>
<tr>
<td>2007</td>
<td>Red Back / Tasiast</td>
<td>Mine</td>
</tr>
<tr>
<td>2008</td>
<td>IAMGOLD / Orezone</td>
<td>Company</td>
</tr>
<tr>
<td>2009</td>
<td>Tie: Franco-Nevada / Palmarejo</td>
<td>Mine</td>
</tr>
<tr>
<td>Tie: Royal Gold / Andacollo</td>
<td>Mine</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>Newcrest/Lihir Gold</td>
<td>Company</td>
</tr>
<tr>
<td>RU</td>
<td>Royal Gold / Mt. Milligan</td>
<td>Dev. Proj.</td>
</tr>
<tr>
<td>2011</td>
<td>Gold Fields / Tarkwa-Damang</td>
<td>Mine</td>
</tr>
<tr>
<td>New Gold-Blackwater</td>
<td>Company</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Regis - McPhillamy's Gold</td>
<td>Dev Proj</td>
</tr>
<tr>
<td>Pan American-Minefinders</td>
<td>Company</td>
<td></td>
</tr>
</tbody>
</table>

Source: BoA Merrill Lynch Global Research, company reports
RU: Runner Up

Top transactions 1998-2012

Table 22 shows what we view as the most successful acquisitions in the global gold sector for the 1998-2012 period. The main criterion for selection is our view of which merger/acquisition added the most benefits to the acquirer (with share price appreciation post the transaction and reserve ounces/share added being the major criteria). In our view, in 2012 the top company transaction was Pan American Silver acquiring Minefinders early in the year, and the top development project was Regis Resources purchasing the McPhillamy's gold project on 9 August 2012. Our database extends only to 1998, so we are missing several world class acquisitions such as Barrick buying Goldstrike in 1986 for less than $100 million.

Key trends for global gold M&A in 2013

- **Asset rationalization expected to continue.** The world senior and mid-tier gold miners likely will continue to rationalize noncore assets and clean up minority interest stakes. For example, in late 2012 Newmont announced plans to dispose of its Hope Bay project, viewed as a noncore asset.

- **Pure gold assets a focus.** The majority of the 2012 transactions were for gold-only assets. This could be because with base metal prices remaining high, hybrid metal assets were likely pricey. Due to the ability to account for multi-metal mines on a byproduct basis (thus lowering the gold per ounce cash cost), we believe companies with copper-gold development projects could be intriguing acquisition opportunities.

- **Politically stable regions more in vogue.** The majority of transactions announced in 2012 were for assets in politically stable regions (or regions for which the acquirers were comfortable operating in).

- **Share transactions for companies likely to continue.** While around half of the 61 transactions in 2012 were cash driven, virtually all of the company mergers were completed using shares (or cash and shares in two cases). Given that rising capital and cash costs are forecast to impact industry free cash flow in 2013, we expect more share backed transactions for companies.

- **Cash flowing assets more attractive than development projects.** While the majority of the 2012 transactions were for development projects and companies with assets not yet in production (just seven were for producing assets), we believe the allure of cash flowing producing assets will grow thanks to the robust gold price environment. In addition, there is no guarantee that development projects will ever move to the production stage.

- **Low cash costs.** Since industry cash costs are forecast to be 10% plus higher in 2013 yoy (due to declining ore grades and higher labor and energy costs), we believe low-cost assets will continue to be viewed as attractive acquisition targets.

- **Mergers of intermediate/junior gold producers to continue.** During 2012, virtually all of the company transactions involved junior/intermediate producers merging to create larger entities with greater liquidity. We expect more junior producers to join to create new mid-tier companies in 2013.

- **Friendly transactions in vogue.** The vast majority of all the transactions announced in 2012 were considered “friendly” in nature, as opposed to being “unsolicited.” We would expect this trend to continue in 2013.
Global gold M&A 2012 in review

We have compiled 61 gold transactions above $20 million in size that occurred during 2012, including 29 for companies, 9 for mines and 23 for development projects. Despite a higher average gold price ($1,669 in 2012 vs. $1,573/oz in 2011), total transactions in 2012 were higher compared to the 51 gold acquisitions in 2011 of 25 companies, 10 mines and 16 development projects. Global gold M&A activity in 2012 was dominated by junior/intermediate gold companies acting as the acquirer for virtually every company transaction. Less than 25% of the company targets had assets in production, no doubt reflecting the relative expensive of in-production assets. Chart 46 and Table 23 show a breakdown of the number and type of transactions for 1998-2012.


<table>
<thead>
<tr>
<th>Year</th>
<th>Company</th>
<th>Mine</th>
<th>Development Project</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>11</td>
<td>4</td>
<td>6</td>
<td>21</td>
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<tr>
<td>1999</td>
<td>2</td>
<td>3</td>
<td>7</td>
<td>12</td>
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<tr>
<td>2000</td>
<td>3</td>
<td>8</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>2001</td>
<td>9</td>
<td>6</td>
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<td>2002</td>
<td>11</td>
<td>7</td>
<td>3</td>
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</tr>
<tr>
<td>2003</td>
<td>9</td>
<td>13</td>
<td>11</td>
<td>33</td>
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<tr>
<td>2004</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>15</td>
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<tr>
<td>2005</td>
<td>9</td>
<td>7</td>
<td>7</td>
<td>23</td>
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<tr>
<td>2006</td>
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<td>2011</td>
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<tr>
<td>2012</td>
<td>29</td>
<td>9</td>
<td>23</td>
<td>61</td>
</tr>
</tbody>
</table>

Source: BoA Merrill Lynch Global Research, Company reports, Bloomberg

Chart 47 shows that the total dollar value of global gold M&A tracked in 2012 was $13.7 billion, versus $13.6 billion in 2011. For 2012, we calculated an average transaction size of $224 million for the 61 deals announced (ranging in size from $20 million to $1.5 billion) versus $267 million for 51 transactions in 2011.


<table>
<thead>
<tr>
<th>Year</th>
<th>Company</th>
<th>Mine</th>
<th>Development Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>335</td>
<td>296</td>
<td>279</td>
</tr>
<tr>
<td>1999</td>
<td>314</td>
<td>377</td>
<td>280</td>
</tr>
<tr>
<td>2000</td>
<td>273</td>
<td>276</td>
<td>242</td>
</tr>
<tr>
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<td>268</td>
<td>256</td>
<td>257</td>
</tr>
<tr>
<td>2002</td>
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<tr>
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<tr>
<td>2004</td>
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<tr>
<td>2007</td>
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<td>711</td>
<td>501</td>
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<td>2008</td>
<td>789</td>
<td>766</td>
<td>781</td>
</tr>
<tr>
<td>2009</td>
<td>712</td>
<td>713</td>
<td>620</td>
</tr>
<tr>
<td>2010</td>
<td>1,132</td>
<td>1,148</td>
<td>748</td>
</tr>
<tr>
<td>2011</td>
<td>1,016</td>
<td>1,076</td>
<td>825</td>
</tr>
<tr>
<td>2012</td>
<td>1,235</td>
<td>1,037</td>
<td>922</td>
</tr>
</tbody>
</table>

Source: BoA Merrill Lynch Global Research, Company reports, Bloomberg

Table 23: Acquisitions by type (1998-2012)

<table>
<thead>
<tr>
<th>Year</th>
<th>Company</th>
<th>Mine</th>
<th>Development Project</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>11</td>
<td>4</td>
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<td>21</td>
</tr>
<tr>
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<td>2</td>
<td>3</td>
<td>7</td>
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</tr>
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<tr>
<td>2002</td>
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<td>7</td>
<td>3</td>
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</tr>
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<td>2003</td>
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<td>2005</td>
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<tr>
<td>2006</td>
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<td>17</td>
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<td>2007</td>
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<td>2010</td>
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<tr>
<td>2011</td>
<td>25</td>
<td>10</td>
<td>16</td>
<td>51</td>
</tr>
<tr>
<td>2012</td>
<td>29</td>
<td>9</td>
<td>23</td>
<td>61</td>
</tr>
</tbody>
</table>

Source: BoA Merrill Lynch Global Research, Company reports, Bloomberg

Table 24: Acquisition prices 1998-2012 (US$/oz)

<table>
<thead>
<tr>
<th>Year</th>
<th>Company</th>
<th>Mine</th>
<th>Development Project</th>
<th>Average Gold Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>335</td>
<td>296</td>
<td>279</td>
<td>294</td>
</tr>
<tr>
<td>1999</td>
<td>314</td>
<td>377</td>
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<td>2000</td>
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<td>276</td>
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<tr>
<td>2001</td>
<td>268</td>
<td>256</td>
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</tr>
<tr>
<td>2002</td>
<td>318</td>
<td>237</td>
<td>215</td>
<td>311</td>
</tr>
<tr>
<td>2003</td>
<td>357</td>
<td>313</td>
<td>328</td>
<td>364</td>
</tr>
<tr>
<td>2004</td>
<td>390</td>
<td>329</td>
<td>305</td>
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<tr>
<td>2005</td>
<td>503</td>
<td>394</td>
<td>388</td>
<td>445</td>
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<td>2006</td>
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<td>513</td>
<td>397</td>
<td>605</td>
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<tr>
<td>2007</td>
<td>766</td>
<td>711</td>
<td>501</td>
<td>697</td>
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<td>2008</td>
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<td>766</td>
<td>781</td>
<td>872</td>
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<td>712</td>
<td>713</td>
<td>620</td>
<td>971</td>
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<tr>
<td>2010</td>
<td>1,132</td>
<td>1,148</td>
<td>748</td>
<td>1,227</td>
</tr>
<tr>
<td>2011</td>
<td>1,016</td>
<td>1,076</td>
<td>825</td>
<td>1,573</td>
</tr>
<tr>
<td>2012</td>
<td>1,235</td>
<td>1,037</td>
<td>922</td>
<td>1,669</td>
</tr>
</tbody>
</table>

Source: BoA Merrill Lynch Global Research, Company reports, Bloomberg
Table 25 shows the measurable transactions and the respective premiums or discounts to the prevailing gold price for all gold transactions announced/completed in 2012 (bold face shows transactions announced in H2’12). Transactions are broken down into total acquisition cost per ounce of recoverable mineable gold reserves, adjusted for working capital, long-term debt and development capital of reserves not yet in production, plus the total cash cost of production. We then calculate the premium/discount to the gold price at the time the transaction was announced.

Table 25: Measurable transactions - premium / discount to the gold price (2012)

<table>
<thead>
<tr>
<th>Date</th>
<th>Acquirer</th>
<th>Target</th>
<th>Reserves acquired (mn oz)</th>
<th>Acq. Price US$/oz</th>
<th>Premium/Discount to Gold/Silver Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company transactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23-Jan-12</td>
<td>Pan American Silver</td>
<td>Minefinders</td>
<td>3.86</td>
<td>1,175</td>
<td>-29%</td>
</tr>
<tr>
<td>1-Feb-12</td>
<td>Elgin Mining</td>
<td>Gold-Ore Resources</td>
<td>0.17</td>
<td>1,590</td>
<td>-9%</td>
</tr>
<tr>
<td>3-Apr-12</td>
<td>Zijin Mining Group</td>
<td>Norton Gold Fields</td>
<td>0.83</td>
<td>1,208</td>
<td>-28%</td>
</tr>
<tr>
<td>16-Apr-12</td>
<td>LionGold Corp</td>
<td>Castlemaine Goldfields</td>
<td>0.04</td>
<td>1,288</td>
<td>-22%</td>
</tr>
<tr>
<td>29-Jun-12</td>
<td>St Barbara</td>
<td>Allied Gold Mining</td>
<td>3.16</td>
<td>1,113</td>
<td>-28%</td>
</tr>
<tr>
<td>13-Jul-12</td>
<td>Weather Investments II</td>
<td>La Mancha Resources</td>
<td>0.93</td>
<td>1,198</td>
<td>-24%</td>
</tr>
<tr>
<td>18-Jul-12</td>
<td>Nord Gold</td>
<td>High River Gold Mines</td>
<td>0.89</td>
<td>906</td>
<td>-43%</td>
</tr>
<tr>
<td>6-Aug-12</td>
<td>Silver Lake Resources</td>
<td>Integra Mining</td>
<td>0.51</td>
<td>1,620</td>
<td>1%</td>
</tr>
<tr>
<td>8-Aug-12</td>
<td>Endeavour Mining</td>
<td>Avion Gold</td>
<td>0.61</td>
<td>1,770</td>
<td>10%</td>
</tr>
<tr>
<td>19-Sep-12</td>
<td>B2 Gold</td>
<td>CGA Mining</td>
<td>3.00</td>
<td>1,203</td>
<td>-32%</td>
</tr>
<tr>
<td>20-Sep-12</td>
<td>Shandong Gold International</td>
<td>Focus Minerals</td>
<td>0.23</td>
<td>2,379</td>
<td>34%</td>
</tr>
<tr>
<td>27-Sep-12</td>
<td>Shandong Zhongrun Property</td>
<td>Noble Mineral Resources</td>
<td>0.32</td>
<td>1,008</td>
<td>-43%</td>
</tr>
<tr>
<td>28-Sep-12</td>
<td>Unity Mining</td>
<td>Cortona Resources</td>
<td>0.23</td>
<td>1,148</td>
<td>-35%</td>
</tr>
<tr>
<td>8-Nov-12</td>
<td>Hochschild Mining</td>
<td>Andina Minerals</td>
<td>6.60</td>
<td>767</td>
<td>-55%</td>
</tr>
<tr>
<td>12-Nov-12</td>
<td>Osisko Mining</td>
<td>Queenston Mining</td>
<td>1.31</td>
<td>947</td>
<td>-45%</td>
</tr>
<tr>
<td>5-Dec-12</td>
<td>Keegan Resources</td>
<td>PMI Gold</td>
<td>2.43</td>
<td>852</td>
<td>-50%</td>
</tr>
<tr>
<td>13-Dec-12</td>
<td>Primero Mining</td>
<td>Cerro Resources</td>
<td>0.68</td>
<td>1,108</td>
<td>-35%</td>
</tr>
<tr>
<td>Average (2012)</td>
<td>1,235</td>
<td></td>
<td></td>
<td></td>
<td>-26%</td>
</tr>
<tr>
<td>Mine transactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-Mar-12</td>
<td>Gold One International</td>
<td>Ezulwini Mine</td>
<td>2.55</td>
<td>1,722</td>
<td>0%</td>
</tr>
<tr>
<td>2-Mar-12</td>
<td>AngloGold Ashanti</td>
<td>Mine Waste Solutions</td>
<td>2.69</td>
<td>738</td>
<td>-57%</td>
</tr>
<tr>
<td>28-Mar-12</td>
<td>Crocodile Gold</td>
<td>Aussie assets (Stawell/Fosterville)</td>
<td>0.47</td>
<td>1,207</td>
<td>-28%</td>
</tr>
<tr>
<td>29-May-12</td>
<td>AngloGold Ashanti</td>
<td>Croxas (Serra Grande) - 50%</td>
<td>0.38</td>
<td>1,412</td>
<td>-11%</td>
</tr>
<tr>
<td>30-May-12</td>
<td>Pan African</td>
<td>Evander Gold Mines</td>
<td>0.62</td>
<td>1,127</td>
<td>-28%</td>
</tr>
<tr>
<td>15-Apr-12</td>
<td>Endeavour Silver</td>
<td>El Cubo</td>
<td>0.67</td>
<td>1,154</td>
<td>-30%</td>
</tr>
<tr>
<td>9-Oct-12</td>
<td>Minera Frisco</td>
<td>Ocampo / Orion</td>
<td>2.31</td>
<td>920</td>
<td>-48%</td>
</tr>
<tr>
<td>Average (2012)</td>
<td>1,037</td>
<td></td>
<td></td>
<td></td>
<td>-38%</td>
</tr>
<tr>
<td>Dev. Proj. transactions</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>25-Jan-12</td>
<td>Eritrean National Mining Corp</td>
<td>Zara Gold Project</td>
<td>0.23</td>
<td>1,134</td>
<td>-32%</td>
</tr>
<tr>
<td>9-Aug-12</td>
<td>Royal Gold</td>
<td>Mt. Milligan</td>
<td>0.75</td>
<td>791</td>
<td>-51%</td>
</tr>
<tr>
<td>20-Aug-12</td>
<td>Franco-Nevada</td>
<td>Cobre Panama</td>
<td>2.27</td>
<td>931</td>
<td>-42%</td>
</tr>
<tr>
<td>5-Dec-12</td>
<td>Sandstorm Gold</td>
<td>Deflector</td>
<td>0.06</td>
<td>1,178</td>
<td>-31%</td>
</tr>
<tr>
<td>Average (2012)</td>
<td>922</td>
<td></td>
<td></td>
<td></td>
<td>-43%</td>
</tr>
<tr>
<td>Overall average (2012)</td>
<td>1,157</td>
<td></td>
<td></td>
<td></td>
<td>-31%</td>
</tr>
</tbody>
</table>

Source: BoA Merrill Lynch Global Research, company reports, Bloomberg

Acquisition prices at substantial discounts to gold in 2012

For 2012, we have calculated that company, mine and development project transactions were priced at discounts to the gold price of 26%, 38% and 43%, respectively. This compared to discounts of 38%, 28% and 47% for companies, mines and development projects in 2011. Acquisition discounts in 2012 were at near record lows over the 15-year history of the survey (Chart 48). The average transaction price for companies rose by 21.6% from $1,016/oz in 2011 to $1,235/oz during 2012, the highest annual average price in 15 years.
Development project acquisition prices rose 11.8% yoy to $922/oz in 2012.

The average price for mine transactions declined by 3.6% from $1,076/oz in 2011 to $1,037/oz in 2012, likely due to the high cost nature of assets purchased.
Reserve-less assets the focus for gold M&A

Just over 54% of the gold M&A transactions in 2012 were for assets with resources only (or no resources at all). This is just below the average for 2007-2010, when resource deals accounted for around 56% of total transactions. Table 27 shows the 2012 resource only acquisitions for all categories.

Table 27: Acquisition targets with no reserves - 2012

<table>
<thead>
<tr>
<th>Date</th>
<th>Acquirer</th>
<th>Target</th>
<th>Deal value (US$M)</th>
<th>Total resource (M oz)</th>
<th>Value/Resource (US$/oz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-Feb-12</td>
<td>Eurasian Minerals</td>
<td>Bullion Monarch Mining</td>
<td>46</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>9-Mar-12</td>
<td>Shandong Gold Mining</td>
<td>Zhongbao Mining</td>
<td>115</td>
<td>0.95</td>
<td>121</td>
</tr>
<tr>
<td>23-Mar-12</td>
<td>Zhaojin Mining</td>
<td>Jin Han Zun Mining</td>
<td>56</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>27-Apr-12</td>
<td>IAMGOLD</td>
<td>Trelawney Mining</td>
<td>607</td>
<td>6.87</td>
<td>88</td>
</tr>
<tr>
<td>14-May-12</td>
<td>Metals X</td>
<td>Westgold Resources</td>
<td>63</td>
<td>3.92</td>
<td>16</td>
</tr>
<tr>
<td>18-Jun-12</td>
<td>Yamana Gold</td>
<td>Extorre</td>
<td>438</td>
<td>2.41</td>
<td>182</td>
</tr>
<tr>
<td>5-Jul-12</td>
<td>Lupaka Gold</td>
<td>Andean American(2)</td>
<td>31</td>
<td>0.82</td>
<td>38</td>
</tr>
<tr>
<td>10-Jul-12</td>
<td>Sovereign Gold</td>
<td>Precious Metal Resources</td>
<td>22</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>27-Aug-12</td>
<td>Western Mining Group</td>
<td>Inter-Citic Minerals</td>
<td>252</td>
<td>4.13</td>
<td>61</td>
</tr>
<tr>
<td>15-Oct-12</td>
<td>Argonaut Gold</td>
<td>Prodigy</td>
<td>348</td>
<td>6.61</td>
<td>53</td>
</tr>
<tr>
<td>18-Oct-12</td>
<td>Riverstone Resources</td>
<td>Blue Gold Mining</td>
<td>28</td>
<td>0.00</td>
<td>NA</td>
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<tr>
<td>17-Dec-12</td>
<td>Canaco Resources</td>
<td>Shark Minerals</td>
<td>35</td>
<td>0.00</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td><strong>Sub-total / average (2012)</strong></td>
<td></td>
<td><strong>2,040</strong></td>
<td><strong>99</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mine transactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-Jun-12</td>
<td>Altyngroup</td>
<td>Kazakhaltyn / Norox Mining</td>
<td>385</td>
<td>0.00</td>
<td>NA</td>
</tr>
<tr>
<td>18-Oct-12</td>
<td>Yinfu Gold</td>
<td>Dayu</td>
<td>24</td>
<td>0.00</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td><strong>Sub-total / average (2012)</strong></td>
<td></td>
<td><strong>409</strong></td>
<td></td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Development transactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-Jan-12</td>
<td>Longyu Mining (Qianxian)</td>
<td>Sino Prosper assets</td>
<td>87</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>3-Feb-12</td>
<td>Cluff Gold (now Amara)</td>
<td>Sega Gold Project</td>
<td>29</td>
<td>0.60</td>
<td>49</td>
</tr>
<tr>
<td>8-Feb-12</td>
<td>Polymetal International</td>
<td>Veduga gold deposit</td>
<td>20</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>23-Mar-12</td>
<td>Zhaojin Mining</td>
<td>Hou Cang Exploration Right</td>
<td>39</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>28-Mar-12</td>
<td>Kirkland Lake Gold</td>
<td>South Claims (Kirkland Lake)</td>
<td>60</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>10-Apr-12</td>
<td>Premier Gold Mines</td>
<td>Cove McCoy Property</td>
<td>48</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>20-Apr-12</td>
<td>SAT &amp; Co</td>
<td>Romalyn Mining</td>
<td>20</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>25-May-12</td>
<td>Barrick Gold</td>
<td>Mill Canyon</td>
<td>24</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>29-May-12</td>
<td>Valor Gold</td>
<td>Red Rock/N. Battle Mountain</td>
<td>27</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>30-May-12</td>
<td>Yamana Gold</td>
<td>American Copper Mining</td>
<td>22</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>1-Jun-12</td>
<td>Highland Gold</td>
<td>Klen deposit</td>
<td>69</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>21-Jun-12</td>
<td>INV Metals</td>
<td>Quimsacocha</td>
<td>30</td>
<td>3.50</td>
<td>9</td>
</tr>
<tr>
<td>6-Jul-12</td>
<td>China Precious Metal Rsr</td>
<td>Sinowise Century Ltd</td>
<td>312</td>
<td>1.68</td>
<td>186</td>
</tr>
<tr>
<td>23-Jul-12</td>
<td>African Barrick Gold</td>
<td>Aviva Mining (Kenya)</td>
<td>21</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>9-Aug-12</td>
<td>Regis Resources</td>
<td>McPhilamys Gold</td>
<td>159</td>
<td>2.50</td>
<td>63</td>
</tr>
<tr>
<td>9-Oct-12</td>
<td>Montague International</td>
<td>El Rihon Prohiboto</td>
<td>54</td>
<td>0.00</td>
<td>NA</td>
</tr>
<tr>
<td>19-Oct-12</td>
<td>AUX Acquisition 3 (EBX)</td>
<td>California Valley assets</td>
<td>69</td>
<td>1.35</td>
<td>51</td>
</tr>
<tr>
<td>19-Oct-12</td>
<td>AUX Acquisition 2 (EBX)</td>
<td>California Valley assets</td>
<td>304</td>
<td>1.09</td>
<td>279</td>
</tr>
<tr>
<td>12-Dec-12</td>
<td>Centerra Gold</td>
<td>Oksut</td>
<td>20</td>
<td>0.57</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td><strong>Sub-total / average (2012)</strong></td>
<td></td>
<td><strong>1,414</strong></td>
<td><strong>162</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Overall total / average</strong></td>
<td></td>
<td><strong>3,862</strong></td>
<td><strong>121</strong></td>
<td></td>
</tr>
</tbody>
</table>

Source: BofA Merrill Lynch Global Research, company reports, Bloomberg
Note: Total resource includes measured and indicated (M&I), and inferred resources. Value/Resource is not adjusted for anticipated recoveries.

We attribute the shift to resource only acquisitions to the record high gold prices pushing buyers away from the more expensive reserve assets (and toward resource only assets). There is no guarantee that resource projects will make it to the mineable stage. Of the 40 plus development projects acquired over the 2010-2012 period, none have made it to commercial production and just five (just over 10%) are currently being developed as operating mines. Due to the current environment of rising operating and capital costs, we would expect that many development projects may well remain mothballed.
The total value of the resource only transactions in 2012 was $3.9 billion, consisting of $2.0 billion for company purchases, $409 million for mine acquisitions and $1.4 billion for development project transactions. The aggregate value for all reserve only transactions in 2012 was $9.8 billion, broken down by $6.7 billion for companies, $1.9 billion for mines and $1.3 billion for projects. Chart 50 shows a breakdown of the number of deals with reserves and without reserves of all transactions in all categories (for 1998-2012).

Chart 50: Percentage of all deals - Reserves vs. Resources (1998-2012)

Of the total, 46% of the gold transactions tracked during 2012 were for companies, mines and development projects with reserves, compared to 33% in 2011, 38% for 2010 and 46% in 2009. We attribute this apparent reversal in trend (back to assets with reserves) to the fact that companies/mines/projects with reserves have become less expensively priced due to gold equities underperforming the gold price for much of 2012.
Section 14: Global gold indices
Below are charts for the various gold equity indices.

Chart 51: Philadelphia Gold Index

Source: BoA Merrill Lynch Global Research, Bloomberg

Chart 52: AMEX Gold Bugs Index

Source: BoA Merrill Lynch Global Research, Bloomberg
Chart 53: S&P/TSX Global Gold Index

Source: BofA Merrill Lynch Global Research, Bloomberg

Chart 54: FT Australasia Gold Index

Source: BofA Merrill Lynch Global Research, Bloomberg

Chart 55: FT Europe-Middle East-Africa Gold Index

Source: BofA Merrill Lynch Global Research, Bloomberg
Section 15: Valuing gold companies

Price to net asset value (P/NAV)

Our primary valuation methodology for our precious metals coverage is discounted cash flow (DCF) (in most cases sum-of-the-parts DCF), as we feel this is the most appropriate way to account for value across the cycle. We use a discount rate of 5% (we model in real terms) across our gold equities in keeping with our global gold coverage. Our long term real gold price forecast stands at $1,400/oz (2019 onward). Our long-term price is based on several factors including:

Three year rolling average gold price

For modeling purposes, we have historically used the three year rolling average gold price to calculate our long term price (which is similar to what the gold industry uses to calculate mineable reserves at year end). Based on our $1,690/oz average price for 2012, the trailing three year average gold price will be $1,496/oz (well above our revised $1,400/oz assumption). For silver, the trailing three year average price will be $28.98/oz, well above our new long term real price of $25.00/sh.

Rising all in-cost structures

For the global gold producers, we estimate an all in-cash cost of around $1,200-$1,400/oz (including sustaining and growth capital). Due to our view that ore grades mined will continue to decline and labor costs keep rising, the cost structure will continue to rise in the future.

Including our short term price forecasts ($1,680/oz for 2013 and $1,810/oz for 2014), our 10 year average gold price stands at $1,600/oz. Looking at Chart 56, the average P/NAV multiples for the North American precious metal companies have ranged between 1 and 3 times asset value.

The South African gold majors have historically traded on an average P/NPV of 1.6x, but we think that this multiple has narrowed somewhat given the increased operational challenges in the country. In the chart below, we look at the P/NPV of the companies under our coverage.
In periods of increased uncertainty, DCFs may seem less valuable, as the focus on valuation generally shifts to the near term. For this reason, we look at a number of other valuation metrics in an attempt to determine the attractiveness of these counters on a near- and longer-term basis.

Chart 57: P/NAV multiples of precious metals companies covered by BofA Merrill Lynch globally

Source: BofA Merrill Lynch Global Research, Bloomberg
Chart 58: Senior gold producers historical PNAV

Source: Bloomberg, BofA Merrill Lynch Global Research estimates

Chart 59: Mid-tier gold producers historical PNAV

Source: Bloomberg, BofA Merrill Lynch Global Research estimates

Chart 60: Intermediate/junior gold producers historical PNAV

Source: Bloomberg, BofA Merrill Lynch Global Research estimates
Price to earnings
Historically, looking at price to earnings ratios (P/E) for gold companies was of little value, as these were often not meaningful (negative or unrealistically high). We believe this still remains the case and prefer price to cash flow as a near-term indicator of relative value. Historically, P/Es have ranged from the 10 times to almost 60 times.
Chart 63: Historical P/E multiple for the Senior and Mid-tier gold producers

Source: Bloomberg, BofA Merrill Lynch

Price to cash flow
The price to cash flow ratio (P/CF) has historically been a preferred alternative to the price to net asset value given its ability capture a similar measure but on a shorter time horizon and with less estimation bias. Historically, P/CF has ranged from 5 times to 30+ times.

Chart 64: Historical P/CF multiple for the Senior and Mid-tier gold producers

Source: Bloomberg, BofA Merrill Lynch
Section 16: Royalties and streams

Royalties

A royalty is the right to receive a percentage of the value of minerals or other products produced or a portion of profit/revenue generated from a mining operation. This right is usually provided in exchange for an upfront payment that is used to fund a project's development but can also originate as part of payment for property interests (as to a prospector or junior mining company), from conversion of a participating interest in a partnership, or as required by statutory laws of an operating jurisdiction (as payment to a government entity).

Royalties are not working interests in a property. Therefore, the royalty holder is generally neither responsible for, nor has an obligation to contribute additional funds for any purpose, including, but not limited to, operating or capital costs, or environmental or reclamation liabilities.

Royalties are a natural hedge against lower gold prices by providing free cash flow from a diversified set of assets with limited or no operating, capital or environmental liability risk, while still retaining upside exposure to further exploration discoveries, reserve expansions and commodity price increases.

Definitions of major royalties

Net Smelter Return (NSR). Based on the gross proceeds paid by a smelter or refinery to the miner. This type of royalty provides cash flow that is free of any operating or capital costs and environmental liabilities.

Net Profit Interest (NPI). A royalty based on the profit after allowing for costs related to production. The expenditures that the operator deducts from revenues are defined in the royalty agreement. NPI payments generally begin after payback of capital costs. The royalty holder is not responsible for providing capital or covering operating losses or environmental liabilities.

Gross Smelter Return (GSR). A defined percentage of the gross revenue from a resource extraction operation (usually oil and gas), with no deduction for any costs paid by or charged to the operator through fixed rate royalties and floors on its sliding-scale royalties.

Net Value Royalty (NVR). A passive interest in a resource extraction operation that is determined on the basis of deducting contract defined processing-related and associated capital costs, but not mining costs.

Overriding royalty. The owner of overriding royalty interests receives a portion of the income from the production of a natural resource (usually oil and gas), and is usually free of any operating, capital and environmental costs.

Advance minimum royalties (AMR). Effectively, rent paid to the royalty holder in lieu of the payment of royalties on production. Once production begins, the payments are often credited against a stream of production royalty payments.

Sliding-scale royalty. A royalty in which the royalty rate increases or decreases as metal prices increase or decrease.

Working interest (often confused as a type of royalty)

Similar to an NPI except working interest holders have an ownership position in the operation and are liable for their share of capital, operating and environmental.
costs usually in proportion to their ownership percentage. Working interests are not considered to be royalties because of their ongoing funding requirements although, for profitable operations, they can be economically similar to NPIs or NPRs.

Limiting considerations in creating a royalty

- Royalty contracts will sometimes limit the payment period to either specific calendar dates or a fixed time period following commencement of production or after reaching a certain production milestone.

- Royalty contracts from time to time will place limits on the payment period to specific production levels. For example, royalty payments may cease following attainment of a cumulative production goal or payments may start at a certain percentage level and decrease or increase over time to a pre-determined level.

- Royalty contracts will sometimes specify payment terms that fluctuate with commodity prices. An example would be increasing or decreasing royalty rates as commodity prices increase, typically on a sliding percentage scale.

Streams

Metal streaming agreements are similar to royalty agreements with several key differences. While metal stream agreements provide an upfront payment in exchange for a share of the value of future metal production:

- The percentage of the value of future metal production is purchased at a cost per unit set-out in the agreement that is normally fixed for the life of the agreement (often with a small escalation for inflation).

- Streaming agreements are structured such that payments are based on the gross value of the metal extracted without adjustments for any costs associated with the extraction process (as these are accounted for in the fixed purchase price per unit set out in the contract).

- Metal streaming agreements in practice have often been applied to byproducts of the mineral extraction process (as opposed to the primary metal); although we know of some exceptions (Silver Wheaton’s silver stream on Pan American’s Navidad project, and some of the gold stream agreements held by Sandstorm Gold).

As a result of the application of many metal stream agreements to byproduct commodities, the percentage of attributable production that is purchased is often much larger than that for royalty agreements (with many stream agreements for 100% of attributable production).
Appendix 1: Glossary of terms
(From the Northern Miner)

A

Acidic precipitation - Snow and rain that have a low pH, caused by sulphur
dioxide and nitric oxide gases from industrial activity released into the
atmosphere.

Acidic rocks - Igneous rock carrying a high (greater than 65%) proportion of silica.

Acidic mine drainage - Acidic run-off water from mine waste dumps and mill tailings
ponds containing sulphide minerals. Also refers to ground water pumped to
surface from mines.

Adit - An opening driven horizontally into the side of a mountain or hill for
providing access to a mineral deposit.

Aerial magnetometer - An instrument used to measure magnetic field strength
from an airplane.

Aeromagnetic survey - A geophysical survey using a magnetometer aboard, or
towed behind, an aircraft.

Agglomerate - A breccia composed largely or entirely of fragments of volcanic rocks.

Agglomeration - A method of concentrating valuable minerals based on their
adhesion properties.

Agitation - In metallurgy, the act or state of being stirred or shaken mechanically,
sometimes accomplished by the introduction of compressed air.

Airborne survey - A survey made from an aircraft to obtain photographs, or
measure magnetic properties, radioactivity, etc.

Alloy - A compound of two or more metals.

Alluvium - Relatively recent deposits of sedimentary material laid down in river
beds, flood plains, lakes, or at the base of mountain slopes. (adj. alluvial)

Alpha meter - An instrument used to measure positively charged particles emitted
by radioactive materials.

Alpha ray - A positively charged particle emitted by certain radioactive materials.

Alteration - Any physical or chemical change in a rock or mineral subsequent to
its formation. Milder and more localized than metamorphism.

Amorphous - A term applied to rocks or minerals that possess no definite crystal
structure or form, such as amorphous carbon.

Amortization - The gradual and systematic writing off of a balance in an account
over an appropriate period.

Amphibolite - A gneiss or schist largely made up of amphibole and plagioclase
minerals.
ANFO - Acronym for ammonium nitrate and fuel oil, a mixture used as a blasting agent in many mines.

Annual report - The formal financial statements and report on operations issued by a corporation to its shareholders after its fiscal year-end.

Anode - A rectangular plate of metal cast in a shape suitable for refining by the electrolytic process.

Anomaly - Any departure from the norm which may indicate the presence of mineralization in the underlying bedrock.

Anthracite - A hard, black coal containing a high percentage of fixed carbon and a low percentage of volatile matter.

Anticline - An arch or fold in layers of rock shaped like the crest of a wave.

Apex - The top or terminal edge of a vein on surface or its nearest point to the surface.

Ash - The inorganic residue remaining after ignition of coal.

Assay - A chemical test performed on a sample of ores or minerals to determine the amount of valuable metals contained.

Assay foot (meter, inch, centimeter) - The assay value multiplied by the number of feet, meters, inches, centimeters across which the sample is taken.

Assay map - Plan view of an area indicating assay values and locations of all samples taken on the property.

Assessment work - The amount of work, specified by mining law, that must be performed each year in order to retain legal control of mining claims.

Authorized capital - see capital stock.

Autogenous grinding - The process of grinding ore in a rotating cylinder using large pieces of the ore instead of conventional steel balls or rods.

B

Back - The ceiling or roof of an underground opening.

Backfill - Waste material used to fill the void created by mining an orebody.

Background - Minor amounts of radioactivity due not to abnormal amounts of radioactive minerals nearby, but to cosmic rays and minor residual radioactivity in the vicinity.

Back sample - Rock chips collected from the roof or back of an underground opening for the purpose of determining grade.

Backwardation - A situation when the cash or spot price of a metal stands at a premium over the price of the metal for delivery at a forward date.

Balance sheet - A formal statement of the financial position of a company on a particular day, normally presented to shareholders once a year.
Ball mill - A steel cylinder filled with steel balls into which crushed ore is fed. The ball mill is rotated, causing the balls to cascade and grind the ore.

Banded iron formation - A bedded deposit of iron minerals.

Basalt - An extrusive volcanic rock composed primarily of plagioclase, pyroxene and some olivine.

Basal till - Unsorted glacial debris at the base of the soil column where it comes into contact with the bedrock below.

Basement rocks - The underlying or older rock mass. Often refers to rocks of Precambrian age which may be covered by younger rocks.

Base camp - Centre of operations from which exploration activity is conducted.

Base metal - Any non-precious metal (eg. copper, lead, zinc, nickel, etc.).

Basic rocks - Igneous rocks that are relatively low in silica and composed mostly of dark-colored minerals.

Batholith - A large mass of igneous rock extending to great depth with its upper portion dome-like in shape. Similar, smaller masses of igneous rocks are known as bosses or plugs.

Bauxite - A rock made up of hydrous aluminum oxides; the most common aluminum ore.

Bear market - Term used to describe market conditions when share prices are declining.

Bedding - The arrangement of sedimentary rocks in layers.

Beneficiate - To concentrate or enrich; often applied to the preparation of iron ore for smelting.

Bentonite - A clay with great ability to absorb water and which swells accordingly.

Bessemer - An iron ore with a very low phosphorus content.

Bio-leaching - A process for recovering metals from low-grade ores by dissolving them in solution, the dissolution being aided by bacterial action.

Biotite - A platy magnesium-iron mica, common in igneous rocks.

Bit - The cutting end of a drill frequently made of an extremely hard material such as industrial diamonds or tungsten carbide.

Blackjack - A miner’s term for sphalerite (zinc sulphide).

Black smoker - Volcanic vent found in areas of active ocean floor spreading, through which sulphide-laden fluids escape.

Blaster - A mine employee responsible for loading, priming and detonating blastholes.

Blast furnace - A reaction vessel in which mixed charges of oxide ores, fluxes and fuels are blown with a continuous blast of hot air and oxygen-enriched air for the chemical reduction of metals to their metallic state.
Blasthole - A drill hole in a mine that is filled with explosives in order to blast loose a quantity of rock.

Blister copper - A crude form of copper (assaying about 99%) produced in a smelter, which requires further refining before being used for industrial purposes.

Block caving - An inexpensive method of mining in which large blocks of ore are undercut, causing the ore to break or cave under its own weight.

Board lot - One hundred shares.

Bond - An agreement to pay a certain amount of interest over a given period of time.

Boom - A telescoping, hydraulically powered steel arm on which drifters, manbaskets and hydraulic hammers are mounted.

Box hole - A short raise or opening driven above a drift for the purpose of drawing ore from a stope, or to permit access.

Break - Loosely used to describe a large-scale regional shear zone or structural fault.

Breast - A working face in a mine, usually restricted to a stope.

Breccia - A rock in which angular fragments are surrounded by a mass of fine-grained minerals.

Broken reserves - The ore in a mine which has been broken by blasting but which has not yet been transported to surface.

Brunton compass - A pocket compass equipped with sights and a reflector, used for sighting lines, measuring dip and carrying out preliminary surveys.

Bulk mining - Any large-scale, mechanized method of mining involving many thousands of tonnes of ore being brought to surface per day.

Bulk sample - A large sample of mineralized rock, frequently hundreds of tonnes, selected in such a manner as to be representative of the potential orebody being sampled. Used to determine metallurgical characteristics.

Bullion - Metal formed into bars or ingots.

Bull market - Term used to describe financial market conditions when share prices are going up.

Bull quartz - A prospector's term for white, coarse-grained, barren quartz.

Byproduct - A secondary metal or mineral product recovered in the milling process.

Cable bolt - A steel cable, capable of withstanding tens of tonnes, cemented into a drillhole to lend support in blocky ground.
Cage - The conveyance used to transport men and equipment between the surface and the mine levels.

Calcine - Name given to concentrate that is ready for smelting (i.e. the sulphur has been driven off by oxidation).

Call - An option to buy shares at a specified price. The opposite of a "put".

Capitalization - A financial term used to describe the value financial markets put on a company. Determined by multiplying the number of outstanding shares of a company by the current stock price.

Capital stock - The total ownership of a limited liability company divided among a specified number of shares.

Captive stope - A stope that is accessible only through a manway.

Carbon-in-pulp - A method of recovering gold and silver from pregnant cyanide solutions by adsorbing the precious metals to granules of activated carbon, which are typically ground up coconut shells.

Cash flow - The net of the inflow and outflow of cash during an accounting period. Does not account for depreciation or bookkeeping write-offs which do not involve an actual cash outlay.

Cathode - A rectangular plate of metal, produced by electrolytic refining, which is melted into commercial shapes such as wirebars, billets, ingots, etc.

Cesium magnetometer - An geophysical instrument which measures magnetic field strength in terms of vertical gradient and total field.

Chalcocite - A sulphide mineral of copper common in the zone of secondary enrichment.

Chalcopyrite - A sulphide mineral of copper and iron; the most important ore mineral of copper.

Change house - The mine building where workers change into work clothes; also known as the "dry".

Channel sample - A sample composed of pieces of vein or mineral deposit that have been cut out of a small trench or channel, usually about 10 cm wide and 2 cm deep.

Charter - A document issued by a governing authority creating a company or other corporation.

Chartered bank - A financial institution that accepts deposits and provides loans.

Chip sample - A method of sampling a rock exposure whereby a regular series of small chips of rock is broken off along a line across the face.

Chromite - The chief ore mineral of chromium.

Chute - An opening, usually constructed of timber and equipped with a gate, through which ore is drawn from a stope into mine cars.
Cinnabar - A vermilion-colored ore mineral of mercury.

Circulating load - Over-sized chunks of ore returned to the head of a closed grinding circuit before going on to the next stage of treatment.

Claim - A portion of land held either by a prospector or a mining company. In Canada, the common size is 1,320 ft. (about 400 m) square, or 40 acres (about 16 ha).

Clarification - Process of clearing dirty water by removing suspended material.

Classifier - A mineral-processing machine which separates minerals according to size and density.

Clay - A fine-grained material composed of hydrous aluminum silicates.

Cleavage - The tendency of a mineral to split along crystallographic planes.

Closed circuit - A loop in the milling process wherein a selected portion of the product of a machine is returned to the head of the machine for finishing to required specification.

Coal - A carbonaceous rock mined for use as a fuel.

Coalification - The metamorphic processes of forming coal.

Collar - The term applied to the timbering or concrete around the mouth of a shaft; also used to describe the top of a mill hole.

Column flotation - A milling process, carried out in a tall cylindrical column, whereby valuable minerals are separated from gangue minerals based on their wetability properties.

Common stock - Shares in a company which have full voting rights which the holders use to control the company in common with each other. There is no fixed or assured dividend as with preferred shares, which have first claim on the distribution of a company's earnings or assets.

Complex ore - An ore containing a number of minerals of economic value. The term often implies that there are metallurgical difficulties in liberating and separating the valuable metals.

Cone crusher - A machine which crushes ore between a gyrating cone or crushing head and an inverted, truncated cone known as a bowl.

Concentrate - A fine, powdery product of the milling process containing a high percentage of valuable metal.

Concentrator - A milling plant that produces a concentrate of the valuable minerals or metals. Further treatment is required to recover the pure metal.

Confirmation - A form delivered by a broker to the client, setting forth the details of stock sales or purchases for the client.

Conglomerate - A sedimentary rock consisting of rounded, water-worn pebbles or boulders cemented into a solid mass.
Contact - A geological term used to describe the line or plane along which two different rock formations meet.

Contact metamorphism - Metamorphism of country rocks adjacent to an intrusion, caused by heat from the intrusion.

Contango - A situation in which the price of a metal for forward or future delivery stands at a premium over the cash or spot price of the metal.

Continuous miner - A piece of mining equipment which produces a continuous flow of ore from the working face.

Controlled blasting - Blasting patterns and sequences designed to achieve a particular objective. Cast blasting, where the muck pile is cast in a particular direction, and deck blasting, where holes are loaded once but blasted in successive blasts days apart, are examples.

Converter - In copper smelting, a furnace used to separate copper metal from matte.

Core - The long cylindrical piece of rock, about an inch in diameter, brought to surface by diamond drilling.

Core barrel - That part of a string of tools in a diamond drill hole in which the core specimen is collected.

Cordillera - The continuous chain of mountain ranges on the western margin of North and South America.

Country rock - Loosely used to describe the general mass of rock adjacent to an orebody. Also known as the host rock.

Crosscut - A horizontal opening driven from a shaft and (or near) right angles to the strike of a vein or other orebody.

Crust - The outermost layer of the Earth; includes both continental and oceanic crust.

Cum-dividend - Buyer entitled to pending dividend payment.

Current assets - Assets of company which can and are likely to be converted into cash within a year. Includes cash, marketable securities, accounts receivable and supplies.

Current liabilities - A company's debts that are payable within a year's time.

Custom smelter - A smelter which processes concentrates from independent mines. Concentrates may be purchased or the smelter may be contracted to do the processing for the independent company.

Cut-and-fill - A method of stoping in which ore is removed in slices, or lifts, and then the excavation is filled with rock or other waste material (backfill), before the subsequent slice is extracted.

Cut value - Applies to assays that have been reduced to some arbitrary maximum to prevent erratic high values from inflating the average.
Cyanidation - A method of extracting exposed gold or silver grains from crushed or ground ore by dissolving it in a weak cyanide solution. May be carried out in tanks inside a mill or in heaps of ore out of doors.

Cyanide - A chemical species containing carbon and nitrogen used to dissolve gold and silver from ore.

D

Day order - An order to buy or sell shares, good only on the day the order was entered.

Debenture - See bonds.

Debt financing - Method of raising capital whereby companies borrow money from a lending institution.

Deck - The area around the shaft collar where men and materials enter the cage to be lowered underground.

Decline - A sloping underground opening for machine access from level to level or from surface; also called a ramp.

Deferred charges - Expenses incurred but not charged against the current year's operation.

Depletion - An accounting device, used primarily in tax computations. It recognizes the consumption of an ore deposit, a mine's principal asset.

Depreciation - The periodic, systematic charging to expense of plant assets reflecting the decline in economic potential of the assets.

Development - Underground work carried out for the purpose of opening up a mineral deposit. Includes shaft sinking, crosscutting, drifting and raising.

Development drilling - drilling to establish accurate estimates of mineral reserves.

Diabase - A common basic igneous rock usually occurring in dykes or sills.

Diamond - The hardest known mineral, composed of pure carbon; low-quality diamonds are used to make bits for diamond drilling in rock.

Diamond drill - A rotary type of rock drill that cuts a core of rock that is recovered in long cylindrical sections, two cm or more in diameter.

Diamond driller - A person who operates a diamond drill.

Dilution (mining) - Rock that is, by necessity, removed along with the ore in the mining process, subsequently lowering the grade of the ore.

Dilution (of shares) - A decrease in the value of a company's shares caused by the issue of treasury shares.

Diorite - An intrusive igneous rock composed chiefly of sodic plagioclase, hornblende, biotite or pyroxene.
Dip - The angle at which a vein, structure or rock bed is inclined from the horizontal as measured at right angles to the strike.

Dip needle - A compass with the needle mounted so as to swing in a vertical plane, used for prospecting to determine the magnetic attraction of rocks.

Directional drilling - A method of drilling involving the use of stabilizers and wedges to direct the orientation of the hole.

Discount - The minimum price below the par value at which treasury shares may legally be sold.

Disseminated ore - Ore carrying small particles of valuable minerals spread more or less uniformly through the host rock.

Dividend - Cash or stock awarded to preferred and common shareholders at the discretion of the company's board of directors.

Dividend claim - Made when a dividend has been paid to the previous holder because stock has not yet been transferred to the name of the new owner.

Dor bar - The final saleable product of a gold mine. Usually consisting of gold and silver.

Drag fold - The result of the plastic deformation of a rock unit where it has been folded or bent back on itself.

Drawpoint - An underground opening at the bottom of a stope through which broken ore from the stope is extracted.

Drift - A horizontal underground opening that follows along the length of a vein or rock formation as opposed to a crosscut which crosses the rock formation.

Drifter - A hydraulic rock drill used to drill small-diameter holes for blasting or for installing rock bolts.

Drill-indicated reserves - The size and quality of a potential orebody as suggested by widely spaced drillholes; more work is required before reserves can be classified as probable or proven.

Dry - A building where the miner changes into working clothes.

Due diligence - The degree of care and caution required before making a decision; loosely, a financial and technical investigation to determine whether an investment is sound.

Dump - A pile of broken rock or ore on surface.

Dyke - A long and relatively thin body of igneous rock that, while in the molten state, intruded a fissure in older rocks.

Electrolysis - An electric current is passed through a solution containing dissolved metals, causing the metals to be deposited onto a cathode.
Electrolytic refining - The process of purifying metal ingots that are suspended as anodes in an electrolytic bath, alternated with refined sheets of the same metal which act as starters or cathodes.

EM survey - A geophysical survey method which measures the electromagnetic properties of rocks.

En echelon - Roughly parallel but staggered structures.

Environmental impact study - A written report, compiled prior to a production decision, that examines the effects proposed mining activities will have on the natural surroundings.

Epigenetic - Orebodies formed by hydrothermal fluids and gases that were introduced into the host rocks from elsewhere, filling cavities in the host rock.

Epithermal deposit - A mineral deposit consisting of veins and replacement bodies, usually in volcanic or sedimentary rocks, containing precious metals or, more rarely, base metals.

Equity financing - The provision of funds by buying shares.

Era - A large division of geologic time - the Precambrian era, for example.

Erosion - The breaking down and subsequent removal of either rock or surface material by wind, rain, wave action, freezing and thawing and other processes.

Erratic - Either a piece of visible gold or a large glacial boulder.

Escrowed shares - Shares deposited in trust pending fulfillment of certain conditions, and not ordinarily available to trading until released.

Ex-dividend - On stocks selling "ex-dividend", the seller retains the right to a pending dividend payment.

Exploration - Prospecting, sampling, mapping, diamond drilling and other work involved in searching for ore.

F

Face - The end of a drift, crosscut or stope in which work is taking place.

Fault - A break in the Earth's crust caused by tectonic forces which have moved the rock on one side with respect to the other.

Feldspar - A group of common rock-forming minerals that includes microcline, orthoclase, plagioclase and others.

Felsic - Term used to describe light-colored rocks containing feldspar, feldspathoids and silica.

Ferrous - Containing iron.

Fine gold - Fineness is the proportion of pure gold or silver in jewelry or bullion expressed in parts per thousand. Thus, 925 fine gold indicates 925 parts out of 1,000, or 92.5% is pure gold.
Fissure - An extensive crack, break or fracture in rocks.

Fixed Assets - Possessions such as buildings, machinery and land which, as opposed to current assets, are unlikely to be converted into cash during the normal business cycle.

Float - Pieces of rock that have been broken off and moved from their original location by natural forces such as frost or glacial action.

Flotation - A milling process in which valuable mineral particles are induced to become attached to bubbles and float as others sink.

Flowsheet - An illustration showing the sequence of operations, step by step, by which ore is treated in a milling, concentration or smelting process.

Flow-through shares - Shares in an exploration company that allow the tax deduction or credits for mineral exploration to be passed to the investor.

Flux - A chemical substance that reacts with gangue minerals to form slags, which are liquid at furnace temperature and low enough in density to float on the molten bath of metal or matte.

Fluxgate magnetometer - An instrument used in geophysics to measure total magnetic field.

Fold - Any bending or wrinkling of rock strata.

Footwall - The rock on the underside of a vein or ore structure.

Forward contract - The sale or purchase of a commodity for delivery at a specified future date.

Fracture - A break in the rock, the opening of which allows mineral-bearing solutions to enter. A "cross-fracture" is a minor break extending at more-or-less right angles to the direction of the principal fractures.

Free milling - Ores of gold or silver from which the precious metals can be recovered by concentrating methods without resorting to pressure leaching or other chemical treatment.

G

Gabbro - A dark, coarse-grained igneous rock.

Galena - Lead sulphide, the most common ore mineral of lead.

Gamma - A unit of measurement of magnetic intensity.

Gangue - The worthless minerals in an ore deposit.

Geiger counter - An instrument used to measure the radioactivity that emanates from certain minerals by means of a Geiger-Mueller tube.

Geochemistry - The study of the chemical properties of rocks.

Geology - The science concerned with the study of the rocks which compose the Earth.
Geophysics - The study of the physical properties of rocks and minerals.

Geophysical survey - A scientific method of prospecting that measures the physical properties of rock formations. Common properties investigated include magnetism, specific gravity, electrical conductivity and radioactivity.

Geothermal - Pertains to the heat of the Earth's interior.

Glacial drift - Sedimentary material that has been transported by glaciers.

Glacial striations - Lines or scratches on a smooth rock surface caused by glacial abrasion.

Glory hole - An open pit from which ore is extracted, especially where broken ore is passed to underground workings before being hoisted.

Gneiss - A layered or banded crystalline metamorphic rock, the grains of which are aligned or elongated into a roughly parallel arrangement.

Gold loan - A form of debt financing whereby a potential gold producer borrows gold from a lending institution, sells the gold on the open market, uses the cash for mine development, then pays back the gold from actual mine production.

Gossan - The rust-colored capping or staining of a mineral deposit, generally formed by the oxidation or alteration of iron sulphides.

Gouge - Fine, putty-like material composed of ground-up rock found along a fault.

Grab sample - A sample from a rock outcrop that is assayed to determine if valuable elements are contained in the rock. A grab sample is not intended to be representative of the deposit, and usually the best-looking material is selected.

Graben - A downfaulted block of rock.

Granite - A coarse-grained intrusive igneous rock consisting of quartz, feldspar and mica.

Gravity meter, gravimeter - An instrument for measuring the gravitational attraction of the earth; gravitational attraction varies with the density of the rocks in the vicinity.

Greenstone belt - An area underlain by metamorphosed volcanic and sedimentary rocks, usually in a continental shield.

Grizzly (or mantle) - A grating, usually constructed of steel rails, placed over the top of a chute or ore pass for the purpose of stopping large pieces of rock or ore that may hang up in the pass.

Gross value - The theoretical value of ore determined simply by applying the assay of metal or metals and the current market price. It must be used only with caution and severe qualification.

Gross value royalty - A share of gross revenue from the sale of minerals from a mine.

Grouting - The process of sealing off a water flow in rocks by forcing a thin slurry of cement or other chemicals into the crevices; usually done through a diamond drill hole.
Grubstake - Finances or supplies of food, etc., furnished to a prospector in return for an interest in any discoveries made.

Guides - The timber rails installed along the walls of a shaft for steadying, or guiding, the cage or conveyance.

Gypsum - A sedimentary rock consisting of hydrated calcium sulphate.

Gyratory crusher - A machine that crushes ore between an eccentrically mounted crushing cone and a fixed crushing throat. Typically has a higher capacity than a jaw crusher.

H

Halite - Rock salt.

Hangingwall - The rock on the upper side of a vein or ore deposit.

Head grade - The average grade of ore fed into a mill.

Heap leaching - A process whereby valuable metals, usually gold and silver, are leached from a heap, or pad, of crushed ore by leaching solutions percolating down through the heap and collected from a sloping, impermeable liner below the pad.

Hedging - Taking a buy or sell position in a futures market opposite to a position held in the cash market to minimize the risk of financial loss from an adverse price change.

Hematite - An oxide of iron, and one of that metal's most common ore minerals.

High grade - Rich ore. As a verb, it refers to selective mining of the best ore in a deposit.

High-grader - One who steals rich ore, especially gold, from a mine.

Hoist - The machine used for raising and lowering the cage or other conveyance in a shaft.

Holding company - A corporation engaged principally in holding a controlling interest in one or more other companies.

Hornfels - A fine-grained contact metamorphic rock.

Horse - A mass of waste rock lying within a vein or orebody.

Horst - An upfaulted block of rock.

Host rock - The rock surrounding an ore deposit.

Hydrometallurgy - The treatment of ore by wet processes, such as leaching, resulting in the solution of a metal and its subsequent recovery.

Hydrothermal - Relating to hot fluids circulating in the earth's crust.
Igneous rocks - Rocks formed by the solidification of molten material from far below the earth's surface.

Ilmenite - An ore mineral of titanium, being an iron-titanium oxide.

Induced polarization - A method of ground geophysical surveying employing an electrical current to determine indications of mineralization.

Industrial minerals - Non-metallic, non-fuel minerals used in the chemical and manufacturing industries. Examples are asbestos, gypsum, salt, graphite, mica, gravel, building stone and talc.

Initial public offering - The first sale of shares to the public, usually by subscription from a group of investment dealers.

Institutional investors - Pension funds and mutual funds, managing money for a large number of individual investors.

Intermediate rock - An igneous rock containing 52% to 66% quartz.

Intrusive - A body of igneous rock formed by the consolidation of magma intruded into other rocks, in contrast to lavas, which are extruded upon the surface.

Ion exchange - An exchange of ions in a crystal with ions in a solution. Used as a method for recovering valuable metals, such as uranium, from solution.

Jaw crusher - A machine in which rock is broken by the action of steel plates.

Jig - A piece of milling equipment used to concentrate ore on a screen submerged in water, either by the reciprocating motion of the screen or by the pulsation of water through it.

Kimberlite - A variety of peridotite; the most common host rock of diamonds.

Lagging - Planks or small timbers placed between steel ribs along the roof of a stope or drift to prevent rocks from falling, rather than to support the main weight of the overlying rocks.

Lamprophyre - An igneous rock, composed of dark minerals, that occurs in dykes; sometimes contains diamonds.

Laterite - A residual soil, usually found in tropical countries, out of which the silica has been leached. May form orebodies of iron, nickel, bauxite and manganese.

Launder - A chute or trough for conveying pulp, water or powdered ore in a mill.

Lava - A general name for the molten rock ejected by volcanoes.

Leachable - Extractable by chemical solvents.
Leaching - A chemical process for the extraction of valuable minerals from ore; also, a natural process by which ground waters dissolve minerals, thus leaving the rock with a smaller proportion of some of the minerals than it contained originally.

Lens - Generally used to describe a body of ore that is thick in the middle and tapers toward the ends.

Lenticular - A deposit having roughly the form of a double convex lens.

Level - The horizontal openings on a working horizon in a mine; it is customary to work mines from a shaft, establishing levels at regular intervals, generally about 50 meters or more apart.

Lignite - A soft, low-rank, brownish-black coal.

Limestone - A bedded, sedimentary deposit consisting chiefly of calcium carbonate.

Limit order - An order made by a client to a broker to buy or sell shares at a specified price or better.

Limonite - A brown, hydrous iron oxide.

Line cutting - Straight clearings through the bush to permit sightings for geophysical and other surveys.

Lode - A mineral deposit in solid rock.

Logging - The process of recording geological observations of drill core either on paper or on computer disk.

London fix - The twice-daily bidding session held by five dealing companies to set the gold price. There are also daily London fixes to set the prices of other precious metals.

London Metals Exchange - A major bidding market for base metals, which operates daily in London.

Long position - Securities owned outright or carried on margin.

Long ton - 2,240 lbs. avoirdupois (compared with a short ton, which is 2,000 lbs.).

M

Mafic - Igneous rocks composed mostly of dark, iron- and magnesium-rich minerals.

Magma - The molten material deep in the Earth from which rocks are formed.

Magmatic segregation - An ore-forming process whereby valuable minerals are concentrated by settling out of a cooling magma.

Magnetic gradient survey - A geophysical survey using a pair of magnetometers a fixed distance apart, to measure the difference in the magnetic field with height above the ground.
Magnetic separation - A process in which a magnetically susceptible mineral is separated from gangue minerals by applying a strong magnetic field; ores of iron are commonly treated in this way.

Magnetic susceptibility - A measure of the degree to which a rock is attracted to a magnet.

Magnetic survey - A geophysical survey that measures the intensity of the Earth's magnetic field.

Magnetite - Black, magnetic iron ore, an iron oxide.

Magnetometer - An instrument used to measure the magnetic attraction of underlying rocks.

Map-staking - A form of claim-staking practiced in some jurisdictions whereby claims are staked by drawing lines around the claim on claim maps at a government office.

Marble - A metamorphic rock derived from the recrystallization of limestone under intense heat and pressure.

Margin - Cash deposited with a broker as partial payment of the purchase price for any type of listed stock. The stock is held by the broker as security for the loan.

Marginal deposit - An orebody of minimal profitability.

Market order - An order to buy or sell at the best price available. In absence of any specified price or limit, an order is considered to be "at the market".

Matte - A product of a smelter, containing metal and some sulphur, which must be refined further to obtain pure metal.

Metallurgical coal - Coal used to make steel.

Metallurgy - The study of extracting metals from their ores.

Metamorphic rocks - Rocks which have undergone a change in texture or composition as the result of heat and/or pressure.

Metamorphism - The process by which the form or structure of rocks is changed by heat and pressure.

Migmatite - Rock consisting of thin, alternating layers of granite and schist.

Mill - A plant in which ore is treated and metals are recovered or prepared for smelting; also a revolving drum used for the grinding of ores in preparation for treatment.

Milling ore - Ore that contains sufficient valuable mineral to be treated by milling process.

Millivolts - A measure of the voltage of an electric current, specifically, one-thousandth of a volt.

Minable reserves - Ore reserves that are known to be extractable using a given mining plan.
Mineral - A naturally occurring homogeneous substance having definite physical properties and chemical composition and, if formed under favorable conditions, a definite crystal form.

Muck - Ore or rock that has been broken by blasting.

Muck sample - A representative piece of ore that is taken from a muck pile and then assayed to determine the grade of the pile.

N

Nanotesla - The international unit for measuring magnetic flux density.

Native metal - A metal occurring in nature in pure form, uncombined with other elements.

Net profit interest - A portion of the profit remaining after all charges, including taxes and bookkeeping charges, such as depreciation, have been deducted.

Net smelter return - A share of the net revenues generated from the sale of metal produced by a mine.

Net worth - The difference between total assets and total liabilities.

Norite - A coarse-grained igneous rock that is host to copper/nickel deposits in the Sudbury area of Ontario.

Nugget - A small mass of precious metal, found free in nature.

O

Odd lot - A block of shares that is less than a board lot.

Open order - An order to buy or sell stock, which is good until cancelled by the client.

Open pit - A mine that is entirely on surface. Also referred to as open-cut or open-cast mine.

Option - An agreement to purchase a property reached between the property vendor and some other party who wishes to explore the property further.

Option (on stock) - The right to buy or sell a share at a set price, regardless of market value.

Ore - A mixture of ore minerals and gangue from which at least one of the metals can be extracted at a profit.

Ore pass - Vertical or inclined passage for the downward transfer of ore connecting a level with the hoisting shaft or a lower level.

Orebody - A natural concentration of valuable material that can be extracted and sold at a profit.

Ore Reserves - The calculated tonnage and grade of mineralization which can be extracted profitably; classified as possible, probable and proven according to the level of confidence that can be placed in the data.
Oreshoot - The portion, or length, of a vein or other structure that carries sufficient valuable minerals to be extracted profitably.

Organic maturation - The process of turning peat into coal.

Orogeny - A period of mountain-building characterized by the folding of a portion of the earth's crust.

Outcrop - An exposure of rock or mineral deposit that can be seen on surface, that is, not covered by soil or water.

Overturned - Where the oldest sedimentary rock beds are lying on top of a younger beds.

Oxidation - A chemical reaction caused by exposure to oxygen that results in a change in the chemical composition of a mineral.

Pan - To wash gravel, sand or crushed rock samples in order to isolate gold or other valuable metals by their higher density.

Participating interest - A company's interest in a mine, which entitles it to a certain percentage of profits in return for putting up an equal percentage of the capital cost of the project.

Par value - The stated face value of a stock. Par value shares have no specified face value, but the total amount of authorized capital is set down in the company's charter.

Patent - The ultimate stage of holding a mineral claim, after which no more assessment work is necessary because all mineral rights have been earned.

Pegmatite - A coarse-grained, igneous rock, generally coarse, but irregular in texture, and similar to a granite in composition; usually occurs in dykes or veins and sometimes contains valuable minerals.

Pellet - A marble-sized ball of iron ore fused with clay for transportation and use in steelmaking.

Pentlandite - Nickel iron sulphide, the most common nickel ore.

Peridotite - An intrusive igneous rock consisting mainly of olivine.

Phaneritic - A term used to describe the coarse-grained texture of some igneous rocks.

Picket line - A reference line, marked by pickets or stakes, established on a property for mapping and survey purposes.

Pig iron - Crude iron from a blast furnace.

Pillar - A block of solid ore or other rock left in place to structurally support the shaft, walls or roof of a mine.

Pitchblende - An important uranium ore mineral. It is black in color, possesses a characteristic greasy luster and is highly radioactive.
Placer - A deposit of sand and gravel containing valuable metals such as gold, tin or diamonds.

Plant - A building or group of buildings in which a process or function is carried out; at a mine site it will include warehouses, hoisting equipment, compressors, maintenance shops, offices and the mill or concentrator.

Plate tectonics - A geological theory which postulates that the Earth's crust is made up of a number of rigid plates which collide, rub up against and spread out from one another.

Plug - A common name for a small offshoot from a large body of molten rock.

Plunge - The vertical angle a linear geological feature makes with the horizontal plane.

Plutonic - Refers to rocks of igneous origin that have come from great depth.

Point - Unit of value of a stock as quoted by a stock exchange. May represent one dollar, one cent or one-eighth of a dollar, depending on the stock exchange.

Polishing pond - The last in a series of settling ponds through which mill effluent flows before being discharged into the natural environment.

Pooling shares - See escrowed shares.

Porphyry - Any igneous rock in which relatively large crystals, called phenocrysts, are set in a fine-grained groundmass.

Porphyry copper - A deposit of disseminated copper minerals in or around a large body of intrusive rock.

Portal - The surface entrance to a tunnel or adit.

Portfolio - A list of financial assets.

Possible reserves - Valuable mineralization not sampled enough to accurately estimate its tonnage and grade, or even verify its existence. Also called "inferred reserves."

Potash - Potassium compounds mined for fertilizer and for use in the chemical industry.

Precambrian Shield - The oldest, most stable regions of the earth's crust, the largest of which is the Canadian Shield.

Preferred shares - Shares of a limited liability company that rank ahead of common shares, but after bonds, in distribution of earnings or in claim to the company's assets in the event of liquidation. They pay a fixed dividend but normally do not have voting rights, as with common shares.

Price-to-earnings ratio - The current market price of a stock divided by the company's net earnings per share for the year.

Primary deposits - Valuable minerals deposited during the original period or periods of mineralization, as opposed to those deposited as a result of alteration or weathering.
Private placement - Sale of shares to individuals or corporations outside the normal market, at a negotiated price. Often used to raise capital for a junior exploration company.

Pro rata - In proportion, usually to ownership, income or contribution.

Probable reserves - Valuable mineralization not sampled enough to accurately estimate the terms of tonnage and grade. Also called "indicated reserves."

Profit and loss statement - The income statement of a company detailing revenues minus total costs to give total profit.

Prospect - A mining property, the value of which has not been determined by exploration.

Prospectus - A document filed with the appropriate securities commission detailing the activities and financial condition of a company seeking funds from the public through the issuance of shares.

Proton precession magnetometer - A geophysical instrument which measures magnetic field intensity in terms of vertical gradient and total field.

Proven reserves - Reserves that have been sampled extensively by closely spaced diamond drill holes and developed by underground workings in sufficient detail to render an accurate estimation of grade and tonnage. Also called "measured reserves."

Proxy - A power of attorney given by the shareholder so that his stock may be voted by his nominee(s) at shareholders' meetings.

Pulp - Pulverized or ground ore in solution.

Put - An option to sell a stock at an agreed upon price within a specified time. The owner can present his put to the contracting broker at any time within the option period and compel him to buy the stock.

Pyramiding - The use of increased buying power to increase ownership arising from price appreciation.

Pyrite - A yellow iron sulphide mineral, normally of little value. It is sometimes referred to as "fool's gold."

Pyrrhotite - A bronze-colored, magnetic iron sulphide mineral.

Q

Quartz - Common rock-forming mineral consisting of silicon and oxygen.

Quartzite - A metamorphic rock formed by the transformation of a sandstone by heat and pressure.

R

Radioactivity - The property of spontaneously emitting alpha, beta or gamma rays by the decay of the nuclei of atoms.
Radon survey - A geochemical survey technique which detects traces of radon gas, a product of radioactivity.

Raise - A vertical or inclined underground working that has been excavated from the bottom upward.

Rake - The trend of an orebody along the direction of its strike.

Rare earth elements - Relatively scarce minerals such as niobium and yttrium.

Reaming shell - A component of a string of rods used in diamond drilling, it is set with diamonds and placed between the bit and the core barrel to maintain the gauge (or diameter) of the hole.

Reclamation - The restoration of a site after mining or exploration activity is completed.

Reconnaissance - A preliminary survey of ground.

Record date - The date by which a shareholder must be registered on the books of a company in order to receive a declared dividend, or to vote on company affairs.

Recovery - The percentage of valuable metal in the ore that is recovered by metallurgical treatment.

Refractory ore - Ore that resists the action of chemical reagents in the normal treatment processes and which may require pressure leaching or other means to effect the full recovery of the valuable minerals.

Regional metamorphism - Metamorphism caused by both the heat of igneous processes and tectonic pressure.

Replacement ore - Ore formed by a process during which certain minerals have passed into solution and have been carried away, while valuable minerals from the solution have been deposited in the place of those removed.

Resistivity survey - A geophysical technique used to measure the resistance of a rock formation to an electric current.

Resource - The calculated amount of material in a mineral deposit, based on limited drill information.

Resuing - A method of stoping in narrow-vein deposits whereby the wallrock on one side of the vein is blasted first and then the ore.

Reverberatory furnace - A long, flat furnace used to slag gangue minerals and produce a matte.

Rhyolite - A fine-grained, extrusive igneous rock which has the same chemical composition as granite.

Rib samples - Ore taken from rib pillars in a mine to determine metal content.

Rights - In finance, a certified right to purchase treasury shares in stated quantities, prices and time limits; usually negotiable at a price which is related to the prices of the issue represented; also referred to as warrants. Rights and
warrants can be bought and sold prior to their expiry date because not all shareholders wish to exercise their rights.

Rock - Any natural combination of minerals; part of the earth's crust.

Rockbolting - The act of supporting openings in rock with steel bolts anchored in holes drilled especially for this purpose.

Rockburst - A violent release of energy resulting in the sudden failure of walls or pillars in a mine, caused by the weight or pressure of the surrounding rocks.

Rock factor - The number of cubic meters of a particular rock type required to make up one tonne of the material. One tonne of a highly siliceous ore may occupy 0.40 cubic meters, while a tonne of dense sulphide ore may occupy only 0.25 cubic meters.

Rock mechanics - The study of the mechanical properties of rocks, which includes stress conditions around mine openings and the ability of rocks and underground structures to withstand these stresses.

Rod mill - A rotating steel cylinder that uses steel rods as a means of grinding ore.

Room-and-pillar mining - A method of mining flat-lying ore deposits in which the mined-out area, or rooms, are separated by pillars of approximately the same size.

Rotary drill - A machine that drills holes by rotating a rigid, tubular string of drill rods to which is attached a bit. Commonly used for drilling large-diameter blastholes in open-pit mines.

Royalty - An amount of money paid at regular intervals by the lessee or operator of an exploration or mining property to the owner of the ground. Generally based on a certain amount per tonne or a percentage of the total production or profits. Also, the fee paid for the right to use a patented process.

Run-of-mine - A term used loosely to describe ore of average grade.

S

Salting - The act of introducing metals or minerals into a deposit or samples, resulting in false assays. Done either by accident or with the intent of defrauding the public.

Sample - A small portion of rock or a mineral deposit taken so that the metal content can be determined by assaying.

Sampling - Selecting a fractional but representative part of a mineral deposit for analysis.

Sandstone - A sedimentary rock consisting of grains of sand cemented together.

Scaling - The act of removing loose slabs of rock from the back and walls of an underground opening, usually done with a hand-held scaling bar or with a boom-mounted scaling hammer.
Scarp - An escarpment, cliff or steep slope along the margin of a plateau, mesa or terrace.

Schist - A foliated metamorphic rock the grains of which have a roughly parallel arrangement; generally developed by shearing.

Scintillation counter - An instrument used to detect and measure radioactivity by detecting gamma rays; more sensitive than a Geiger counter.

Secondary enrichment - Enrichment of a vein or mineral deposit by minerals that have been taken into solution from one part of the vein or adjacent rocks and redeposited in another.

Sedimentary rocks - Secondary rocks formed from material derived from other rocks and laid down under water. Examples are limestone, shale and sandstone.

Seismic prospecting - A geophysical method of prospecting, utilizing knowledge of the speed of reflected sound waves in rock.

Self-potential - A technique, used in geophysical prospecting, which recognizes and measures the minute electric currents generated by sulphide deposits.

Semi-autogenous grinding (SAG) - A method of grinding rock into fine powder whereby the grinding media consist of larger chunks of rocks and steel balls.

Serpentine - A greenish, metamorphic mineral consisting of magnesium silicate.

Shaft - A vertical or inclined excavation in rock for the purpose of providing access to an orebody. Usually equipped with a hoist at the top, which lowers and raises a conveyance for handling workers and materials.

Shale - Sedimentary rock formed by the consolidation of mud or silt.

Shear or shearing - The deformation of rocks by lateral movement along innumerable parallel planes, generally resulting from pressure and producing such metamorphic structures as cleavage and schistosity.

Shear zone - A zone in which shearing has occurred on a large scale.

Sheave wheel - A large, grooved wheel in the top of a headframe over which the hoisting rope passes.

Shoot - A concentration of mineral values; that part of a vein or zone carrying values of ore grade.

Short selling - The borrowing of stock from a broker in order to sell it in the hope that it may be purchased at a lower price later on.

Short ton - 2,000 lbs. avoirdupois.

Shrinkage stoping - A stoping method which uses part of the broken ore as a working platform and as support for the walls of the stope.

Siderite - Iron carbonate, which when pure, contains 48.2% iron; must be roasted to drive off carbon dioxide before it can be used in a blast furnace. Roasted product is called sinter.
Silica - Silicon dioxide. Quartz is a common example.

Siliceous - A rock containing an abundance of quartz.

Sill - An intrusive sheet of igneous rock of roughly uniform thickness that has been forced between the bedding planes of existing rock.

Silt - Muddy deposits of fine sediment usually found on the bottoms of lakes.

Sinter - Fine particles of iron ore that have been treated by heat to produce blast furnace feed.

Skarn - Name for the metamorphic rocks surrounding an igneous intrusive where it comes in contact with a limestone or dolostone formation.

Skip - A self-dumping bucket used in a shaft for hoisting ore or rock.

Slag - The vitreous mass separated from the fused metals in the smelting process.

Slash - The process of blasting rock from the side of an underground opening to widen the opening.

Slate - A metamorphic rock; the metamorphic equivalent of shale.

Slickenside - The striated, polished surface of a fault caused by one wall rubbing against the other.

Sludge - Rock cuttings from a diamond drill hole, sometimes used for assaying.

Sodium cyanide - A chemical used in the milling of gold ores to dissolve gold and silver.

Solvent extraction-electrowinning (SX-EW) - A metallurgical technique, so far applied only to copper ores, in which metal is dissolved from the rock by organic solvents and recovered from solution by electrolysis.

Spelter - The zinc of commerce, more or less impure, cast from molten metal into slabs or ingots.

Sphalerite - A zinc sulphide mineral; the most common ore mineral of zinc.

Split - The shareholder-approved division of a company’s outstanding common shares into a larger number of new common shares.

Spot price - Current delivery price of a commodity traded in the spot market.

Station - An enlargement of a shaft made for the storage and handling of equipment and for driving drifts at that elevation.

Step-out drilling - Holes drilled to intersect a mineralization horizon or structure along strike or down dip.

Stock exchange - An organized market concerned with the buying and selling of common and preferred shares and warrants by stockbrokers who own seats on the exchange and meet membership requirements.
Stockpile - Broken ore heaped on surface, pending treatment or shipment.

Stope - An excavation in a mine from which ore is, or has been, extracted.

Stop-loss order - An arrangement whereby a client gives his broker instructions to sell a stock if and when its price drops to a specified figure on the market.

Stratigraphy - Strictly, the description of bedded rock sequences; used loosely, the sequence of bedded rocks in a particular area.

Streak - A diagnostic characteristic of minerals, where scratching a sample on a piece of unglazed porcelain leaves powder of a characteristic color.

Street certificate - A certificate representing ownership in a specified number of shares that is registered in the name of some previous owner who has endorsed the certificate so that it may be transferred to a new owner without referral to transfer agent.

Striations - Prominent parallel scratches left on bedrock by advancing glaciers.

Strike - The direction, or bearing from true north, of a vein or rock formation measure on a horizontal surface.

Stringer - A narrow vein or irregular filament of a mineral or minerals traversing a rock mass.

Strip - To remove the overburden or waste rock overlying an orebody in preparation for mining by open pit methods.

Stripping ratio - The ratio of tonnes removed as waste relative to the number of tonnes of ore removed from an open-pit mine.

Strip mine - An open-pit mine, usually a coal mine, operated by removing overburden, excavating the coal seam, then returning the overburden.

Sub-bituminous - A black coal, intermediate between lignite and bituminous.

Sublevel - A level or working horizon in a mine between main working levels.

Subsidiary company - A company in which the majority of shares (a controlling position) is held by another company.

Sulphide - A compound of sulphur and some other element.

Sulphide dust explosions - An underground mining hazard involving the spontaneous combustion of airborne dust containing sulphide minerals.

Sulphur dioxide - A gas liberated during the smelting of most sulphide ores; either converted into sulphuric acid or released into the atmosphere in the form of a gas.

Sump - An underground excavation where water accumulates before being pumped to surface.

Sustainable development - Industrial development that does not detract from the potential of the natural environment to provide benefits to future generations.
Syenite - An intrusive igneous rock composed chiefly of orthoclase.

Sylvite - potassium chloride, the principal ore of potassium mined for fertilizer manufacturing.

Syncline - A down-arching fold in bedded rocks.

Syngenetic - A term used to describe when mineralization in a deposit was formed relative to the host rocks in which it is found. In this case, the mineralization was formed at the same time as the host rocks. (The opposite is epigenetic.)

Taconite - A highly abrasive iron ore.

Tailings - Material rejected from a mill after most of the recoverable valuable minerals have been extracted.

Tailings pond - A low-lying depression used to confine tailings, the prime function of which is to allow enough time for heavy metals to settle out or for cyanide to be destroyed before water is discharged into the local watershed.

Talus - A heap of broken, coarse rock found at the base of a cliff or mountain.

Telluride - A chemical compound consisting of the element tellurium and another element, often gold or silver.

Thermal coal - Coal burned to generate the steam that drives turbines to generate electricity.

Thickener - A large, round tank used in milling operations to separate solids from liquids; clear fluid overflows from the tank and rock particles sink to the bottom.

Tonnes-per-vertical-meter - Common unit used to describe the amount of ore in a deposit; ore length is multiplied by the width and divided by the appropriate rock factor to give the amount of ore for each vertical meter of depth.

Trading floor - the area of a stock exchange building where shares are bought and sold.

Trading post - An area on the trading floor of a stock exchange where current stock prices are listed and where the floor traders (representatives of brokerage firms) meet to buy or sell the stocks listed at that particular post.

Tram - To haul cars of ore or waste in a mine.

Treasury shares - The unissued shares in a company's treasury.

Trench - A long, narrow excavation dug through overburden, or blasted out of rock, to expose a vein or ore structure.

Trend - The direction, in the horizontal plane, of a linear geological feature, such as an ore zone, measured from true north.

Tube mill - An apparatus consisting of a revolving cylinder about half-filled with steel rods or balls and into which crushed ore is fed for fine grinding.
Tuff - Rock composed of fine volcanic ash.

Tunnel - A horizontal underground opening, open to the atmosphere at both ends.

Tunnel-boring-machine - A machine used to excavate a tunnel through soil or rock by mechanical means as opposed to drilling and blasting.

U

Umpire sample or assay - An assay made by a third party to provide a basis for settling disputes between buyers and sellers of ore.

Uncut value - The actual assay value of a core sample as opposed to a cut value which has been reduced by some arbitrary formula.

Underwrite - A firm commitment made by a broker or other financial institution to purchase a block of shares at a specified price.

Uraninite - A uranium mineral with a high uranium oxide content. Frequently found in pegmatite dykes.

Uranium - A radioactive, silvery-white, metallic element.

V

Vein - A fissure, fault or crack in a rock filled by minerals that have travelled upwards from some deep source.

Vendor - A seller. In the case of mining companies, the consideration paid for properties purchased is often a block of treasury shares. These shares are termed vendor shares and are normally pooled or escrowed.

Visible gold - Native gold which is discernible, in a hand specimen, to the unaided eye.

Volcanic rocks - Igneous rocks formed from magma that has flowed out or has been violently ejected from a volcano.

Volcanogenic - A term used to describe the volcanic origin of mineralization.

Voting right - The stockholder's right to vote in the affairs of the company. Most common shares have one vote each. Preferred stock usually has the right to vote when preferred dividends are in default.

Vug - A small cavity in a rock, frequently lined with well-formed crystals. Amethyst commonly forms in these cavities.

W

Wall rocks - Rock units on either side of an orebody. The hangingwall and footwall rocks of an orebody.

Warrant - See Rights.

Waste - Unmineralized, or sometimes mineralized, rock that is not minable at a profit.
Wedge - A technique of directing a diamond drill hole in a desired direction away from its current orientation.

Winze - An internal shaft.

Witness post - A claim post placed on a claim line when it cannot be placed in the corner of a claim because of water or difficult terrain.

Working capital - The liquid resources a company has to meet day-to-day expenses of operation; defined as the excess of current assets over current liabilities.

Writeoffs - Amounts deducted from a company's reported profit for depreciation or preproduction costs. Writeoffs are not an out-of-pocket expense, but reduce the amount of taxable profit.

Xenolith - A fragment of country rock enclosed in an intrusive rock.

Yield - The current annual dividend rate expressed as a percentage of the current market price of the stock.

Zone - An area of distinct mineralization.

Zone of oxidation - The upper portion of an orebody that has been oxidized.
Appendix 2: Bibliography

General
McIsaac, George, Boyd A. Davis, Dave Love. Basics of Geology, Mining, and Processing. Course offered through the Robert M. Buchan Department of Mining, Queen’s University. Toronto: Queen’s University, 2012. Print.

[Authors note: for those interested in attending Basics of Geology, Mining, and Processing contact George McIsaac.]


Introduction

Section 4: Geology


Section 5: Deposit types


Section 6: Mining project life cycle

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Appendix A
Link to Definitions
Basic Materials
Click here for definitions of commonly used terms.
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<table>
<thead>
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<th>Investment rating</th>
<th>Total return expectation (within 12-month period of date of initial rating)</th>
<th>Ratings dispersion guidelines for coverage cluster*</th>
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<tr>
<td>Buy</td>
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</tr>
<tr>
<td>Underperform</td>
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<td>≥ 20%</td>
</tr>
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</table>

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