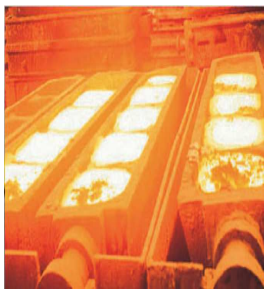
basinvest

Valuation of Metals and Mining Companies

Author: Svetlana Baurens
E-Mail: baurens@basinvest.ch

Date: 7.11.2010

In collaboration with the University of Zürich,
Swiss Banking Institute and Prof. Dr. T. Hens



Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF EXHIBITS

APPENDIX

ABBREVIATIONS

AMC	Adjusted Market Capitalization
EBITDA	Earnings before Interests, Taxes, Depreciations and Amortizations
EPS	Earnings per Share
EV	Enterprise Value
IRR	Internal Rate of Return
NPV	Net Present Value
PER	Price Earnings Ratio
PV	Present Value
ROE	Return on Equity
ROC	Return on Capital
ROIC	Return on Invested Capital
ROV	Real Options Valuation
VAT	Value-added tax

1 Introduction

1.1 Motivation

Mining and metals continue to be among the best performing global equity sectors, but conflicting issues – from "pricing bubbles", "imminent recessions", "demand destruction" to "resource scarcity"- are confusing investors. Nevertheless, the importance of mining to the world has become very apparent in recent years, as commodity and equity prices have exceeded most expectations.[1] Therefore, investments in commodities become more attractive as a long-term investment as they are a safe haven in times of economic crisis and provide a protection against currency devaluation. Thus, it is useful to know how to value metals and mining companies.

The prediction of the value of a mining company is a complex matter. Various methods are available to estimate a company's value but many are not useful or applicable. The reason is the specific nature of mining industry. Aside from the usual financing risk in the case of mining producers, and financing and "finding" risk in the case of pure exploration companies, there are price cyclicality, ongoing changes in operating and capital cost structures, stock market vagaries, and volatility in circumstances.

Consequently, even traditional methods such as Discounted Cash Flow, Relative Multiples or Real Options cannot be applied without some adjustments and demarcations. For example, cash flow or earnings based valuation methodologies may not be relevant for the valuation of a mining exploration company that has no production assets or revenues, neither operating cash flow or earnings.

The purpose of this paper is to find out which valuation methods are available for valuing metals and mining companies and explain why these companies are valued this way in practice.

The paper takes the reader through different stages of metals and mining companies from mineral exploration to mine production and provides an overview of suitable valuation approaches, discussing some of the difficulties and limitations that arise in using these approaches.

1.2 Structure

This study is organized into eight chapters:

Chapter 1 introduces the study and provides definitions of specific terms used in the metals and mining industry.

In Chapter 2 special features of metals and mining companies are discussed to provide the broad basis that is essential to understanding the nature of the mining sector. A subchapter of Chapter 2 summarizes various valuation approaches usually applied for valuation of mining and metals companies and defines methods which are in the focus of

[1] Brebner, Daniel/ Tanners, Timna/ Snowdowne, Andrew: UBS Investment research, Mining and Steel Primer, June 2008

this paper. A second subchapter characterizes resources and reserves to give readers' clear understanding of important differences between a mineral resource and a mineral reserve.

Chapter 3 describes exploration properties and suitable valuation methods for them, such as Appraised Value and Comparable Transactions.

Chapter 4 explains why economic and price cycles are very important when valuing mining companies. It also gives an idea how to avoid commonly made mistakes when valuing metals and mining companies.

Chapter 5, 6 and 7 describes Discounted Cash Flow, Multiples and Real Options methods and discusses applications for metals and mining companies.

Chapter 8 is a practical chapter. A copper mining group, Antofagasta, is valued with different valuation methods.

1.3 Definition of terms

Valuation approaches for metals and for mining companies are similar; therefore, for convenience the term "mining companies" will be used for "metals and mining companies".

It is necessary to know what some subject-specific terms mean. Thus, there are some important terms definitions:

Metallurgy is the study of metals: the study of the structure and properties of metals, their extraction from the ground, and the procedures for refining, alloying, and making things from them.[2]

Mining is the science, technique, and business of mineral discovery and exploitation. Mining includes all activities related to extraction of metals, minerals and gemstones. Strictly, the word connotes underground work directed to severance and treatment of ore or associated rock. Practically, it includes opencast work, open cut work, quarrying, alluvial dredging, and combined operations, including surface and underground attack and ore treatment.[3]

Exploration is searching for natural resources: the testing of a number of places for natural resources, e.g. drilling or boring for samples that will be examined for possible mineral deposits. Exploration aims at locating the presence of economic deposits and establishing their nature, shape, and grade.[4]

Desktop-study is an archaeological research to outline the Site History, Geology and Hydrogeology, and any environmental risk associated with that particular plot. Desktop Study is often required by local planning authorities, when applying for planning permission.[5]

---

[2] Encarta Dictionary, found at http://encarta.msn.com/encnet/features/dictionary/DictionaryResults.aspx?lextype=3&search=metallurgy, accessed date 11.03.2010

[3] Hacettepe University Department of Mining Engineering, found at http://www.maden.hacettepe.edu.tr/dmmrt/, accessed date 11.03.2010

[4] Hacettepe University Department of Mining Engineering, found at http://www.maden.hacettepe.edu.tr/dmmrt/, accessed date 11.03.2010

[5] Southwest Environmental Limited, found at http://www.desktop-study.co.uk/, accessed date 30.03.2010

There are at least four "feasibility" studies that mining companies often undertake in making a decision to develop a project. These studies vary in the depth of inquiry and reliability of the geological and cost data and evaluations included, although the content is often similar. Here are their definitions (presented ascending in the depth of inquiry and reliability…):

Scoping Study is an early stage study based on the economics of a mining project used for development planning. It is generally based on assumptions and estimated costs, and is neither as detailed nor as reliable as a feasibility study. Scoping study may also be called a preliminary economic assessment.

Pre-Feasibility Study is a comprehensive study of the viability of a mineral project that has advanced to a stage where the mining method, in the case of underground mining, or the pit configuration, in the case of an open pit, has been established, where an effective method of mineral processing has been determined, and includes a financial analysis based on a reasonable assumptions of technical, engineering, legal, operating and economic factors and evaluation of other relevant factors which are sufficient for a competent person, acting reasonable, to determine if all or part of the Mineral resource may be classified as a Mineral Reserve.[6]

Feasibility study is a comprehensive study of a mineral deposit in which all geological, engineering, legal, operating, economic, social, environmental and other relevant factors are considered in sufficient detail that it could reasonably serve as the basis for a final decision by a financial institution to finance the development of the deposit for mineral production.[7]

"*Bankable" feasibility study* is a comprehensive forward analysis of a project's economics to be used by financial institutions to assess the credit-worthiness for project financing. The feasibility part is guided by a set of assumptions, a strategy, development conditions and a planned outcome. The outcome is uncertain and targets and objectives may not be achievable. The bankable part relates to the basis and conditions for a future financial agreement to collateralize mining assets for a project loan, to set a premium and a repayment schedule, with appropriate risk/reward factors. Then a lender would accept or not accept a feasibility study prepared by a borrower or the borrower's consultants as the basis for financing a project.[8]

Mineable Reserve is those parts of the ore body, both economic and uneconomic, that are extracted during the normal course of mining.

Mineral Resource is a concentration or occurrence of material of intrinsic economic interest in or on the Earth's crust in such form and quantity that there are reasonable prospects for eventual economic extraction. Portions of a deposit that do not have reasonable prospects for eventual economic extraction should not be included in a Mineral Resource. The location, quantity, grade, geological characteristics and continuity of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge.[9]

---

[6] In chapter 2.3 you will find detailed description of Mineral Resources and Mineral Reserves
[7] Canadian Institute of Mining (CIM), Metallurgy and Petroleum, 2009, p.79
[8] Infomine, found at www.infomine.com/publications/docs/Evans2007.ppt, accessed date 25.05.2010
[9] See South African Mineral Resource Committee, found at http://www.geolsoc.org.uk/webdav/site/GSL/shared/pdfs/Fellowship/South%20Africa%20Code.pdf, accessed date 13.03.2010

Mineral Reserve is the economically mineable part of a Measured or Indicated Mineral Resource demonstrated by at least a preliminary feasibility study. 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. A mineral reserve includes diluting materials and allowances for losses that may occur when the material is mined.

Ore is a mixture of valuable minerals and gangue minerals from which at least one of the minerals can be extracted economically. An ore body is a natural concentration of valuable material amenable to economic extraction.

By-product is a secondary or additional product recovered in the extraction process (e.g. molybdenum is a common by-product of copper).

Mine Design is a framework of mining components and processes taking into account mining methods, access to the ore body, personnel, material handling, ventilation, water, power and other technical requirements such that mine planning can be undertaken.[10]

*Dredging is r*emoving solid matter from the bottom of an area covered by water.[11]

Open pit mining is a method of extracting rock or minerals from the earth by their removal from an open pit or borrow. Mining companies choose this way to get rocks and minerals out of the ground because it is the easiest and cheapest way to do it. Open-pit mining is only used if the rocks or minerals are close to the surface of the land or if a normal tunnel-type of mine isn't possible.

Underground mining is carried out when the rocks, minerals, or gemstones are located at a distance far beneath the ground to be extracted with surface mining. To facilitate the minerals to be taken out of the mine, the miners construct underground rooms to work in. Underground mining is typically employed to gain access to richer, deeper and smaller ore bodies where open-pit mining is not considered practical. Underground mines are usually higher cost due to tunneling, ventilation, water control and safety issues.[12]

Units of measurement:

1 troy ounce (oz) = 31.1034748 grams
1 pound (lb) = 16 oz = 0.4536 kg
1 tonne (t) = 2 204.62262 lb
1 kilotonne (kt) = 1000 tonnes

Characteristics of precious and industrial metals

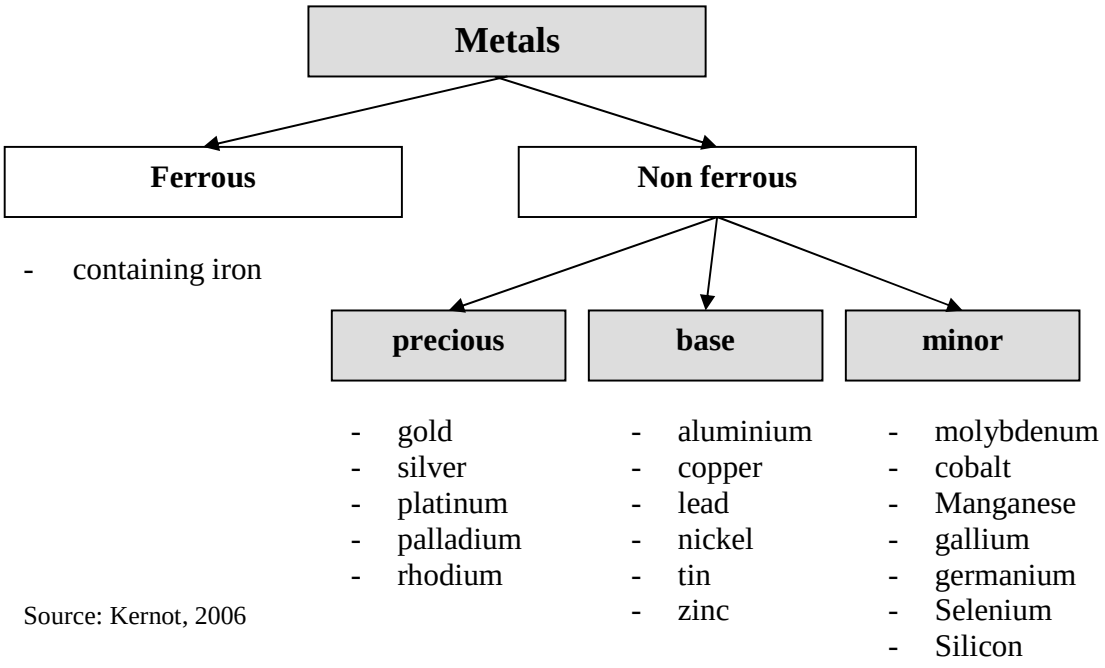
All mining activity takes places within the Earth's crust, about the top 7-35 km of the solid matter comprising the bulk of the planet. The distribution of metals within the crust can be seen by the differences in the types of rock which it contains: limestone, granite, sandstone or basalt. Nevertheless, these different rock types are generally of uniform composition and further concentrations need to occur in order to produce concentrations of material which can be mined and sold at a profit. Therefore, the importance of the

[10] CIM, Metallurgy and Petroleum, 2009, p.491
[11] Hacettepe University Department of Mining Engineering, found at http://www.maden.hacettepe.edu.tr/dmmrt/, access date 2.04.2010
[12] For more details see OracleThinkQuest, found at http://library.thinkquest.org/05aug/00461/open.htm, access date 5.04.2010

concentration factor[13] in determining the value of mining company should not be undervalued. A company with a lower grade of ore will have to process more rock, possibly at greater cost in order to obtain a given amount of economically valuable material.[14]

Metals classification is presented in the Figure 1. The precious metals are relatively rare but, having formed the basis of currencies and jewellery, they are widely traded and are thought of as secure havens in times of war or financial crisis. The base metals have wide range of applications throughout industry and could be thought of as the industrial metals.[15] The minor metals are produced very often both as by-products of the extraction of the major metals or are required for specific applications and are therefore produced sometimes in small quantities from primary deposits. It can happened that, if new producer brings a low cost mine into production or if there is a massive increase in demand due to the discovery of a new application, prices swing widely.[16]

Figure 1: Classification of Metals



Source: Kernot, 2006

A lower grade gold ore would contain something like 5 grams per tonne (5 parts per million). So, gold ore needs to be concentrated by about 1,000 times above its average dispersion to become viable for gold mining.

[13]The generally accepted background concentrations of the major metallic elements and the concentration factors required for economic viability are detailed in Table 5, page 41

[14] Kernot, 2006, p. 57-72

[15] Iron is separated for historical reasons and because of the much larger amount of the metal which is produced

[16] Kernot, 2006, p. 58-60

The perceived advantage of investing in gold mining shares is that their value is usually more sensitive to the price of gold than even a gold bar. This is because gold mining shares are valued on the basis of their anticipated profits through the life of the mine[17], and these depend on the reserves, and on the relationship between gold mining production costs and the anticipated value of the gold extracted.

Valuing mining company a price forecasting should be undertaken. After this we can see if the company's profit is consistently above the level of operating cost and if the company generates any return. There are some significant differences between price forecasting of industrial and precious metals. Industrial metals tend to be strongly influenced over the long term by supply/demand factors whilst precious metals are not influences by these factors. One more special future of industrial metals is their respective market, which tend to be either small or localized with other factors such as transport cost accounting for a significant part of their price.[18]

2 Valuation models in mining and metals industry

2.1 Special features of metals and mining companies

The different methods of valuing commodity companies are complicated because of highly cyclical nature of mining and metals industry. There are two cycles in the game: commodity price and/ or economic cycle. Commodity companies are, mostly, price takers with exception of Nickel and Iron producers. Such companies as Norilsk Nickel, BHP Billiton and Vale can determine the price of commodity by changing amount of their production. Because of big changes in the prices of mining company's products, they are characterized by highly volatile earnings and cash flows over a number of years.[19]

The resulting valuation will greatly depend on where in the cycle (economic or commodity price) we are. When commodity prices are in upswing or in boom phase, all producers of this commodity benefit, whereas an extended economic downturn or a lengthy phase of a low commodity prices burdens operators, even the best companies in the business. Consequently, commodity companies are exposed to cyclical risk over which they have little control.[20]

The value of the commodity company is not only affected by the price of the commodity but also by the expected volatility in that price. Commodity companies experience far greater price volatility than manufactures or services do.[21] This leads again to volatile revenues, earnings and cash flows of the commodity company.

[17] See an example with a gold mine on the page 42
[18] Kernot, 2006, p. 155-176
[19] See Mc Kinsey & Company, Inc. Copeland/ Koller/ Murrin, 2000, p. 327
[20] See Damodaran, 2010, p.417-449
[21] Jacks and Fraser, 2009 in their research "Commodity Price Volatility and World Market Integration since 1700" explore commodity and manufactures price over the past three centuries and conclude that commodities always have shown greater price volatility than manufactures. But also that commodity price volatility did not increased over time

The other special feature is high fixed cost, thus commodity companies may have to keep mines operating even during low points in price cycles. The reasons for this are prohibitive costs of shutting down and reopening operations.[22] Indeed, in a worst case scenario such events could even force the mine to close and put the company into liquidation before the exhaustion of its reserves.[23]

It is important to mention that for metals and mining firms to get started, large infrastructure investments are needed. It has led to the fact that many of these companies are significant users of debt financing. Because of this, the volatility in operating income that we referred to earlier manifests itself in even greater swings in net income.[24] Also when a commodity company will seek opportunities to extend its existence beyond the life of its reported reserves in new areas, one of the main financing will be debt financing.[25] Consequently, metals and mining companies have high volatility in equity values and debt ratios.

Next, the mining industry has long lead times (e.g. ordering equipment like a mill) to bring on new capacity. The mine development process is very specific and can typically take 5-10 years or more. Thus, most of these projects will begin their operations after many years. The consequence of long lead times is a high risk for mining projects.

Mining projects may have many different risks, depending on the specific situation of the project. The most serious risks include:

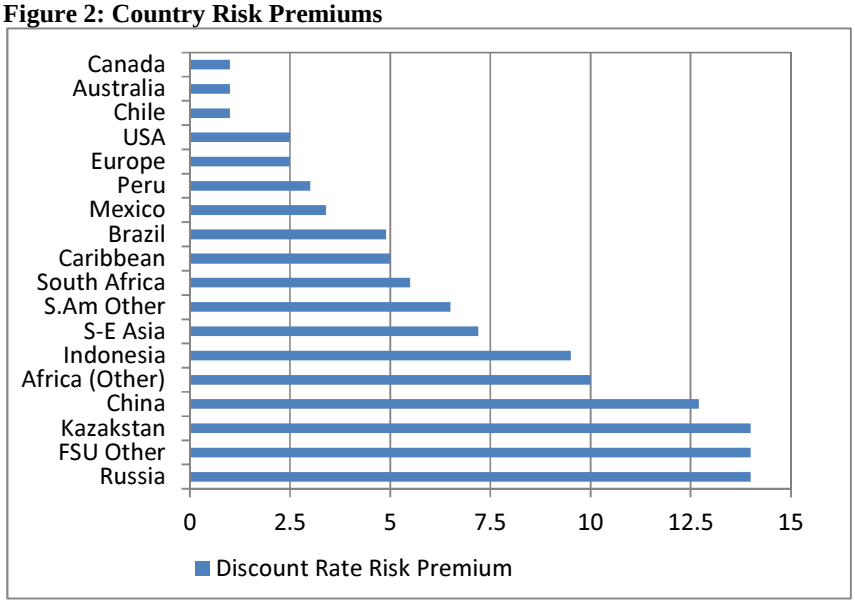
- financing risk: equity (can funds be raised in the market), debt (interest rate, requirement of hedging by the lenders)
- permitting risk
- Issues associated with geology (size and grade of the mineable portion of the ore body) and how the deposit can be economically mined.
- Metallurgy (often underestimated – how much of the metal can be recovered, what is the preferred recovery method; are there any impurities or associated minerals that could affect this?)
- Economics (metal markets and their forecast behavior, transportation costs, interest rates)
- Country risk:
    - political risk (government stability, taxation instability, laws, environmental policy)
    - economic risk (currency stability, foreign exchange restrictions). Metals prices and metals' stock performance are strongly correlated to exchange rates and particularly to the US dollar. This is primarily because over 70% of materials production comes from outside US dollar-denominated regions. As the dollar strengthens/weakens it alters the production economics of suppliers and consumers.
    - Geographic risk (transportation, climate)

[22] See Damodaran, 2010, p.417-449
[23] See Kernot, 2006, p.192-199
[24] See Damodaran, 2010, p.417-449
[25] See Kernot, 2006, p.145

- social risk (corruption, availability of workers and local labour laws, ethnic or religious differences within the indigenous population)[26]

The country risk premium ranges from 0% to 14%, this range is presented in Figure 2.

Figure 2: Country Risk Premiums



Source: Lawrence, CIM MES Survey

Lastly, this planet has finite quantity of natural resources; therefore metals and mining is a finite business. Mineral deposits contain a certain amount of ore and when that ore is mined out the deposit is depleted, no matter what one does or wishes. Lord Harris, Chairman of the board of Consolidated Gold Fields of South Africa summed up in the year 1911: "some years earlier the directors had a discussion as to whether Gold Fields was to be a company with a terminable or, so far mundane things go, was it to have an interminable existence, and the board came to the conclusion that what the investing public would expect of such company as Gold Fields was that it should be interminable but we are a company which habitually invests in properties which have terminable lives".[27] The longevity of a commodity company depends consequently on astute acquisitions, successful exploration, and/or a range of non-mining or downstream businesses.

When valuing commodity companies, scarcity of resources will play a role in what our forecasts of future commodity prices will be and may also operate as a constraint of assuming perpetual growth.

[26] Brebner/ Tanners/ Snowdowne, UBS Investment research, June 2008, p. 100
[27] Kernot, 2006, p. 195

2.2 Classification of valuation models

There are three different approaches to valuation, which are applied to three main categories of mineral properties. These are exploration properties, development properties and production properties. The definitions of these categories are below. They will help to understand why different approaches apply to different types of mineral properties as do different methods, as illustrated in Table 1.

Exploration Properties are those on which an economically viable mineral deposit has not been demonstrated to exist. The real value of an exploration property lies in its potential for the existence and discovery of economically viable mineral deposit. Only a very small number of exploration properties will ultimately become mining properties, but until exploration potential is reasonably well tested, they have very little value.

Development properties are those on which economically viable deposit has been demonstrated to exist by a Feasibility Study or Pre-feasibility Study, but is not yet financed or under construction. Such properties are at a sufficiently advanced stage or are former producing mines. There is enough reliable information available to value the property by discounted cash flow methods, with a reasonable degree of confidence. In general, such information includes reasonably assured mineable reserves, workable mining plan and production rate, metallurgical test results and process recoveries, capital and operating cost estimates, environmental and reclamation cost estimates, and commodity price projections.[28]

Production Properties are mineral assets that are in production.[29]

Table 1: Valuation Approaches and Methods for Different Types of Mineral Properties

VALUATION APPROACH	DESCRIPTION	VALUATION METHOD	EXPLORATION PROPERTIES	DEVELOPMENT PROPERTIES	PRODUCTION PROPERTIES
Income or Cash Flow	Relies on the "value-in-use" principle and requires determination of the present value of future cash flows over the useful life of the Mineral Property	**Discounted Cash Flow**	Not generally used	Widely used	Widely used
		Real Options	Less widely used	Quite widely used	Quite widely used
		Monte Carlo Analysis	Less widely used	Less widely used	Less widely used
		Probabilistic Methods	Not widely used	Not widely used	Not widely used
Market	Relies on the principle of substitution. The Mineral Property being valued is compared with the transaction value of similar Mineral Properties, transacted on an open market	**Comparable Transactions**	Widely used	Widely used	Widely used
		Option Agreement Terms	Widely used	Widely used	Quite widely used
		Gross "in Situ" Metal Value	Not acceptable		
		Net Metal Value per unit of metal	Widely used rule of thumb		

[28] CIM, Metallurgy and Petroleum, 2009, p.606
[29] CIM, Metallurgy and Petroleum, 209, p.491

		Value per Unit Area	Widely used	Not widely used	Not widely used
		Market capitalization	More applicable to single property asset junior companies		
Cost	Relies on historical and/or future amounts spent on the Mineral Asset	**Appraised Value**	Quite widely used	Not widely used	Not generally used
		Multiples	Quite widely used	Quite widely used	widely used
		Geoscience Factor	Not widely used	Not widely used	Not generally used

Source: Canadian Institute of Mining, Metallurgy and Petroleum

The three approaches should not be viewed as being independent of each other. Generally, they draw mainly on the same sources of data, but the data are analyzed using different methods. The underlying idea is that the three approaches should complement the findings of each other.

This paper will focus on the methods that are gray colored. The approaches used to value a business depend on how marketable its assets are, whether it generates cash flow, and how unique it is in terms of its operations.[30] There can be significant differences in outcomes, depending on which approach is used. One of the objectives of this paper is to explain the reasons for such differences in value across different models, and to help in choosing the right model to use for a specific task.

This paper will focus on the valuation methods which are acceptable by the Exchanges.

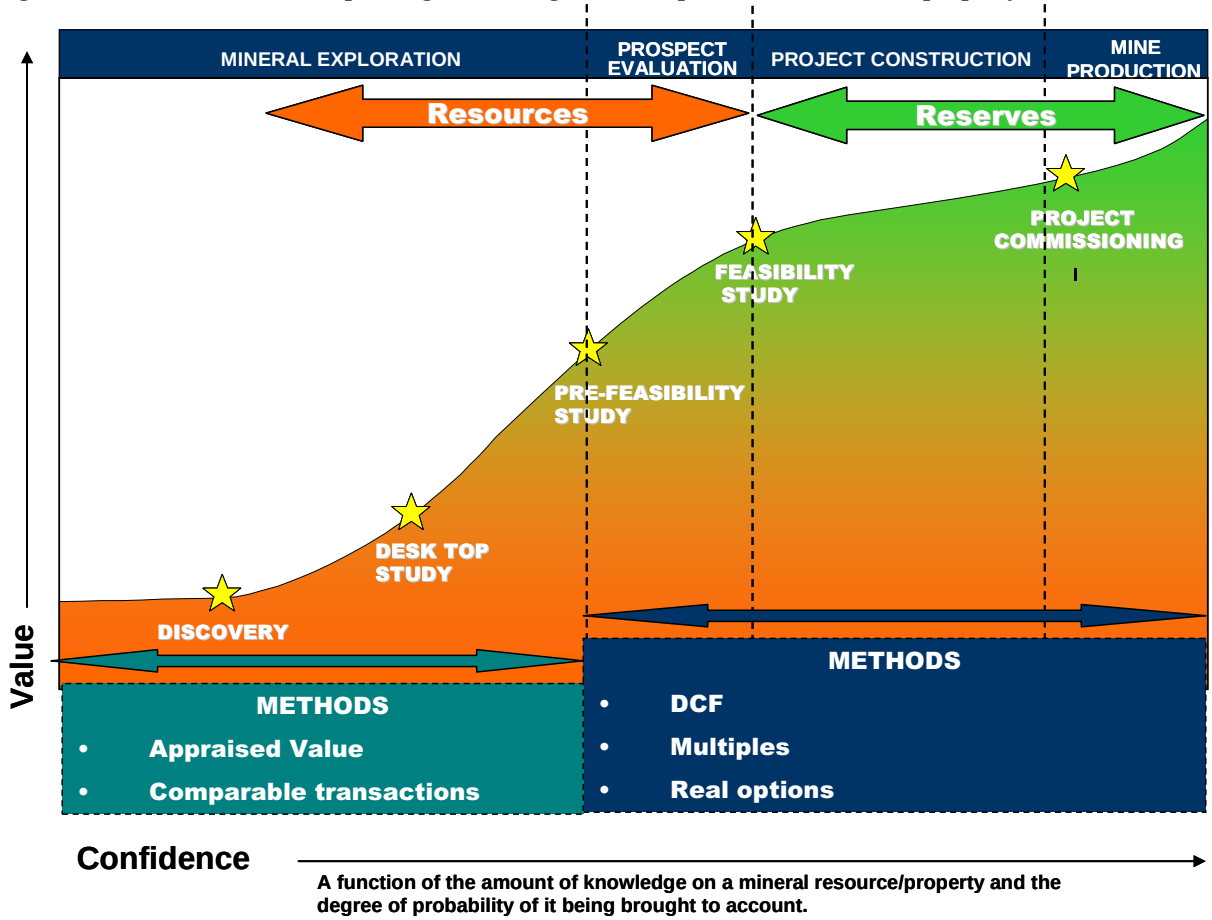
For properties *with mineral reserves*: Discounted Cash Flow/ Net Present Value.

For properties *without mineral reserves*: Comparable Transactions, whereby the market value can be determined through Modified Appraised Value, whereby only the retained past expenditures ("historical costs" or "replacement costs") are included.[31]

Figure 3 illustrates different applicable valuation methods which should be applied depending on the stages of development for the mineral property. It is, however, important to note that mineral properties represent a continuum from early stage to late stage and therefore the transition from one method to another will demand some level of judgment.[32]

[30] See Damodaran, 2002, p.946-
[31] Canadian Institute of Mining (CIM), 2009, p. 512
[32] CIM, 2009, p. 527-532

Figure 3: Valuation methods depending on the stage of development on the mineral property



Source: MVENMYN

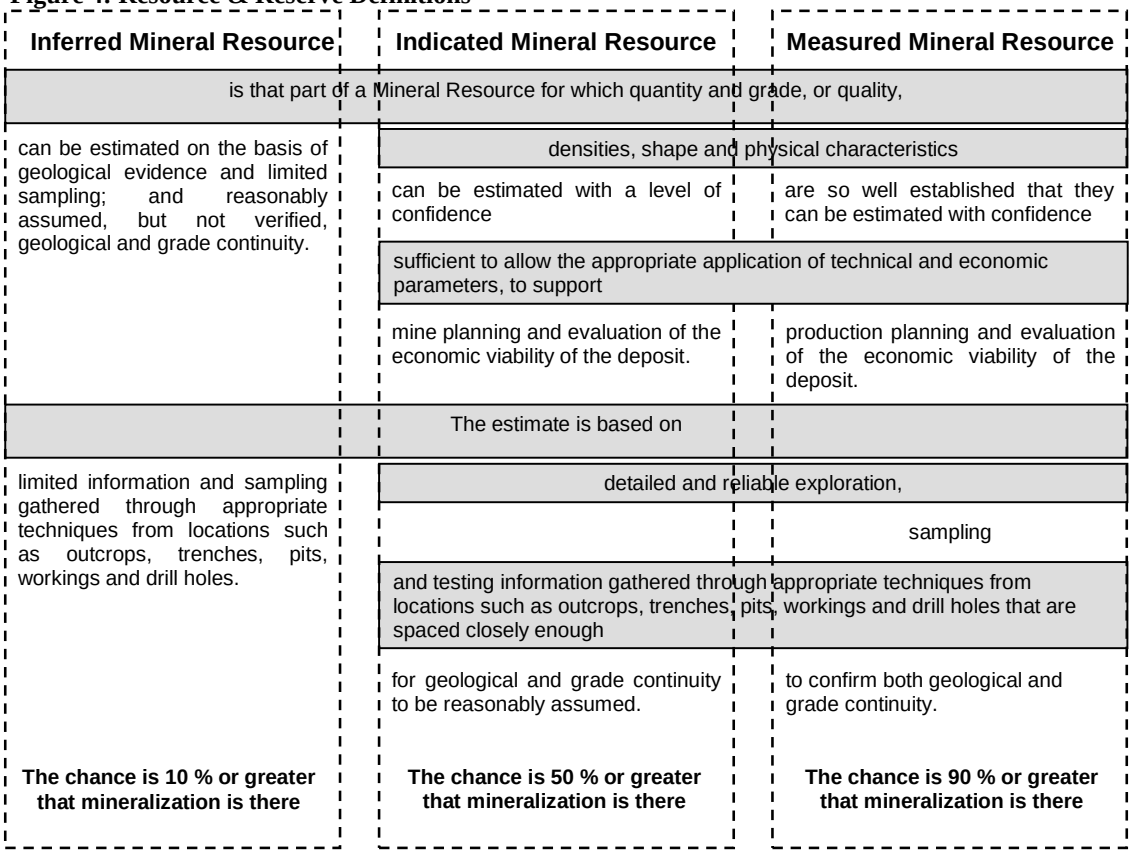
2.3 Resource and Reserve

For all property types, asset value is a joint product of any potentially extractable mineral resources located under the earth's surface and any invested capital that is used to extract this mineral resource. In order to perform a fundamental valuation of a mining company the amount of mineral reserves must be estimated. Given the importance to the mining industry to distinguish the definitions of Mineral Reserve and Mineral Resource, definitions are given here in full.

Mineral Resource is a concentration or occurrence of material of intrinsic economic interest in or on the Earth's crust in such form and quantity that there are reasonable prospects for eventual economic extraction. Portions of a deposit that do not have reasonable prospects for eventual economic extraction should not be included in a Mineral Resource. The location, quantity, grade, geological characteristics and continuity of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge.

Mineral Resources are sub-divided in order of increasing geological confidence, into inferred, indicated, and measured categories as it is shown in Figure 4:

Figure 4: Resource & Reserve Definitions[33]



Source: own presentation

Mineral Resources can be estimated on the basis of geo-scientific information with input from relevant disciplines. The main message to take away from these definitions is that the most uncertain category of resources, Inferred Resources, is so uncertain and so unlikely to transfer one for one into more certain resources that no income projections can reasonable be made. The Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (JORC) determine the chance of 10% or greater that mineralization is there for Inferred Resources. Indicated Resources would mean 50% or greater that mineralization is there and Measured Resources 90% or greater.[34] As a result Inferred Resources have highly speculative value and are worth little per unit until upgraded to the Indicated or Measured categories through additional exploration work.

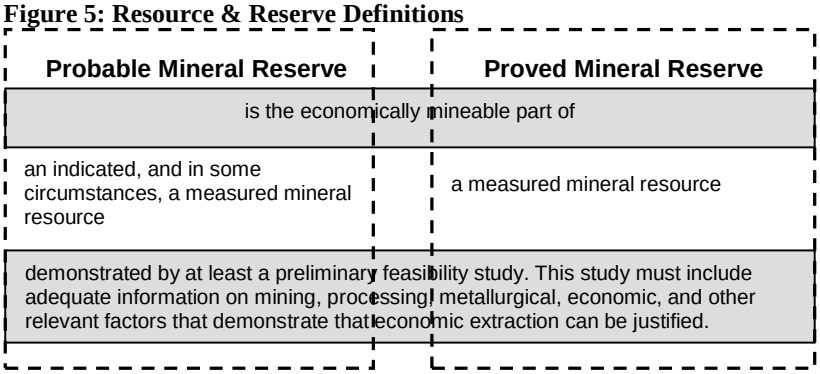
Mineral Reserve is the economically mineable part of a Measured or Indicated Mineral Resource demonstrated by at least a preliminary feasibility study. This study must include adequate information on mining, processing, metallurgical, economic, and other relevant factors that demonstrate (at the time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

[33] See the text definitions of resources and reserves in Appendix 2

[34] The JORC Code and Guidelines, found at http://www.jorc.org/jorc_code.asp, accessed date 12.06.2010

Mineral Reserves are sub-divided in Probable and Proven Mineral Reserves. The definitions of them are given in the Figure 5:

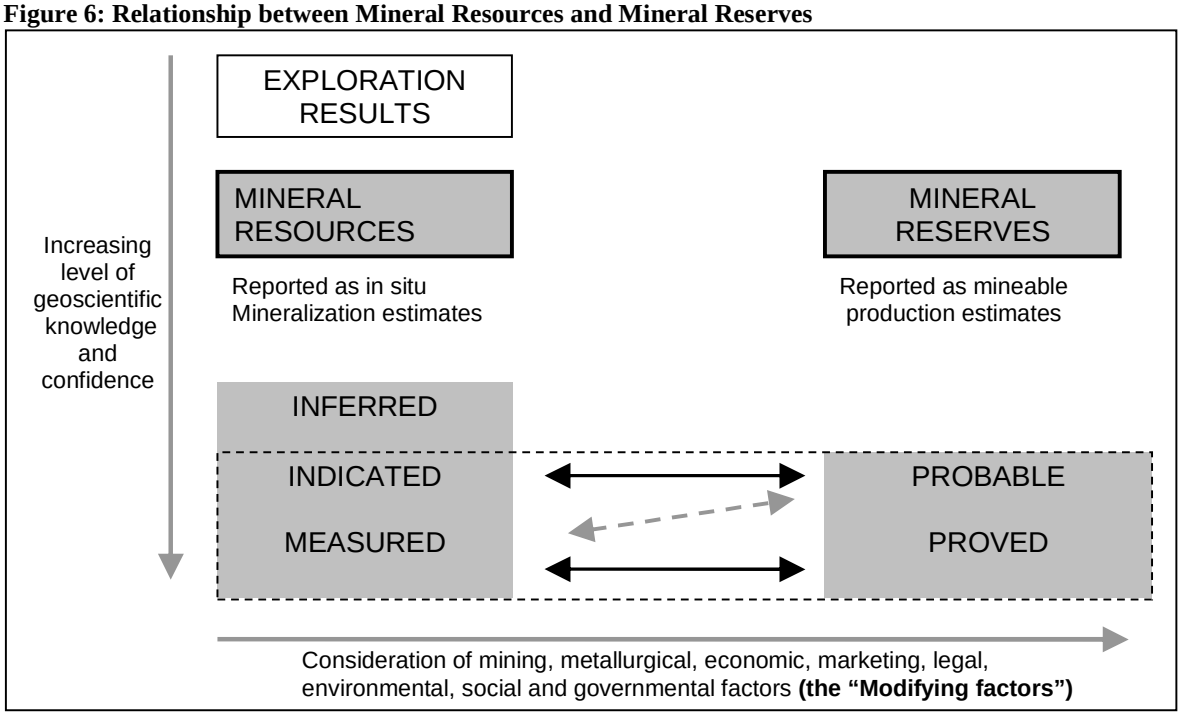
Figure 5: Resource & Reserve Definitions



Source: own presentation

Mineral reserves, which are a modified sub-set of the indicated and Measured Mineral Resources (shown with the dashed outline in Figure 5), require consideration of factors affecting extraction, including mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors, and should in most instances be estimated with input from a range of disciplines.[35] Figure 6 is reflecting the relationship between Mineral Resources and Mineral Reserves.

Figure 6: Relationship between Mineral Resources and Mineral Reserves



Source: South African Mineral Resource Committee, 2000

[35] South African Mineral Resource Committee, found at http://www.geolsoc.org.uk/webdav/site/GSL/shared/pdfs/Fellowship/South%20Africa%20Code.pdf, accessed date 13.03.2010

In general, before an extraction program can begin, Resources and Probable Reserves must be "proven up" to the category of Proven Reserves, the most geologically certain category. This requires additional cost - expenditure on drilling (information gathering) at the site, which will make assets in the category of Resources and Probable Reserves less valuable then Proven Reserves. There is a significant premium paid for operating mines, where reserve and cost uncertainty has been reduced. According to major gold property acquisitions during the 1990s, Proven and Probable Reserves are valued at a 44% discount, Measured and Indicated Resources at an 83% discount, with no value being attributed to Inferred Resources. The uncertainty surrounding the estimate of extractable reserve is called reserve risk.[36]

Mining companies may also commence production from a deposit with only a small amount of reserves, in the hope that additional reserves will be discovered as mining proceeds. The Dome mine, owned by Placer Dome (and now Goldcorp) is a good example: it has now been mined continuously for 88 years and it has never had more than about 3 years mine life. As the mine has progressed underground, more of the vein has been opened up for mining; consequently the life of the mine has been extended.[37]

3 Valuations of Explorations Properties

Mineral exploration properties are those on which an economically viable mineral deposit has not been discovered. Exploration Properties have asset values derived from their potential for the discovery of economically viable mineral deposits.[38]

"Exploration companies do not have assets, cash flow or earnings. They typically only have a management team, sometimes a bit of cash, and one to several properties."[39] The main attraction of exploration companies to investors is the potentially massive increase in share price which a company may experience when it finds a new deposit. This is the initial spurt in the life-cycle of a mining share, and it is possible that the shares will never regain the heights seen in the initial days of trading following the announcement of a discovery.[40]

Figure 7 illustrates up and downswings of a mining share price depending on where in the life cycle the mine is. During discovery and exploration, there is usually an increase in stock price as investors speculate, based on preliminary drilling or other sampling results, whether the company has found anything. As the company defines resources and releases further results, institutional investors usually become interested in the stock. At these stages, the stock price tends to increase.

Once a decision is made to proceed with feasibility, the stock price may decline as investors worry that a feasibility report may deem the project uneconomic. If a decision is

[36] See Ludeman, 2000
[37] See Kernot, 2006, p.69-81
[38] CIM, 2009, p.490
[39] Eeden, January 2006, found at http://www.paulvaneeden.com/Valuing.an.exploration.company, accessed date 6.06.2010
[40] Kernot, 2006, 55-68

made to go into production, the stock will still remain relatively flat, as investors are uncertain whether a company can secure financing and permits. Once financing and permits are in place, the stock may start to increase again, although at a slower pace, due to uncertainty regarding cost over-runs and other surprises.

As the mine starts production, the stock should then increase at a faster rate. The above discussion is a simplification as the stock is also influenced by general market risk and commodity price risk.[41]

Figure 7: The Life Cycle of a mine

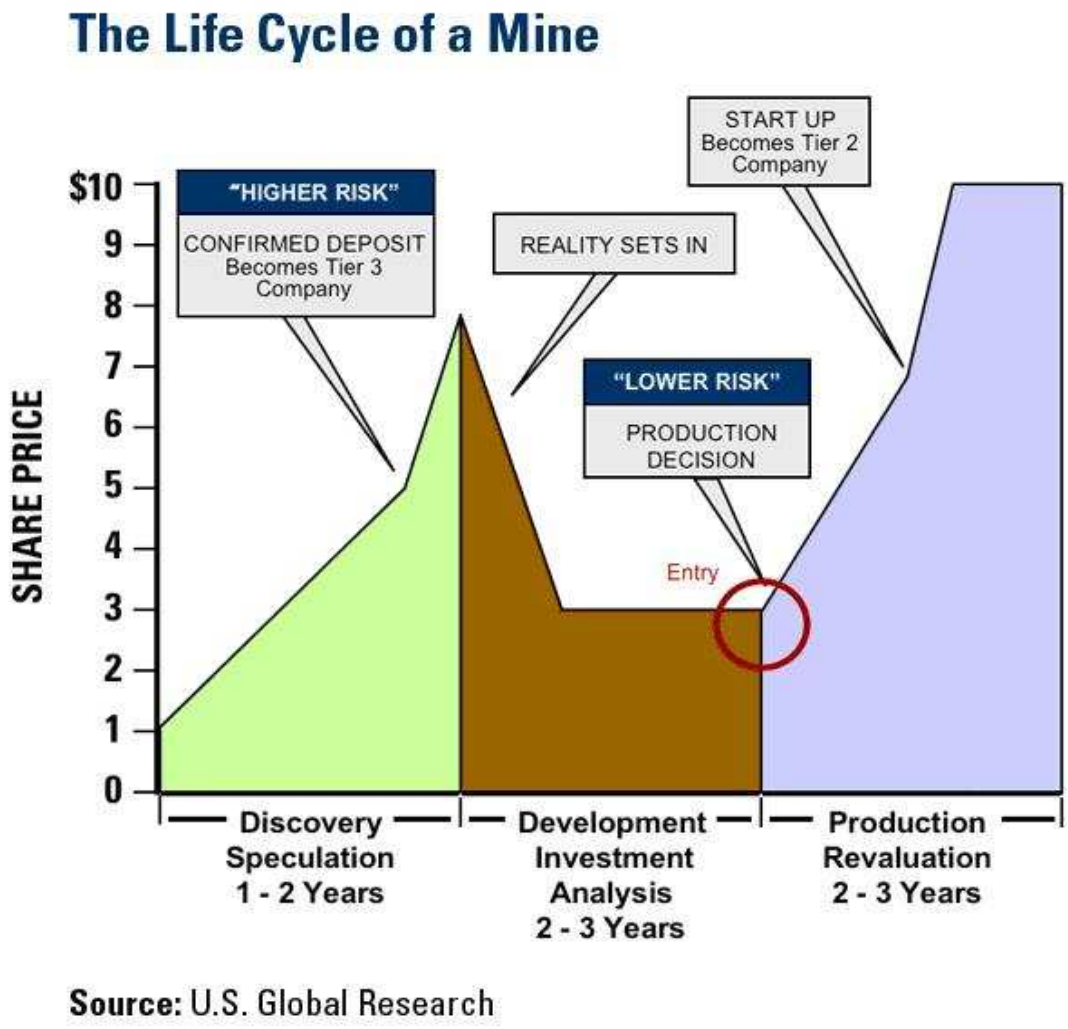
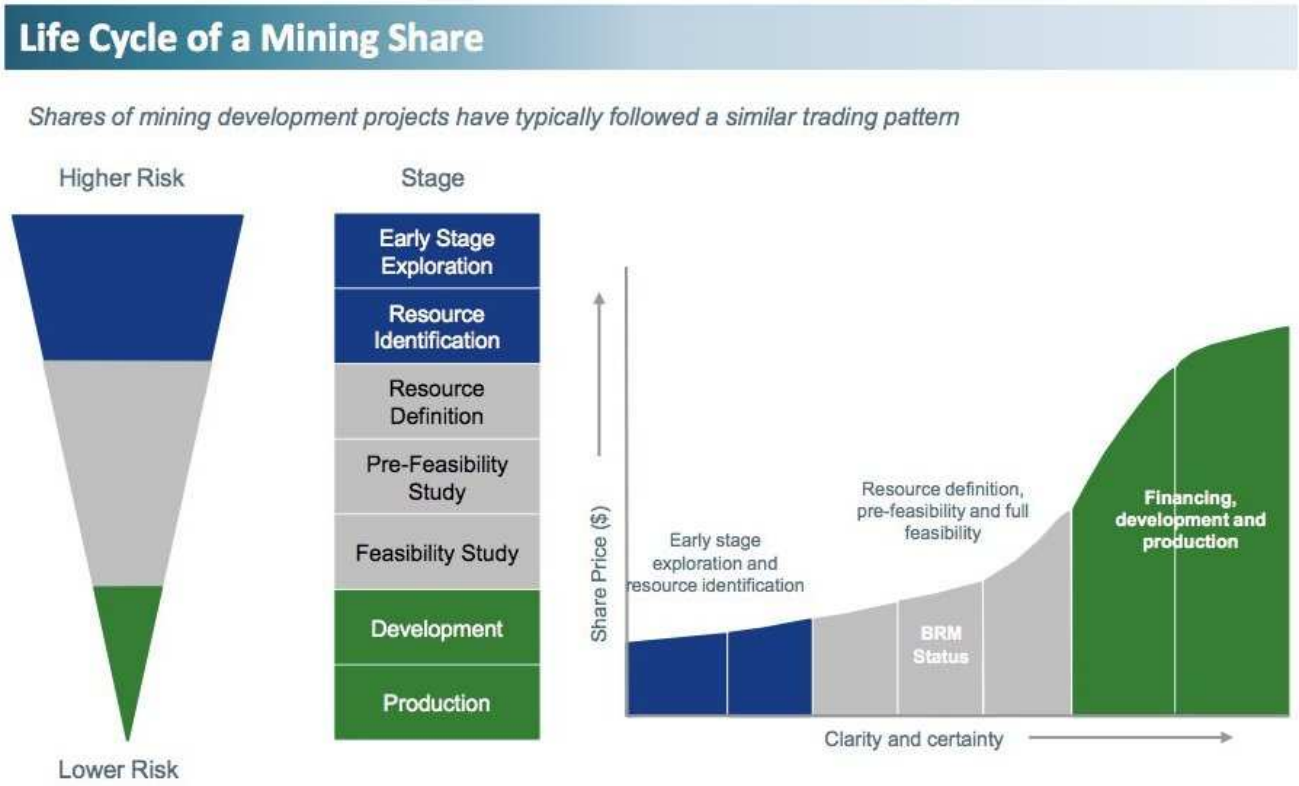


Figure 8 demonstrates the life cycle of a mining share, which shows how the share price behaves depending on the stage of the mining project. At more mature stages of the project the risk goes down and the share price goes up.

[41] Tang, March-April 2010, found at http://magazine.mining.com/issues/1003/Vol03-02-DeterminingTheRealValueOfJnrMiningCompanies-08-10.pdf, accessed date 7.05.2010

Figure 8: Life Cycle of a Mining share



Source: US Global Research

As mentioned in the Chapter 2.1, mining is a depleting business – "the more you mine, the less you have left to mine and without exploration, mining will cease very rapidly. The mining companies know they need access to good exploration projects and, more importantly, good exploration teams."[42] Therefore it is important that a company's management has the ability to generate new exploration projects – brownfied or greenfield[43], and the business acumen to joint venture those projects to major mining companies. They provide financial capital to the junior exploration company using its intellectual capital to generate exploration ideas.

Valuation of exploration companies has a higher subjectivity compared to mining companies. Therefore, investment in exploration properties is the realm of the professional investor that is able to access the relative probability of an economic discovery.

[42] Eeden, January 2006, found at http://www.paulvaneeden.com/Valuing.an.exploration.company, accessed date 6.06.2010

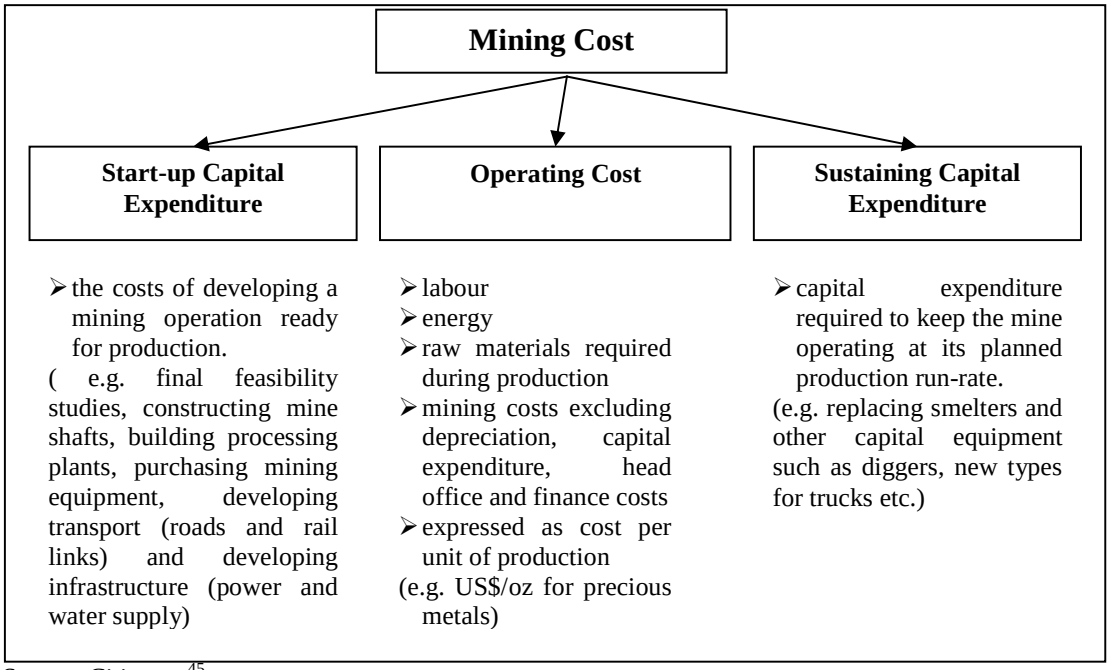
[43] With a b*rownfield* exploration project a mining company can discover new ore zones and extend existing ones "in the shadow of a headframe". It is the most prospective geologically and it is also fundamentally more economical to find ore near existing mining infrastructure. Brownfields exploration is less risky, as the geology is better understood and exploration methodology is well known, but since most large deposits are already found the rewards are incrementally less.

A g*reenfield* project involves the discovery and/or the development of a land that has not been previously developed for commodity mining and starts mining of that commodity there, found at http://www.quantecgeoscience.com/Minesite/index.php, access date 15.06.2010

3.1 Appraised Value Method (Cost Approach)

The Appraised Value Method is based on the premise that the real value of an Exploration Property or a marginal development property lies in its potential for the existence and discovery of an economic mineral deposit. The Appraised Value Method assumes that the amount of exploration expenditure is related to its value.[44] Therefore, it is important to understand the definition of capital expenditure in mining industry. They are given below in the Figure 9.

Figure 9: Different Cost in Mining Industry



Source: Citigroup[45]

The appraised value is the sum of the meaningful past exploration expenditures and warranted future costs. Only those past expenditures that are considered reasonable and that have contributed to identification of exploration potential are retained as contributors to value. Warranted future costs comprise a reasonable exploration budget to test the identified potential.[46] However, the Exchanges do not generally accept the inclusion of warranted future expenditures for the purposes of the appraised value method. Also associated administrative costs will generally not be accepted.[47]

Appraised Value = Retained Past Expenditures + (Warranted Future Costs)

Past expenditures are usually analyzed on an annual basis, using technical expertise to assess which expenditures to retain and which to reject in terms of

[44] Roscoe, found at: http://www.cim.org/mes/pdf/VALDAYBill_Roscoe.pdf, accessed date 3.04.2010
[45] Citygroup: Fitzpatrick, Sainsbury, Jansen, August 2007
[46] Oliver/ Roscoe/ Chamois, December 2008
[47] CIM, 2009, p. 512

identifying remaining exploration potential. Usually little of the expenditures more than five or so years prior to the effective valuation date are retained. In the case of dual or multiple property ownership, the Appraised Value of the whole property is determined first, and then the value is apportioned to one or more of the property owners.[48]

In this method a property is deemed to be worth what has been spent on it, with a premium, if results are positive, or a discount if results are poor. If we are valuing past producing mines which have some usable infrastructure available, we should take into account what the replacement value of this infrastructure might be at today's prices and accordingly add some premium to the value of the mine.

R. Lawrence and Agnerian restrict the accumulation of such expenditures to the past three or four years, rather than to all historic costs, with the accumulation basis ranging from 100% positive results, to 25% for negative results but with some exploration potential, to 0%-10% with little or no potential.[49]

The appraised value method is best applied to properties which are actively being explored. It is more difficult to apply the method to properties that have been idle for some years, especially those which have had substantial expenditures in the past.

One advantage of the Appraised Value Method is that exploration cost information and technical data are readily available for most exploration properties and marginal development properties. It is a good way of comparing the relative values of exploration properties. The main disadvantage is that experienced judgment is required to separate the past expenditures considered to be productive from those considered not to contribute to the value of the property, and to assess what is a reasonable future exploration program and cost. This leaves the method open to misuse and possible abuse.[50]

It is prudent to compare the Appraised Value of an exploration property with values obtained from other methods, particularly those which use Market Approach, as summarized in the next part of this paper.

3.2 Comparable Transactions (Market Approach)

Comparable methods allow the value estimated for a mining project to be benchmarked against mining project values established in the market. Comparable methods thus are a key tool for ensuring value estimates are congruent with what the market would actually pay.[51]

The comparable transaction method uses the transaction price of comparable properties to establish a value for the subject property.

Determinative factors of the value an exploration property:

[48] Roscoe, found at: http://www.cim.org/mes/pdf/VALDAYBill_Roscoe.pdf, accessed date 3.04.2010
[49] See Thompson, found at: http://www.cim.org/mes/pdf/VALDAYIanThompson.pdf, accessed date 21.04.2010
[50] Domingo/ Lopez-Dee, March 2007, found at http://unstats.un.org/unsd/envaccounting/londongroup/meeting11/LG11_14a.pdf, accessed date 10.05.2010
[51] Roberts, found at http://www.infomine.com/publications/docs/Roberts2006.pdf, accessed date 15.05.2010

- potential for the existence and discovery of an economic deposit
- geological attributes: ore grade (high or low) depends of the amount of impurities in the ore. Separation of impurities gives rise to higher cost. A low grade ore will mean more material has to be processed to produce a tonne of metal versus a higher grade ore.
- mineralization, exploration results and targets, neighboring properties
- Infrastructure: a fully developed infrastructure will benefit mines through cheaper and more efficient transport links, water supply, energy supply etc.
- area and location of an exploration property: exploration properties in established mining areas often have a premium value because of the higher perceived potential for discovery of a mineral deposit, and because of developed infrastructure. Ore bodies located in remote areas, such as some Chilean copper mines high in the Andes, or deep underground, such as some South African gold mines, will have higher unit costs due to the difficulties of extraction. However, this can normally be compensated by other beneficial factors such as a high ore grade and / or valuable by-products.
- Existing permits

Challenges:

- There are a limited number of transactions for mineral properties
- There are no true comparables in the mining industry (unlike oil and gas). Each property is unique with respect to key factors such as geology, mineralization, costs and stage of exploration.
- Effective date of valuation is important (value of a property will vary widely from day to day, week to week and year to year because of the volatility of mineral price). Therefore, especially for purposes of litigation, it is necessary to establish a date on which to value the asset.
- Subjective judgment is needed to identify similar properties

Exploration property transactions give an indication of how active the market may be at any given time. It should be noted again that exploration is cyclical, and in periods of low metal prices there is often no market, or a market at a very low price. For example, if there are relatively few explorations property transactions, because of the depressed state of exploration and mining industries, market values will be relatively low. [52]

Comparable transactions are indispensable for valuing speculative and exploration properties, where there is not enough information to perform a reasonable fundamental NPV analysis. This method, when available, can provide a benchmark for development and producing properties when calculating the fundamental value of the asset. Comparable transactions also take into account the market factor for reserve and other risk.[53]

[52] Roscoe, found at: http://www.cim.org/mes/pdf/VALDAYBill_Roscoe.pdf, accessed date 3.04.2010
[53] Davis, 2002, found at http://www.bvappraisers.org/contentdocs/Conference/Graham_Davis_Economic_Method.pdf, accessed date 25.05.2010

To allow market values to be compared among projects, they are generally expressed (or normalized) as ratios of the form:

Market value / Fundamental project parameter

Table 2 summarizes the terminology typically used to distinguish between fundamental and market value, and between project and corporate value.

Table 2: Value Matrix

	Fundamental Value	**Market Value**
Project Value	Net Present Value (NPV)	Adjusted Market Capitalization (AMC) or Enterprise Value (EV) or Asset Transaction Price
Corporate Value	Net Asset Value (NAV)	Market Capitalization or Corporate Transaction Price

Source: Roberts, Craig

The market value of a mining company's project(s) (AMC or EV) is estimated from the market value of the company (market capitalization) that holds the project(s) is calculated in the following manner:

+ Company market capitalization
- Working capital
- Value of other investments
+ / - Value of hedge book
+ Liabilities
(+ Capital to production)
= Implied market value of mining projects *(AMC or EV)*

The principle is that in addition to value the projects held by a mining company, the market also takes into account things such as working capital, debt, hedge book value and other investments when deciding what to pay for a share in a company. When taking these considerations into account the market value have to be adjusted according to the table above. After the adjustment, the value of the mining project itself is isolated from the other assets and liabilities undertaken by the company.[54]

[54] Roberts, found at http://www.infomine.com/publications/docs/Roberts2006.pdf, accessed date 15.05.2010

A *company's net* asset value (NAV) is calculated from the estimated aggregate net present values (NPV's) of the company's projects, by essentially the reverse back in comparison to the AMC:

Aggregate net present value of company's projects:

+ Working capital

+ Value of other investments

+ Value of hedge book

- Liabilities

= **Net asset value of the company (NAV)**

Now it is possible to compare the implied market value of a company's mining projects (AMC or EV) to the estimated fundamental value (NPV) of its projects. A valuation indicates whether the estimated fundamental values are above or below the values that would likely be realized in the market.

Similarly, by comparing a company's market value (market capitalization) to its estimated fundamental value (NAV), an analyst can calculate the premium or discount the market is paying to a particular fundamental value (NAV) estimate.[55]

Table 3 shows some examples of comparable project parameters and market valuation ratios of a comparable project.

Table 3: Parameters for relative PV valuation

Comparable project parameter	Market valuation ratio of comparable project
Geological resource	AMC / oz resource
Mineable reserve	AMC / oz reserve
Operating cash flow (= EBITDA)*	AMC / operating cash flow or EBITDA
Cash flow after capital (= EBIT)*	AMC / EBIT
Net cash flow (= Earnings)*	AMC / NCF or earnings
Net present value	AMC / NPV

Source: Roberts

As the table moves down, more information of the project is taken into account, including all information in the upper parameters. The AMC / NPV ratio includes all the quantifiable information about a project comparables to derive a single ratio for market to fundamental value.

Equity Value / Current Resources ratio is also one of the widely used ratios. Table 4 gives an example of iron ore transactions comparables and this ratio. If two companies would have approximately the same Current Resources but different Equity Value, logically the ratio of the company with higher Equity Value would have higher Equity

[55] Roberts, found at http://www.infomine.com/publications/docs/Roberts2006.pdf, accessed date 15.05.2010

Value / Current Resources ratio. But the advantage would have the company with lower ratio.[56]

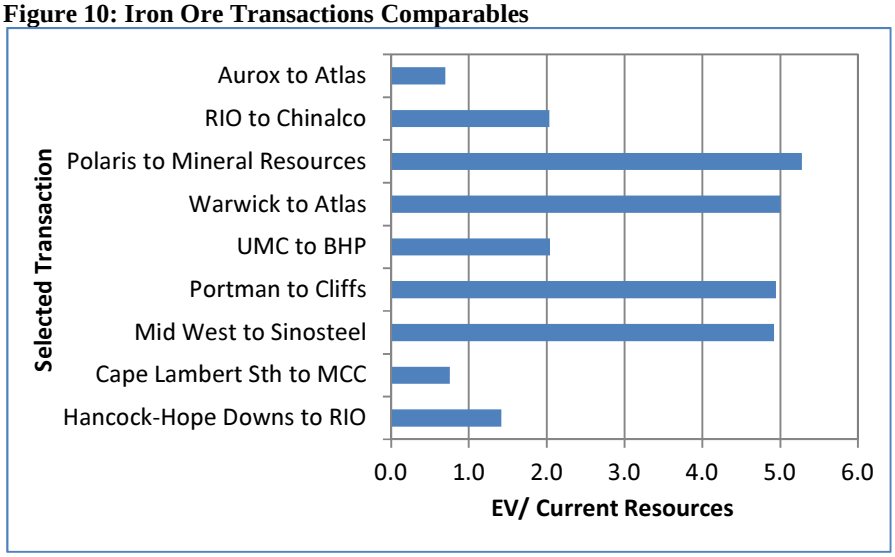
Table 4: Iron Ore Transactions Comparables

Transactions	Date	Current Resources (Mt)	Capex required (US$M)	Full Cost (EV+Capex) (US$M)	Equity Value (EV) (US$M)	EV/ Current Resources
Hancock-Hope Downs to RIO	Jul 05	423	1330	1930	600	1.4
Cape Lambert Sth to MCC	Aug 08	487	2000	2368	368	0.8
Mid West to Sinosteel	Seo 08	243	2956	4152	1196	4.9
Portman to Cliffs	Nov 08	94	Na	465	465	4.9
UMC to BHP	Oct 09	92	123	311	188	2.0
Warwick to Atlas	Dec 09	15	Na	na	75	5.0
Polaris to Mineral Resources	Feb 10	25	115	247	132	5.3
RIO to Chinalco	Mar 10	1487	6600	9624	3024	2.0
Aurox to Atlas	Mar 10	205	1178	1321	143	0.7
Average						3
Median						2

Source: Ocean Equities Ltd, Ferrous Resources Limited, p. 38

Figure 10 shows that Cape Lambert Sth to MCC and Aurox to Atlas companies have the lowest EV/ Current Resources Ratio. Therefore, they have an advantage over the other companies at first view leaving aside any of the determinative factors described earlier (infrastructure access, ore grade, existing permits etc.).

Figure 10: Iron Ore Transactions Comparables



Source: Ocean Equities Ltd

Implementing market comparable analysis involves a number of challenges, for example in selecting valid comparables, and in estimating the market value of comparable projects from the companies that own those projects.

[56] Ocean Equities Ltd, May 2010, p. 38

Any of approaches should not be used as stand-alone valuations methods for any rigorous valuation of advanced mining projects or operating mines. By estimating both market and fundamental values for the comparables, rather than only the market value of the comparables, the valuator is able assess how the market is really valuing projects relative to their estimated fundamental value. Market and fundamental approaches can and should be combined into an integrated valuation procedure.

4 Cycle importance in valuation of mining and metals companies

Before going to the detail of DCF and Multiples methods, it is useful to know which errors analysts commonly make when valuing mining companies. As far as mining companies are concerned, the cycles are doubly important because they suffer falling demand and falling prices, yet cost and interest bills on new deposits will continue to rise.[57]

Usually analysts ignore the economic or commodity price cycle or they fixate on it (put a great deal of weight on current financial statements). The consequences are listed below:

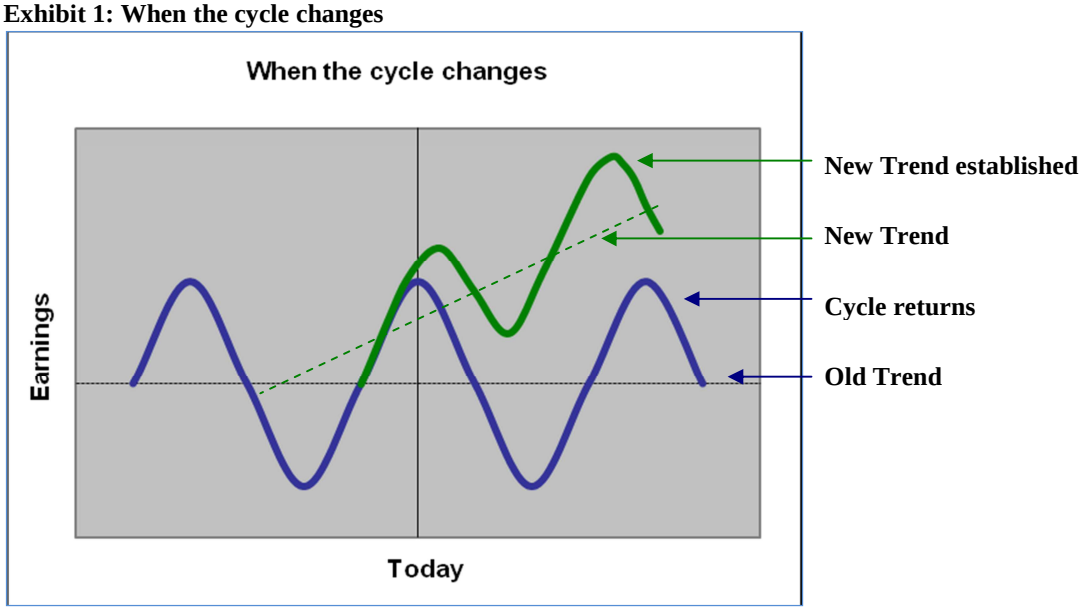
Base year fixation:

- If the base year is at or close to the peak of a cycle, and we use the numbers from that year as the basis for valuation, we overvalue the companies.
- If the base year represents the bottom or trough of a cycle, we consistently underestimate their values.
- Inputs are skewed such as
  - *Profitability measures* (profit margins, Return on Equity (ROE), Return on Capital (ROC))
  - *Reinvestment measures* (capital expenditures and investments in working capital)
  - *Debt ratios and cost of funding*
  - *Risk –free rates and risk premiums* change over the economic cycle, with the former decreasing and the latter increasing as economy slows. Thus, cost of financing changing from period to period.[58]

The cycles are hard to predict, particularly their inflection points. The share price volatility of metals and mining companies can be explained by the uncertainty over the direction of the industry cycle. An example of a new cycle is illustrated in the Exhibit 1. Of course, a new cycle trend can also lie under the old cycle trend.

[57] See Kernot, 2006, p.202
[58] Damodaran, 2010, p. 417-449

Exhibit 1: When the cycle changes



Source: McKinsey & Company, Inc, 2000

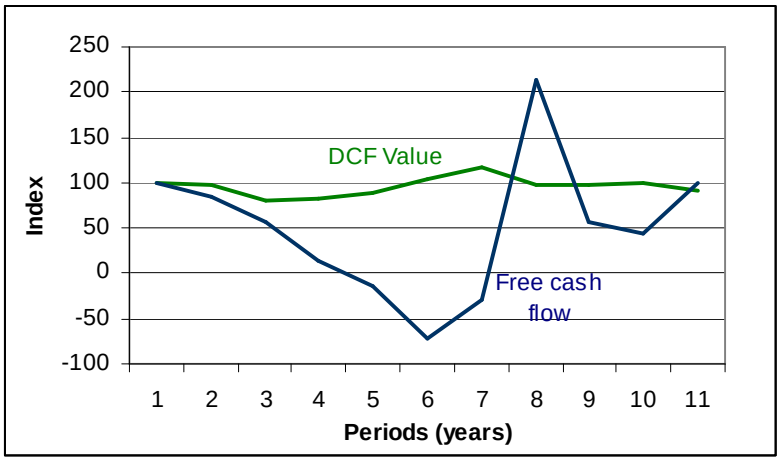
The cyclicality could also include the start-up of new mines leading to the oversupply of a thinly traded commodity or the introduction of new tax incentives to try to encourage the development of new operations. Such cycles are important, but unfortunately, somewhat unpredictable. However, they do occur and need to be included in any discounted valuation.[59]

In order to reduce mistakes, at least the price cycle of the commodity should be included in any analysis of mining company cash flows – especially companies with only a relatively short projected life.[60]

DCF reduces future expected cash flow to a single value. Therefore DCF Value has much lower volatility than the earnings or cash flows included in the valuation. This is illustrated in exhibit 2.

[59] Kernot, 2006, p. 179-202
[60] See Kernot, 2006, p. 192-203

Exhibit 2: The Long-Term View: Free Cash Flow and DCF Valuation

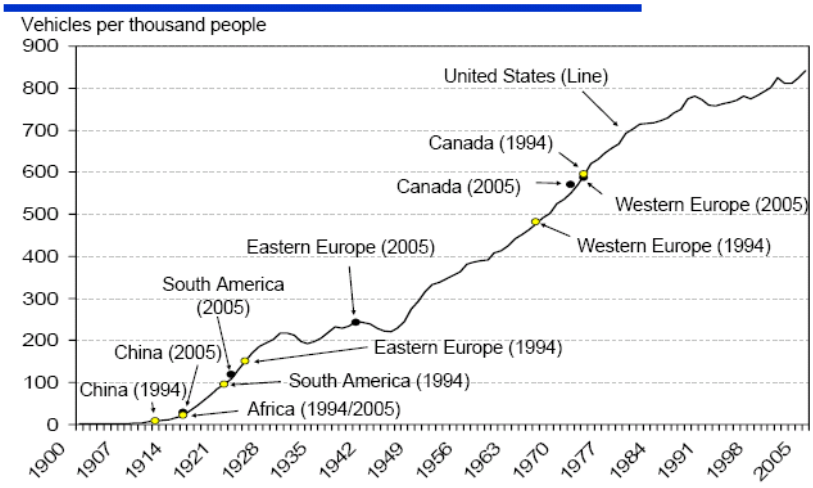


Source: McKinsey & Company, 2000, the data for this chart are presented in the Appendix 1.

As a result, any single year is not important when valuing a mining company with DCF method, as the high cash flows cancel the low cash flows. Therefore, many financial analysts use the reversion to the mean in their price forecasting.[61] The idea of this method is that both, high and low prices are temporary and that a price will tend to have average price adjusted for inflation, over time. Thus, only the long-term trend really matters and long-term commodity prices are widely used in DCF valuation.

However, there are some facts against the reversion to the mean methodology. "The world is hungry for commodities. Urbanization drives infrastructure development; increased economic development drives wealth which drives consumption… this will be a commodity demand driver for several decades to come".[62] Exhibits 3, 4, 5 and 6 confirm this tendency:

Exhibit 3: China and India lagging behind

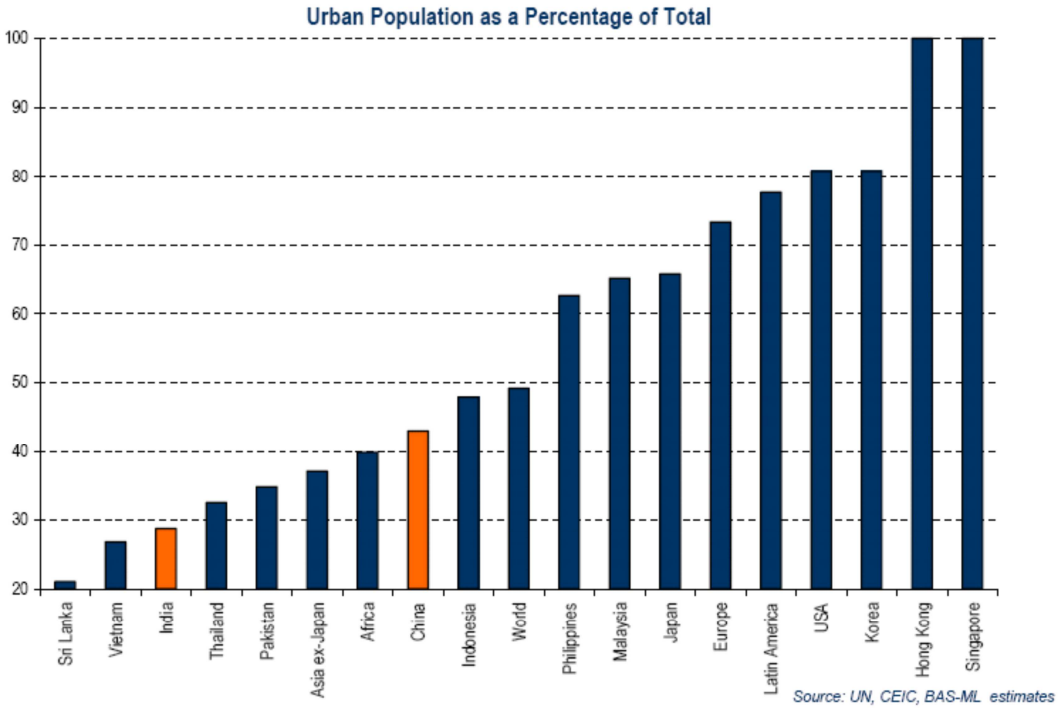


Source: Basinvest AG

[61] Real Options in Petroleum, found at http://www.puc-rio.br/marco.ind/revers.html, access date, 14.06.2010

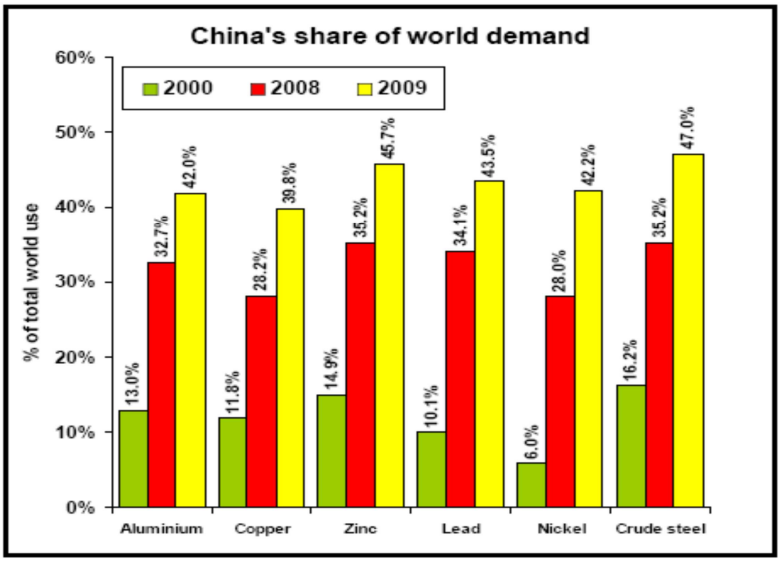
[62] Basinvest, 2010, see Exhibit 3, 4, 5 and 6

Exhibit 4: China, India: Urbanization drives commodity use



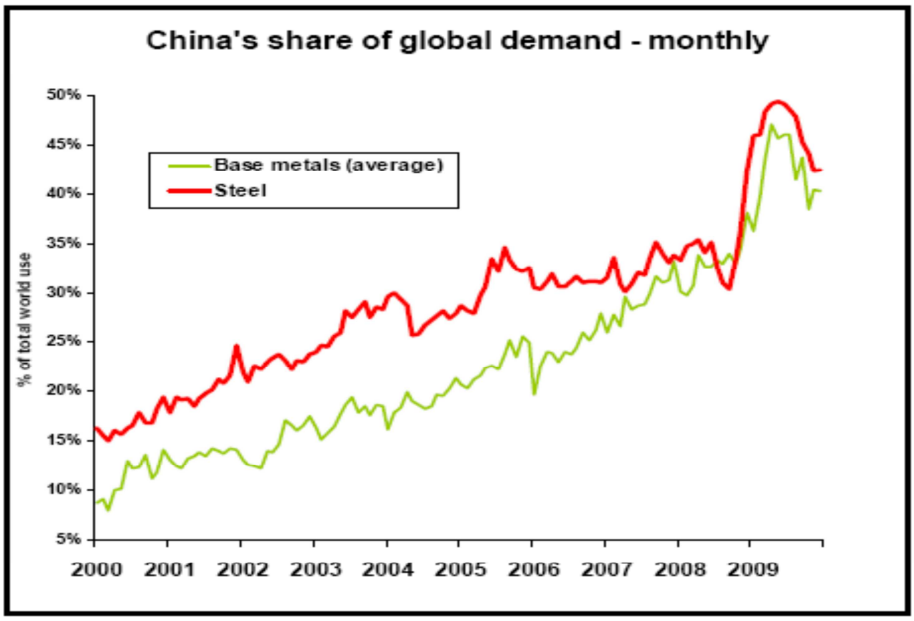
In recent months, China has represented 46–49% of world steel demand and 45–46% of World base metal demand compared with 34.4% and 32.8%, respectively, in 2008.

Exhibit 5: China‘s share of global demand soars in



Source: China Metals, Macquarie Research, January 2010

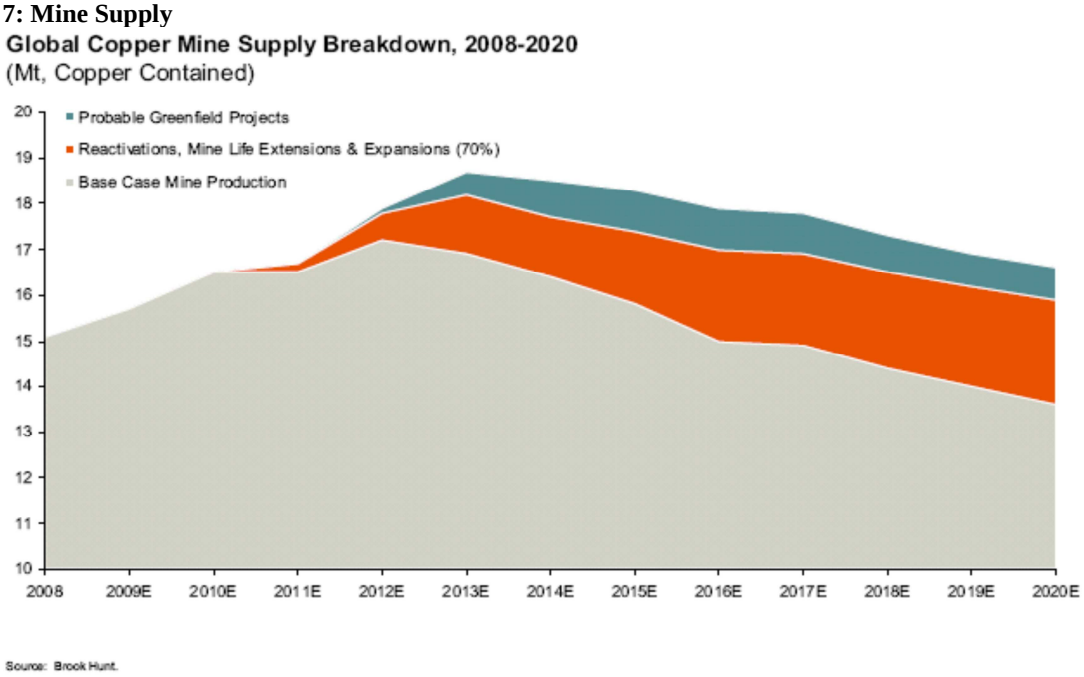
Exhibit 6: China`s share of global demand - monthly



Source: China Metals, Macquarie Research, January 2010

The problem is that supply for non-renewable commodities grows slower than its demand (see Exhibit 7).[63]

Exhibit 7: Mine Supply



[63] Basinvest, 2010

Therefore the prices of commodities in the long-term view should increase and not stay constant like it is assumed in reversion to the mean methodology.

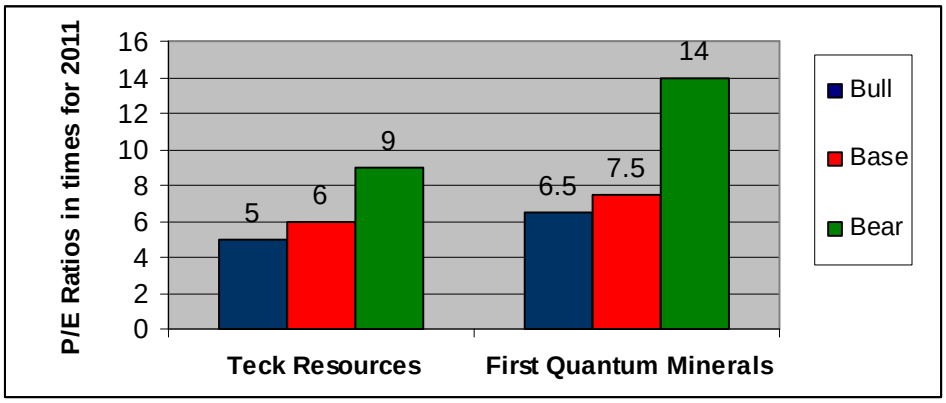
Regarding multiples valuation, which will be in detail described in chapter 5.1, the price cycle can be included in the valuation at following manner. Reasonable valuation approach is to build three scenarios and calculate price/earnings ratio for each of them and compare their values.

Example:

1. "Bull market" scenario: with a certain percent probability the industry breaks out of the cycle and follows a new long-term up-trend based on current improved environment.
2. Base market scenario: with a certain percent probability the cycle will follow the past, and that the industry will turn down in the next year so.
3. "Bear market" scenario: with a certain percent probability the industry breaks out of the cycle and follows a new long-term downtrend based on current improved environment.[64]

Exhibit 8 illustrates this approach for two mining companies: Teck Resources and First Quantum Minerals. It shows also that P/E ratios are usually lower in the bull market case than in the bear market case, because of higher commodity prices at the bull market and hence earnings of commodity companies.

Exhibit 8: P/E Ratios for Different scenarios

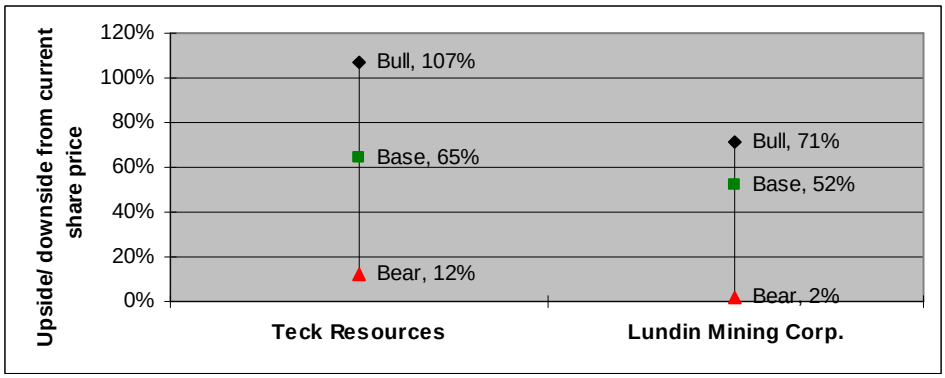


Source: Bank of America Merrill Lynch, Global Metals and Mining

Exhibit 9 presents upside and downside potential from current share price of two mining companies. You can see that Teck Resources offers better upside and downside protection than Lundin Mining Corporation in all scenarios.

[64] The terms bull market and bear market describe upward and downward market trends, respectively

Exhibit 9: Upside and downside potential according to different scenarios



Source: Bank of America Merrill Lynch, Global Metals and Mining

This probabilistic approach avoids the traps of the single forecast and allows the exploration of a wider range of outcomes and their implications. "If cycles did not exist then a mining company would not make a point of being a low cost producer.[65] Indeed, in such a situation, there would be no need to worry about massive declines in prices, revenues and earnings which occur at the bottom of a recession."[66]

5 Discounted Cash Flow

5.1 Introduction

Delimitation: there are different variations of the Discounted Cash Flow concept.[67] This paper will not describe the wide range of them, but will illustrate the use of the DCF method specifically for mining companies.
In order to calculate an accurate valuation of a mining company it is necessary to have access to detailed information (i.e. primary research) about all aspects of the company – its deposit, mine plan, process routes, operating costs, financial structure, tax regime and management qualities.[68]

In undertaking any discounted cash flow analysis, it is important to recognize certain fundamental attributes of the mining industry:

- The basis of any mineral development is the existence of an ore reserve.
- Costs are determined by the number of pounds or ounces mined and processed, while revenues are determined by the number of pounds or ounces of metal sold times price of the metal. The two are related by the recovered grade of the ore.

[65] Appendix 3 gives a sample calculation of low and high cost producer margins and explains the leverage of high cost producer.
[66] Kernot, 2006, p. 203
[67] Kruschwitz/ Löffler, 2005, p. 1-30. In this book different variations of DCF concept and the economic differences between them are clarified
[68] Kernot, 2010, p. 192

- Profit is typically more sensitive to changes in revenue than it is to changes in cost due to the high fixed cost nature of the business.
- Commodity price is a principal determinant of revenue, but it is also the factor with which the greatest level of financial risk is associated.[69]

It must be taken into consideration that DCF is not applicable to early stage projects without reasonably assured mineral reserves, workable mining plants with rates, metallurgical test results and process recoveries, capital and operating cost estimates, environmental and reclamation cost estimates and commodity price projections.[70] The reason of this is the theory behind DCF: the value of every asset is simply the present value of the cash flows this asset produces over the lifetime. One must have enough information that we can reasonably estimate cash flows from production. Therefore DCF is only appropriate for mineral properties in production, very near production or for mineral properties at the stage of development.[71] In these cases, the economic viability of the property will be based on preliminary estimates of production, revenue and cost. Despite the preliminary nature of the underlying estimates, it is still generally accepted that discounted cash flow analysis is the best method of valuing mineral properties at this stage of development.[72]

5.2 Inputs and Mechanics of DCF analysis

The most important factors in DCF method is **the Discount Factor** and **the assumption of long-term prices**. The other principal factors which need to be estimated in providing input to a DCF analysis are:

- **Tonnage and grade of the mineable reserve**
- **Revenue** (volume x price)
- **Production costs**
    - **Operating Costs**
    - **Capital Expenditure**
    - **Taxes and Royalties**[73]

These inputs are shown in a figure 11, a simplified example of a spreadsheet for DCF valuation. The left-hand column of the spreadsheet list the various factors (typically in much greater detail than shown in Figure 11) which influence the levels of cash revenue and cash expenditure associated with the property being valued. The top line specifies the time periods, typically years, over which the property is to be valued. This time period should cover the full productive life of the known reserves and may be extended further to account reasonably for the discovery of new reserves, should the

[69] Lattanzi, found at http://www.cim.org/mes/pdf/VALDAYChrisLattanzi.pdf, accessed date 31.05.2010
[70] See Damodaran, 2010, p. 417-449
[71] Tang, March-April 2010, found at http://magazine.mining.com/issues/1003/Vol03-02-DeterminingTheRealValueOfJnrMiningCompanies-08-10.pdf, accessed date 7.05.2010
[72] Lattanzi, found at at http://www.cim.org/mes/pdf/VALDAYChrisLattanzi.pdf, accessed date 31.05.2010
[73] Lawrence, found at http://www.cim.org/mes/pdf/VALDAYLarrySmith.pdf, accessed date 30.05.2010

geological potential of the property warrant this. In practical terms the value today of cash flow in year 25 is relatively small and so it is not normally necessary to take such long life reserves into account in the valuation process.

Figure 11*:* Simplified Discounted Cash Flow Valuation (all Units in thousands)

	Year 0	Year 1	Year 2	Year 3	Total
Gold produced		200	250	280	730
Gold price		500	500	500	500
Sales Revenue		**100'000**	**125'000**	**140'000**	**365'000**
Less: Site Operating Cost		55'000	70'000	70'000	195'000
Refining		1'500	1'700	1'700	4'900
Operating Profit		**43'500**	**53'300**	**68'300**	**165'100**
Less: Income Tax		5'000	9'000	11'000	25'000
Capital Expenditure	80'000	640	1'600	9'600	91'840
Net Cash Flow	**-80'000**	**37'860**	**42'700**	**47'700**	**48'260**
Discount Factor (13%)		0.885	0.783	0.693	2
Net Present Value	**-80'000**	**33'504**	**33'440**	**33'058**	**20'003**
Total Net Present Value ($ millions)	**20'003**				

Source: C. Lattanzi

Obviously, the accuracy of the numbers, representing the forecast level of a particular factor at a specified future period of time, will determine the validity of the resultant estimates of profitability and rate of return on invested capital.[74]

In the simplified valuation shown in Figure 11, the computed net present value of the stream of future annual cash flows, at a assumed discount rate of 13% per year, is $20'003 million. This means that, if an investor paid $80'000 million for this property, the future cash flow stream would be sufficient to return the entire $80'000 million.

In order to perform a proper discounted cash flow analysis, therefore, it is necessary to make a separate and reasoned estimate of the future value of each of the factors which will influence cash revenue and cash expenditure. The more comprehensive the available data, the more reliable will be the discounted cash flow valuation.

5.3 Discount Factor

The first variable that has a greatest impact on a discounted cash flow valuation is the discount rate. Depending on the life of the project the different discount rates cause a variation of a more than 50% in the value placed on a project! Consequently it is crucial to calculate an appropriate discount rate. Most of the books and articles focus on the calculation of the corporate cost of capital. However, it is possible to determinate a discount rate that is appropriate for an individual project on the basis of industry expectations for project returns (Internal Rate of Return[75]), the risk factors associated with mineral projects in general, and the risks related to the specific project.[76]

[74] Lattanzi, found at http://www.cim.org/mes/pdf/VALDAYChrisLattanzi.pdf, accessed date 31.05.2010
[75] Internal Rate of Return (IRR) reflects the rate of interest or discount factor that reduces the future cash inflows to the value of the initial cash outflow, Kernot, 2006, p.203/204
[76] Lawrence, found at http://www.cim.org/mes/pdf/VALDAYLarrySmith.pdf, accessed date 30.05.2010

The formula for calculating IRR of a project using iterative techniques in computer spreadsheet packages is:

$$X = \sum \frac{Y(n)}{(1+i)^n}$$

where: X = *the initial outflow*
$Y(n)$ = *the inflow in year n*
i = *the internal rate of return (IRR)*

By comparing the IRR of a project with its cost of capital a company will be able to determine whether or not the mine will be economically viable.[77]

Cost of Debt

Most mining companies assume that the cost of funding is calculated on the basis of the company's weighted average cost of capital. In the countries where debt service costs can be offset against taxable income the cost of capital calculation is weighted to take account of the tax efficiency of debt.[78]

The cost of Debt is calculated on an after tax basis. Consequently, the actual yield of the company's long term debt is adjusted for the local marginal tax rate of the company. Risk of a project and of the country where the company is situated must be included in the calculation of cost of debt:

$$Cd = (r_f + r_p) \times (1 - t)$$

Where: Cd = *Cost of Debt*
r_f = *Risk-free country rate*
t = *the company's marginal tax rate expressed in percent*
r_p = *risk premium which adequately reflects risk of the project*[79]

Cost of Equity

Cost of equity capital is, perhaps, one of the most contentious elements of the whole calculation process and it is too wide a subject to be covered in detail here.

The *Capital Asset Pricing Model (CAPM)* is perhaps the most widely used method of assessing the cost of equity capital and expressing it as an interest rate. The cost of equity is related to the assumed market cost of equity and the beta of the company's own shares to give the premium or discount to the market cost of equity for the specific company:

$$Ce = r_f + \beta * (r_m - r_f)$$

[77] Kernot, 2006, p. 203-205
[78] Kernot, 206, p. 205
[79] Viebig/ Poddig / Varmaz, 2008, p. 37

where:

Ce = cost of equity

r_f = the risk-free Rate

β = the beta of the company (expresses the variability of the common stock with respect to the variability of the market as a whole)[80]

r_m = the markets cost of equity

$r_m - r_f$ = can be also described as a market premium[81]

Weighted Average Cost of Capital (WACC)

Using the results of the previous calculations the formula to generate a company's weighted average cost of capital (WACC) is calculated as follows:

$$WACC = \frac{(Equity \times Ce) + (Debt \times Cd)}{(Equity + Debt)}$$

where:

Equity = *market value of equity*

Debt = *market value of debt*

Given that the cost of finance will include an inflation component it is necessary to allow for inflation in the forecasts. At its lowest levels in decades, it still reflects itself as cost increases of 2% to 3% each year. The inclusion of inflation in the forecasting process is a necessity as the cost of capital used in calculation will include an inflationary component, effectively the interest premium of a long term government bond over the interest rate of an equivalent dated index linked security.[82] One example from the praxis is illustrated in exhibit 10. Almost half of Rio Tinto's[83] increase in capital expenditure between 2003 and 2006 was absorbed by inflation.

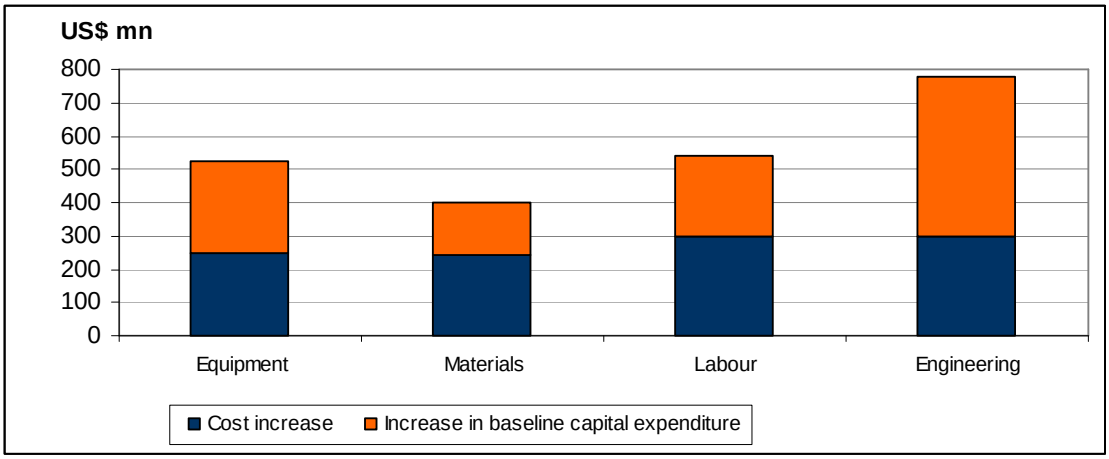
[80] By definition, the beta of the market is 1.00. A stock with a beta greater than 1, will tend to outperform the market, should it rise or fall, whereas one with a beta of less than 1 will underperform. During a bull market a portfolio should therefore be constructed with a beta greater than 1, during a bear market the converse should be the case. Kernot, 2006, p.226

[81] Mc Kinsey & Company, Inc. Copeland/ Koller / Murrin, 2006, p. 231

[82] Kernot, 2006, p. 205-208

[83] Rio Tinto is one of the world's leading mining and exploration companies, found at www.riotinto.com, accessed date, 26.05.2010

Exhibit 10: Breakdown of capital expenditure increases 2003-2006 for Rio Tinto



Source: Rio Tinto. Banc of America Securities-Merrill Lynch Commodity Research

Risk Components in a Mineral Project

A discount rate for a mineral project comprises three principal components:

- *Risk-Free Interest Rate* The value of the long-term, risk-free, real (no inflation) interest rate is approximately 2.5%. Long term averages range from 2.3% to 2.6%. The 2.5% value is supported by numerous references in the literature and is set out in Ontario law.[84]
- *Mineral Project Risk* include risks associated with reserves (tonnage, mine life, grade), mining (mining method, mining recovery, dilution, mine layout), process (labour factors, plant availability, metallurgy, recoveries, material balances, reagent consumption), construction (costs, schedules, delays), environmental compliance, new technology, cost estimation (capital and operating), and price and market.
- *Country Risk* refers to risks that are related to country-specific social, economic, and political factors.[85]

Using these components, it is possible to calculate a project specific discount rate:

+ Real, risk-free, long-term interest rate	2.5%
+ Mining project risk (varies with level of knowledge)	3.0%-16%
+ Country risk	0.0%-14%
= Project specific discount rate (constant dollar, 100% equity)	5.5%-32.5%[86]

[84] Bruce, Christopher: Ontario`s Mandated Discount Rate – Rule 53.09(1), August 2000, found at http://www.economica.ca/ew05_3p2.htm, accessed date 1.06.2010
[85] Country risk is described in the chapter 2.1 of this paper
[86] Lawrence, found at http://www.cim.org/mes/pdf/VALDAYChrisLattanzi.pdf, accessed date 31.05.2010

5.4 Mineable Reserve

The fundamental asset which underpins the value of any mining project is its ore reserve, and a thorough understanding of the reserve is the first requirement of any discounted cash flow valuation.[87]

The tonnage (size) and grade of any reserve is estimated from a limited number of samples which constitute a very small proportion of the total deposit. Sampling, by its nature, is a statistical procedure and so is the estimation of reserves. All reserve estimates, therefore, are subject to a greater or lesser degree of uncertainty.

It is fundamental to the economics of mining that costs are determined by the number of pounds or ounces mined and processed, while revenues are determined by the number of pounds or ounces of metal sold times price of the metal. These two factors, cost and revenue, are related by the grade of the ore. Dilution by waste rock increases the tonnage of material mined and reduces the grade. It increases cost and reduces revenue. It reduces value. Therefore, the importance of the concentration factor[88] in determining the value of mining company should not be undervalued. A company with a lower grade of ore will have to process more rock, possibly at greater cost in order to obtain a given amount of economically valuable material.[89]

Inaccurate analysis leads to an overestimation of reserves grade and an inadequate allowance for dilution leading further over-estimation in mined grade. This in turn, leads to over-estimation of revenue.[90]

5.5 Revenue

Revenue is determined by the price of the commodity, which dictates the payback period and the level of profit and hence dividends that shareholders expecting to receive.
Following factors have a great impact on the revenue in a mining context:

- The annual tonnage of ore mined and processed

For the major precious and base metals, once they have been smelted and refined, there are lenders of last resort, such as the London Metal Exchange, which are capable of absorbing the entire output from a new mining project. Often mining companies enter into take-off agreements to reduce commodity price risk and to ensure the profit. This is an agreement between the "buyer" and the mining company where the "buyer" obligates to buy certain amount of goods produced by the mining company at certain date.

- The rate of ore production

In the valuation of an existing mine, future rates of production can generally be forecast reliably on the basis of historical operating experience. For an undeveloped property, however, there is no such body of experience and valuation must be based on a design production rate. Valuation should be based on an estimated rate of ore production during the initial year of 60% to 75% of the design rate, depending on the complexity of the mining cycle and the process circuitry.

---

[87] The chapter 2.3 gives definitions and helps to understand differences of reserves
[88] The generally accepted background concentrations of the major metallic elements and the concentration factors required for economic viability are detailed in Table 5, page 42
[89] Kernot, 2006, p. 57-72
[90] Lattanzi, found at http://www.cim.org/mes/pdf/VALDAYChrisLattanzi.pdf, accessed date 31.05.2010

- The metallurgical recovery of saleable commodity

This is a function of the mined grade of the ore and the level of metallurgical recovery. Typically, metallurgical recovery will be estimated on the basis of test work. If a mine has been in operation for some time, the throughput of ore, the mined grade of ore and the metallurgical recovery are reasonably well identified and are, to some extent at least, controllable. The generally accepted background concentrations of the major metallic elements and the concentration factors required for economic viability are detailed in Table 5:

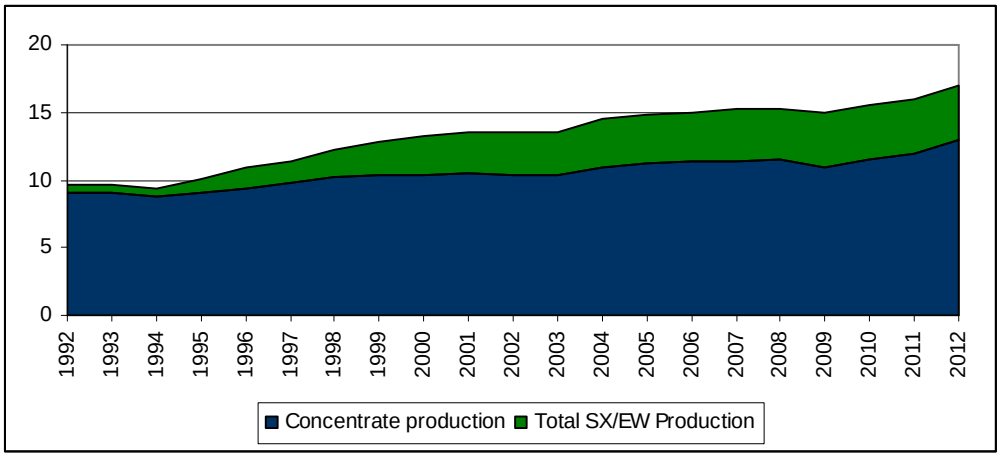
Table 5: Background concentrations of the major metallic elements

Element	Abundance wt, %	Economic grade, %	Concentration factor, x
Silicon	27.7	100	2.1
Aluminum	8.1	30	3.7
Iron	5	25	5.0
Copper	0.005	0.4	80.0
Nickel	0.0075	0.5	66.7
Zinc	0.007	4	571.0
Manganese	0.092	35	380.0
Tin	0.0002	0.5	2500.0
Chromium	0.097	30	3080.0
Lead	0.001	4	4000.0
Gold	0.0000004	0.000002 (about 5gramm/tonne)	5.0

Source: Kernot, 2006

Different types of ore are processed with different methods of extraction which have a visible impact on the cost of production. For example, oxidized copper ore bodies may be treated via a solvent extraction and electrowinning (SX-EW) plant while concentration-floatation process is used for sulfide ore bodies. Traditional sulfide ore grades require conventional milling, smelting, refining and are extremely energy intensive (comprising about 20-25% of copper production) while SX/EW allows the processing of low-grade oxide ores at much lower costs.[91] The problem is that there is not so much oxide ore left on the earth. Exhibit 11 illustrates world copper mine production by process in million tones.

Exhibit 11: World Copper mine production by process, mt



Source: Bank of America Merrill Lynch

[91] See Bank of America, Merrill Lynch, April 2010

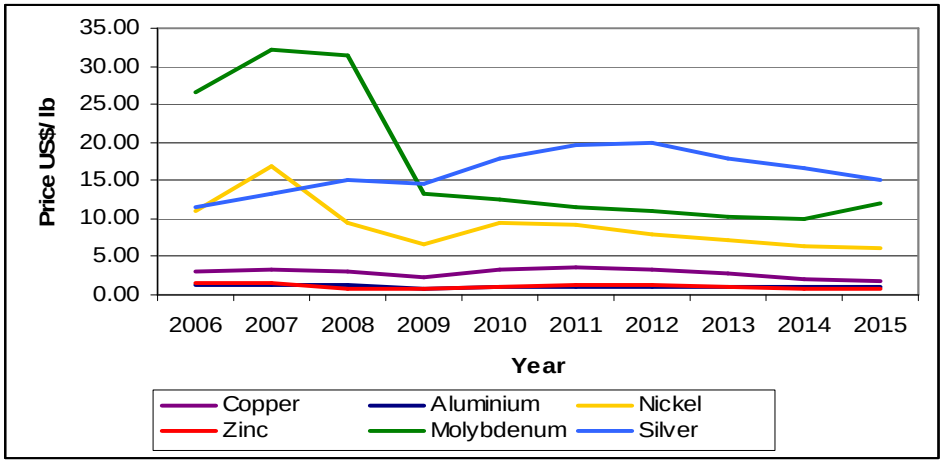
- The price of the commodity

Is normally totally beyond the control of the individual mine operator. It is, nonetheless, not only the most important determinant of revenue, but also the most important determinant of overall value. It is true that future metal prices are notoriously difficult to forecast accurately, but this does not mean that no attempt should be made to do so. Therefore, a thorough, well-reasoned forecast of supply, demand and price is an integral part of any valuation. It is clear, however, that there is a great deal of uncertainty and risk inherent in any such forecast.[92]

Mining companies make hedging using derivative financial instruments to reduce exposure to commodity price movements. They can buy and sell futures trying to eliminate underlying market price exposure.

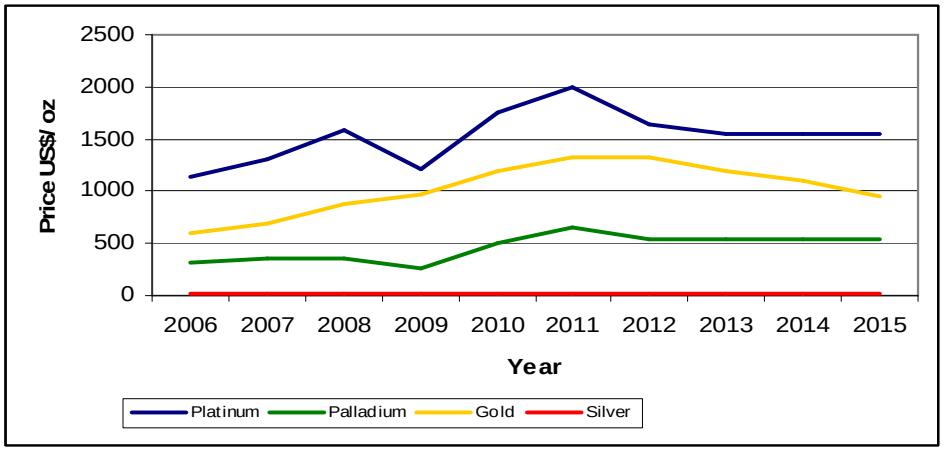
As mentioned in the chapter 4, many analysts use reversion to the mean in the price forecasting.[93] The idea of this method that both, high and low prices are temporary and that a price will tend to have average price inflation adjusted, over time is illustrated in exhibits 12 and 13.

Exhibit 12: Base Metals Price Forecasts



Source: Merryll Lynch

Exhibit 13: Precious Metals Price Forecasts



Source: Merryll Lynch

[92] Lattanzi, found at http://www.cim.org/mes/pdf/VALDAYChrisLattanzi.pdf, accessed date 31.05.2010
[93] Real Options in Petroleum, found at http://www.puc-rio.br/marco.ind/revers.html, access date, 14.06.2010

London Metal Exchange (LME) has Special Contract Rules or quality (purity) rules for each of commodities traded on LME. For example, contract/ quality for Primary Aluminium has 99.70 % purity of Aluminium, maximum 0.10% Si (Silicium) and 0.20% Fe (Latin: *ferrum*; Iron). Therefore, any deviations from quality standards will be reflected in the price: premium/ discount to LME price for higher/lower quality accordingly.[94]

To avoid subjective judgments and thus not to under- or overvalue a company, one should use the price of commodities from forward and futures markets estimating cash flows in the next few years, and use today's prices of the commodities for the current year.[95]

5.6 Production Costs:

Operating Cost

The sum of the operating cost of these three activities, such as mining, beneficiation and administration. In more detail: labour costs, consumables (energy, steel expenses), power, water, exploration and evaluation costs, stripping and mine development adjustments, third-party smelting, refining and transport costs, by-product deduction costs, administrative and distribution expenses, closure provision, severance charges, currency gain and losses other operating expenses give the Operating Cost of mining.[96]

In general, cash operating costs consist of:

- On-site costs (producing the commodity which is shipped from the property)
- Off-site costs (transportation and downstream processing of that commodity into saleable end products)

For a *gold mining* operation producing doré bars, the costs of transportation and of refining[97] the bars into gold and silver metal are typically not material in relation to the ultimate value of the metal produced. In these cases, inaccuracies in the estimate of transportation and refining cost have little impact on the results of the discounted cash flow analysis. Where gold is recovered in a sulphide concentrate, such as a copper concentrate, however, the costs of transportation, smelting and refining take on added significance. In these instances, the on-site processing plant is typically operated to maximize gold recovery, with the result that the copper grade of the concentrate is frequently relatively low. Considerable care must be taken in determining the terms under which such concentrates can be sold, since copper smelters are likely to increase their charges for treating low-grade concentrates.

For *base metal* operations producing, say, copper, zinc or lead concentrates, the costs of transportation, smelting and refining typically account for a significant proportion of the gross value of

[94] London Metal Exchange (LME) , found at www.lme.com, accessed date 15.04.2010
[95] Damodaran, 2010, p.417-449
[96] Antofagasta and BHP Billiton Annual Reports, found at www.antofagasta.co.uk, www.bhpbilliton.com, accessed date 17.05.2010
[97] Refining – remove impurities: to produce a purer form of something by removing the impurities from it, or become pure through such a process, found at http://encarta.msn.com/encnet/features/dictionary/DictionaryResults.aspx?lextype=3&search=refining, accessed date 6.06.2010

metal contained in the concentrate. In the general case, after allowing for concentrate transportation costs and smelter terms, the mine operator will receive net revenue, at the mine gate, of only about 50% of the gross value of lead and zinc contained in concentrate, and about 70% of the gross value of contained copper.

"The amount of costs depends on how far the company is vertically integrated in a supply chain. The deeper the vertical integration is the higher bound capital and fix costs are. In particular newly industrialized countries have interest to keep possibly large part of the value added in the country. The mining company Ivanhoe (Joint Venture with Rio Tinto) has Copper-Gold project "Oyu Tolgoi" in Mongolia and the company was forced to build a smelter plant. Ferro-chrome producers in South Africa are punished with a high export-tax if they want to export unprocessed ore containing chrome without processing it in ferrochrome."[98]

Clearly, then, the cost of downstream processing of base metal concentrates is a significant factor in discounted cash flow valuation, and it is imperative that these costs be accurately identified and accounted for.[99]

Capital Expenditure

Capital Expenditure is defined as development, construction, indirect costs (engineering, management), contingencies, startup, inventories, working capital, inflation cost, replacement and sustaining capital and closure costs.

In the general case, capital expenditure estimates will need to be prepared of:

- Initial preproduction cost of constructing a new mining company (will be typically vary from 500 million to 3-5 Billion dollars over a period of two or three years)
- On-going cost of replacing worn out equipment throughout the productive life of the operation (will be at a lower order of magnitude, but, since they are incurred in each operating year, they can be quite significant in total)

The degree of accuracy of preproduction capital expenditure can vary in the region of plus or minus 30%, depending of a stage of the project.

Contingency allowances of the order of 8% to 12% are typically applied to the estimates of surface capital expenditure, with somewhat higher allowances applied to the estimated cost of capital mine development. Generally speaking, discounted cash flow valuation is not sensitive to the annual allowances for sustaining capital, and relatively gross methods of estimation may be acceptable.

Equipment has a limited economic life and works fall out of use, therefore an annual depreciation[100] charge must be considered as part of the cost. The two calculated charges, depreciation and depletion[101] may be considered as giving the Capital or Investment Cost.[102]

The most common errors which occur in the estimation of preproduction capital expenditures relate to over-optimism in the construction schedule and under-estimation of

[98] Ronald Wildmann, portfolio manager von der Firma Basinvest AG, www.basinvest.ch
[99] Lattanzi, found at http://www.cim.org/mes/pdf/VALDAYChrisLattanzi.pdf, accessed date 31.05.2010
[100] Depreciation provides for the recurring expenditure on necessary replacements and for the complete redemption of the related capital expenditure before the inevitable closure sets in.
[101] An annual depletion charge is calculated to redeem the previous purchase or the exploration cost of the mineral property.
[102] See Truscott, 1984, p. 175-187

owner's cost. The estimates prepared in conjunction with a bankable feasibility study are based on a considerable amount of engineering study and detailed cost estimation.

Most commonly, the owner's capital account is also burdened by the costs of insurance, permits and licenses, environmental baseline studies and impact assessments, associated public meetings, and similar items.

Finally, there is one more point which deserves high attention, and that is the issue of reclamation cost upon closure. Under today's environmental regulations in most jurisdictions, and internationally accepted best practices it is almost invariably, that the cost of final reclamation outweighs, by a large measure, the value of salvageable equipment. In the discounted cash flow valuation this has a little significance for a mine with a projected operating life more than ten years, but can be important in the valuation of projects with lives of ten years or less.[103]

Royalties and Taxes

Across the globe, no type of tax on mining causes as much controversy as royalty tax. It is a tax that is unique to the natural resources sector and one that has manifested itself in a wide variety of forms, sometimes based on measures of profitability but more commonly based on the quantity of material produced or its value.[104]

Since 1985 over 100 countries have introduced new mining law, most of them have reformed or are now reforming their mining sector fiscal system so as to attract investors. Many mineral-exporting countries have reduced their general income tax rates and have exempted mining operations, and many other industrial activities, from other taxes such as import, duty, export duty, and value-added tax, or they have zero rated them (assessed the tax but set the rate at zero). Many nations impose royalty tax, but some nations—as diverse as Chile, Greenland, Mexico, Sweden, and Zimbabwe—do not.[105]

However, there are also some countries which lead opposite policy. In May 2010 Australia has warned mining companies their state mining taxes may increase up to 40% on profits. On one hand, that could encourage smaller mining companies looking at Australia who might not have invested to invest now, because mines in early development which are not making a profit in their early years would not pay the tax.[106] On the other hand such taxes will burden mining companies in production and their share price, such as BHP Billiton.[107] Figure 12 illustrates comparison of global mining tax burdens and shows the impact of *Resource Super Profit Tax* (RSPT) in Australia.

---

[103] Lattanzi, found at http://www.cim.org/mes/pdf/VALDAYChrisLattanzi.pdf, accessed date 31.05.2010

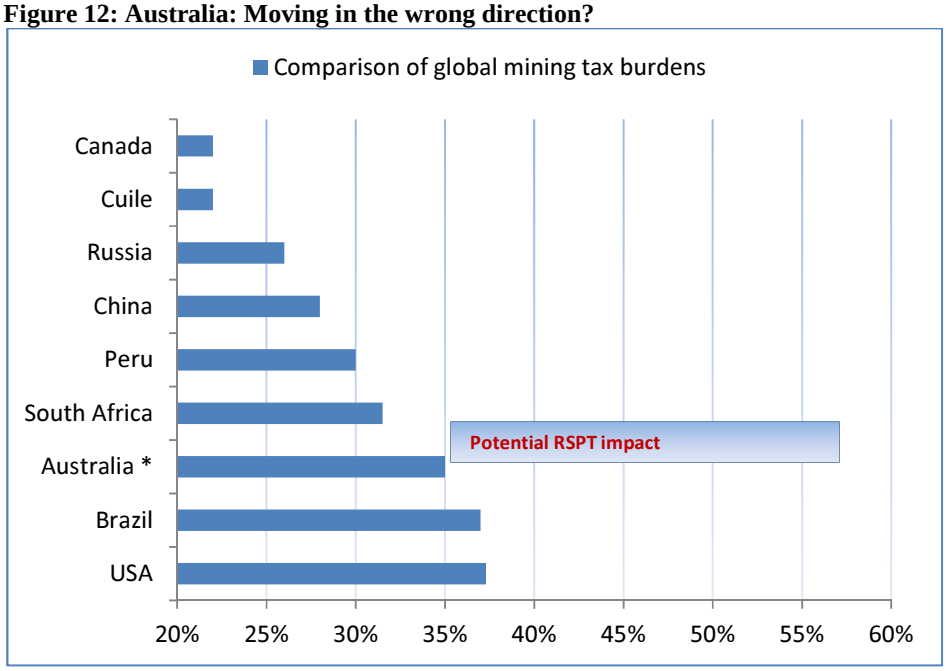
[104] The World Bank, 2006, found at http://siteresources.worldbank.org/INTOGMC/Resources/336099-1156955107170/miningroyaltiespublication.pdf, accessed date 25.05.2010

[105] The World Bank, 2006, found at http://siteresources.worldbank.org/INTOGMC/Resources/336099-1156955107170/miningroyaltiespublication.pdf, accessed date 25.05.2010

[106] Business with The Wall Street Journal, May 2010, found at http://www.theaustralian.com.au/business/in-depth/state-royalty-payments-may-increase-south-australia-warns-miners/story-fn5eo6td-1225861497831, accessed date 10.05.2010

[107] "Royalty rates will increase from 3.75 per cent of sales revenue to 5.625 per cent for Fines and from 3.25 per cent to 5.0 per cent for Beneficiated Ore. The Lump royalty will be 7.5 per cent, which is already the prevailing rate for most of the Lump ore produced from projects managed by BHP Billiton", found at http://www.bhpbilliton.com/bb/investorsMedia/news/2010/bhpBillitonAnnouncesAgreementWithTheGovernmentOfWesternAustraliaToAmendRoyaltiesAndStateAgreements.jsp, accessed date 12.05.2010

Figure 12: Australia: Moving in the wrong direction?



Source: USGS, E&Y, Citigroup

Regulations governing the levels of taxation applicable to mining companies vary from jurisdiction to jurisdiction.

Usually applied taxes:

- income tax: 25% to 35%
- withholding tax on dividends, loan interest and services: 10% to 20%
- royalty: 2% to 4%
- land use fees per square unit area: low
- administrative fees and transaction charges: low

Rarely applied taxes:

- excess profits taxes: very rare
- import and export duties: zero rated or exempt
- Value-added tax (VAT): refunded, offset, exempted
- free equity dividends: indirect taxation[108]

Since the cash taxes payable are invariably a significant component of the valuation, it is a task which must be undertaken with a degree of care.[109]

Table 6 illustrates Top 10 countries with the most attractive Tax System.

[108] Otto, 2006, found at www.siteresources.worldbank.org/INTOGMC/.../miningtaxationotto.ppt, access date 2.04.2010

[109] Lattanzi, found at http://www.cim.org/mes/pdf/VALDAYChrisLattanzi.pdf, accessed date 31.05.2010

Table 6: Top 10 Selected Jurisdictions, Ranked by Tax System Attractiveness

Jurisdiction	Percentage of companies that rate tax system as attractive	Royalty system (for most nonbulk minerals)
Nevada	29	Profit based
British Columbia	26	Profit based
Chile	25	No royalty
Ontario	22	Profit based
India	20	Ad valorem[110]
Western Australia	19	Ad valorem
New South Wales	17	Ad valorem and profit-based
Zambia	17	Ad valorem
Saskatchewan	16	Profit based and ad valorem
Ghana	14	Profit linked ad valorem

Source: Fraser Institute "Annual Survey of Mining Companies 2004/05."

Table 7 contains Total Effective Tax Rate for a Model Copper Mine in Selected Countries and States.

Table 7: Foreign Investor Internal Rate of Return and Total Effective Tax Rate for a Model Copper Mine in Selected Countries and States

Country	Total effective tax rate (%)
Lowest taxing quartile	
Sweden	28.6
Chile	36.6
Argentina	40
Papua New Guinea (2003)	42.7
Zimbabwe	39.8
Philippines	45.3
2nd lowest taxing quartile	
South Africa	45
Greenland	50.2
Kazakhstan	46.1
Western Australia	36.4
China	41.7
United States (Arizona)	49.9
2nd highest taxing quartile	
Indonesia (7th, COW)	46.1
Tanzania	47.8
Ghana	54.4
Peru	46.5
Bolivia	43.1

[110] An ad valorem tax (Latin for according to value) is a tax based on the value of real estate or personal property, found at http://en.wikipedia.org/wiki/Ad_valorem_tax, accessed date 12.05.2010

Mexico	49.9
Highest taxing quartile	
Indonesia (non-COW 2002)	52.2
Poland	49.6
Papua New Guinea (1999)	57.8
Ontario, Canada	63.8
Uzbekistan	62.9
Côte d'Ivoire	62.4
Burkina Faso	83.9

Source: Otto, 2002

Finally, it is important to realize that DCF only calculates the value of the company relative to the market on the date that is completed. This means that for an investor to obtain a positive return from an investment in a mining company the shares have to be purchased at a discount to the present value calculation – otherwise the investor would be better served placing the money in a bank and earning interest.[111]

6 Multiples

This chapter describes relative valuation methods which have a significant philosophical difference compare to DCF valuation. In discounted cash flow valuation, we were attempting to estimate the intrinsic value of an asset based upon its capacity to generate cash flows in the future. In relative valuation, we are making a judgment on how much an asset in worth by looking at what the market is paying for similar assets.

6.1 Price/ Earnings Ratio (PER)

The price-earnings ratio (PER) is the most widely used and misused of all multiples. Easy application makes it attractive, but its relationship to a firm's financial fundamentals is often ignored, leading to significant errors in application.

The price-earnings ratio is defined as the ratio of the market price per share to the earnings per share:

$$PER = \frac{P}{EPS}$$

where:

PER = price-earnings ratio
P = market price per share
EPS = Earnings per share[112]

[111] Kernot, 2006, p. 208-220
[112] Damodaran, 2002, p. 468

The problem with PERs is the variations of earnings per share over the economic cycle and inconsistent estimates of value where key variables such risk, growth or cash flows are ignored.

We can develop a simple formula improving the performance of the earnings-multiple approach by adding investment and risk to the equation:

$$PER = \frac{1 - \frac{g}{k}}{r - k}$$

where:

g = the long-term rate in earnings and cash flows
k = the rate of return earned on new investment
r = the discount rate[113]

There is one belief that one company is cheap if it's PER is below that of another even though both may be significantly overvalued. Therefore, PERs are based on what the respective players in any particular market are willing to pay for an asset at any one time.

The essential problem with earnings-multiple valuation approach is that it doesn't value directly what matters to investors.[114]

Comparisons are often made between price-earnings ratios in different countries with the intention of finding undervalued (markets with lower price-earnings ratios) and overvalued (markets with higher price-earnings ratios) markets. Analysts often come to wrong conclusions because they ignore wide differences that exist between countries on fundamentals. Table 8 illustrates the differences you should expect to see by changing one of fundamentals, other things remaining equal.

Table 8: PER in Markets with Different Fundamentals

Fundamentals changing		Consequences on PER
interest rates	higher	higher
	lower	lower
risk premiums (riskier countries)	higher	lower
	lower	higher
expected real growth	higher	higher
	lower	Lower
return on investments (more efficient companies)	higher	higher
	lower	Lower

Source: Damodaran, 2002, p. 477

Large swings in profitability of the mining companies at different stages of the economic cycle has led to classical assumption that investors should buy mining shares on high PERs (i.e. when earnings are low) and sell them on low PERs (i.e. when earnings are high). But in fact, there is a shift in PERs due to market expectations. Specifically, during the downward leg of the cycle, the stock market will be already anticipating a fall

[113] Mc Kinsey & Company, Inc. Copeland/ Koller/ Murrin, 2000, p. 62-67
[114] See Mc Kinsey & Company, Inc. Copeland/ Koller/ Murrin, 2000, p. 62-67

in earnings, even before the release of the company's peak cycle earnings. Consequently, although peak earnings will normally coincide with a trough PER this will follow the share price's peak. On the other hand the classic time to buy shares in mining companies has tended to assume that the most opportune moment is when they stand on high PERs.

This clearly never happens because of a shift in PERs as the market will always be discounting an improving economy, and hence rising earnings, at the time when the lowest earnings are reported. Consequently, those who buy shares at the peak of the PER will have missed the trough of the share price and will be buying into a recovery that is already well underway. Therefore the trough in the share price normally tends to coincide with the middle of the PER range. The middle of the range is, however, also passed at the top of the cycle as well as at the bottom. In view of this the general state of the economy must be taken into account, in order to determine whether or not earnings are rising or falling, before making an investment decision.[115]

6.2 Enterprise Value to EBITDA Multiple

The enterprise value to EBITDA Multiple relates to the total market value of the firm, net of cash, to the earnings before interest, taxes, depreciation, and amortization of the firm:

$$\frac{EV}{EBITDA} = \frac{Equity + Debt - Cash}{EBITDA}$$

where:

EV = *enterprise value*
EBITDA = *earnings before interest, taxes, depreciation, and amortization*
Equity = *Market value of equity*
Debt = *Market value of debt*

$$EV = \frac{FCF_1}{c - g}$$

where:

FCF_1 = *Free Cash flow to Firm in the next year*
c = *Cost of Capital*
g = *Expected Growth Rate*

When buying a business, as opposed to just the equity in the business, it is common to examine the value of the firm as a multiple of the operating income or EBITDA.[116]

Far fewer firms have negative EBITDA than have negative earnings per share or net income. Since earnings multiples cannot be computed for these firms, there is less potential for bias with EBITDA multiples than with PE ratios.

Multiples are a very effective tool when it is necessary to obtain quick results. They can also be useful to identify under/overvalued companies out of a large sample.

[115] Kernot, 2006, p. 215-220
[116] Viebig/ Poddig / Varmaz, 2008, p.361-367

The identified companies can then additionally be valued with a DCF Approach in order to increase the accuracy of the results.

However, applying multiples for mining companies is also strongly criticized. As an example, here is a part of an article of an independent analyst Paul von Eden:

"Take a hypothetical mining company that has only one mine as an example. Let us assume that mine is going to produce for another five years before the ore will be depleted. Now, let us say that the company's price to earnings ratio is ten. A hypothetical auto parts manufacturer also has a price to earnings ratio of ten. Based on just this one metric, we cannot differentiate between the two stocks. Let us also assume that the prevailing ten-year interest rate is five percent. …

The auto parts manufacturer has a price to earnings ratio of ten. That means for every dollar's worth of stock you buy, you expect to earn ten cents, or ten percent, in earnings. … Then you look at the mining stock and notice that it, too, has a price to earnings ratio of ten and, therefore, you can also make ten percent a year if you bought that stock. But you would be wrong. The mining company's mine only has a five-year life ahead of it. So, if it has a price to earnings ratio of ten it means that for every dollar of stock you buy you get ten cents in earnings. But the earnings are only going to last another five years, so your total earnings per dollar of cost will only be fifty cents - half of what you paid for the stock - and then the mine is depleted.

That's why comparing a mining stock to other investment opportunities on the basis of price to earnings, price to cash flow, or dividend yield is complete nonsense. It is just as futile to compare mining stocks to each other based on these metrics because mining companies have different mine lives in their operations."[117]

7 Real Options Valuation

7.1 Description

Real option valuation (ROV) is one of the modern valuation methods that provide a tool to adapt and revise mining projects under uncertainty and future variable movements.
This is a proprietary valuation model is based on the Black-Scholes option pricing model.[118]

Option valuation is all about the value of flexibility. For example, temporary mine closure (for an open pit mine). When metal prices drop, some mining operations are able to temporarily close and avoid losses. This type of option is analogous to a put option – incurring closure costs are exercising the option in order to avoid further (perhaps larger) losses. Once closed, however, the project takes on the characteristic of a call option. Incurring reopening costs when metal prices have moved higher is analogous to exercising the option. Therefore, options theory can be extremely helpful, assisting management in making mine opening and closure decisions by providing the optimal metal price at which a closure (or opening) should be made.[119]

Valuing early stage projects with the real option method one can essentially treat the resource in the ground as an option. However, ROV in the minerals industry is most

[117] Eeden, January 2006, found at http://www.paulvaneeden.com/Valuing.an.exploration.company, accessed date 6.06.2010
[118] The Black-Sholes model is described in the Appendix 4
[119] CIM, 2009, p. 623-628

applicable to those projects that have progressed at least the pre-feasibility stage, because there will likely be a defined resource and a reasonable estimation of capital and operating costs.

Most mine investment projects comprise three factors:

- *irreversible investment* (partially or completely). This means that capital investment is required to establish the operation, with the initial investment not able to be recouped. The assumption that all investments are irreversible is a fundamental weakness of most DCF methods.
- *uncertainty* over the future rewards from the investment (commodity prices, ore body characteristics and operating cost may have significant effects on the mine future)
- *the investment* in a mine *does not happen immediately* in the reality; there is a delay between making the decision to mine and the investment occurring in the project.[120]

Consequently, in any mining project, uncertainty will increase its risk, and the manager or decision maker requires flexibility to manage risks in the project. One of the significant advantages of ROV is being able to evaluate mining projects in different scenarios at the beginning of the project. The mining project would have responded by changing production rates there by capitalizing on the new circumstances of the project.

The most important variables that have affected the value of the opened mine are mineral commodity price, the size of reserve, time and mine operation policy. The mine operating policy demonstrates the options in mining to open, close, defer, expand, shrink, or abandon the project in various ways at different stages, based on new information. Real options valuation allows putting a quantitative value on assets that would otherwise be virtually impossible to value.[121]

In valuing exploration options, the analyst must consider the same factors that influence the value of all options. Table 9 represents analogy of the parameters in financial and real option models. The left column lists the six parameters that serve as inputs to the Black-Scholes-Merton (BSM) financial option pricing model. The center column lists the real option valuation parameters corresponding to the financial option parameters in the left column. The right column lists examples of the sources of uncertainty for the corresponding real option valuation model.

Table 9: Analogous parameters in financial and real option models

BSM Parameter	Analogous ROV Parameters	Example Sources of Uncertainty	Inputs into valuing Natural Resources Option
Value of underlying asset, S_t	Present value of expected cash flows from investment	Market demand for commodities, labor supply and cost, materials supply and cost	Estimated value of natural resources reserve. Usually estimated as the quantity of resources times the current price

[120] Drieza/ Kicki/ Saluga, 2002

[121] Tang, March-April 2010, found at http://magazine.mining.com/issues/1003/Vol03-02-DeterminingTheRealValueOfJnrMiningCompanies-08-10.pdf, accessed date 7.05.2010

The exercise or strike price, K	Present value of required investment costs in real asset	Availability, timing and price of real assets to be purchased	Cost of developing the reserve. Generally assumed to be known and fixed
The volatility of the underlying asset, σ	Volatility of underlying cash flows	Volatility in market demand, labour cost, materials cost, correlation of model assumptions	Since the quantity of the resource is assumed to be known, the volatility in price of natural resources
The time of expiration, T	Period for which investment opportunity is available	Product life cycle, competitive advantage	Can be defined in one of two ways: - If rights to the reserve are for a finite period, use that period. - The number of years of production it would take to exhaust the estimated reserve. (Gold mine with a mine inventory of 3m ounces and capacity output rate of 150000 ounces a year will be exhausted in 20 years)
Dividend rate, δ	Cash flows lost to competitors	Product life cycle, competitive advantage, convenience yield	Annual cash flow as a percentage of the value of the underlying asset. Once the reserve becomes viable, this is what the firm is losing by not developing the reserve (also cost of delay)
Risk-free interest rate, r	Risk-free interest rate	Inflation, money market behavior	Risk-free interest rate

Source: Damodaran, 2010, Cobb/ Charnes

The Black-Scholes-Merton (BSM) model for a valuing call option is shown in equation form:[122]

$$C(S_t, T-t) = S_t \times N(d_1) - K \times e^{-r\times(T-t)} \times N(d_2) \qquad (1)$$

$$d_1 = \frac{\ln(\frac{S_t}{K}) + (r - \delta + \frac{\sigma^2}{2}) \times (T-t)}{\sigma \times \sqrt{t}} \qquad (2)$$

$$d_2 = d_1 - \sigma \times \sqrt{(T-t)} \qquad (3)$$

The variables not mentioned above are:

ln = natural logarithm
N(x) = standard normal cumulative distribution function
e = the exponential function

[122] Black / Scholes, 1973 p.637-654, Merton, 1973, p.141-183

For valuing a mining company that owns multiple reserves, the preferred approach would be consider each reserve separately as an option, value it, and cumulate the values of the options to get the firm's value. For large mining companies which own hundreds of such reserves, a variation of this approach is to value all the undeveloped reserves as one option. The estimation procedure of inputs in the table 7 in column 4 will have few differences. One must consider cumulate undeveloped reserves owned by a company, aggregate cost to the company to develop all this undeveloped reserves and weighted average of the lives across undeveloped reserves, with weights based in reserve quantities. Once we have valued the undeveloped reserves as options, we can value developed reserves with conventional discounted cash flow.

Value of a mining company:

Value of Developed Reserves (DCF Valuation: represent value of expected cash flow from extraction and sale of natural resources in developed reserves)
+
Value of Undeveloped Reserves (Option Valuation: Option Value of undeveloped reserves (valued either Individually or in the aggregate))

= Value of Operating Assets

Higher commodity prices increases the value of developed and undeveloped reserves; higher volatility in this price may reduce the value of developed reserves by increasing the risk and discount rate, but it increase the value of undeveloped reserves by increasing option time premium.[123]

Consequently, if we regard undeveloped reserves as options, DCF valuation generally undervalues the natural resources companies, because it ignores the value of the option – the additional value of flexibility in the face of future uncertain events. This can lead to poor decision making by analysts and managers, and loss of potential value to the firm.[124] The difference is greatest for firms with significant undeveloped reserves and with commodities where price volatility is highest.

It's not only flexibility in decision making for mining stocks to trade at higher value than the net asset value of their constituent mines. Mining stocks offer leverage to commodity prices. For example, we look at a gold mining company. Assume we have a company that mines gold for a total cost of $400 an ounce, and let us pretend the gold price is $800 an ounce. The net present value of the mine would be calculated based on the $400 margin. If the gold price increases by 25% to $1000 an ounce the net present value of the mine will increase to 50%, since the margin would now be $600 an ounce. Thus the value of the company increased more than the increase in the gold price. Most people buy mining stocks because of this leverage.[125]

The way to quantify the premium that one should pay for a mining stock to incorporate the leverage to the underlying commodity price is to add optionality of

[123] Damodaran, 2010, p. 444
[124] CIM, 2009, p. 623-628
[125] Eeden, January 2006, found at http://www.paulvaneeden.com/Valuing.an.exploration.company, accessed date 6.06.2010

mining shares to the net present value of the mines themselves. You can do this by calculating the discounted net present value of the all the company's mines and then add the "option value" of the mines as calculated by the Black Sholes formula to obtain a more realistic asset value per share. Such result can be used to compare different mining companies to each other, and mining companies to investments in other sectors.[126]

The complicity of ROV and the lack of widely available tools for analyst have been slowing new valuation technologies adoption over the years. Nowadays spreadsheet tools are widely available that make it easy to compute option values for the types of problems that can be handled at least at the simple level with the Black-Scholes-Merton model. [127] In the fourth part of this paper a company will be valued using an Excel spreadsheet tool for real options valuation.

While options theory is a valuable additional to the valuator's toolbox, it is not applicable in every situation; it complements, rather than replaces, other valuation methods. A weakness of this approach is that it often requires assumptions that verge on the ridiculous given the structure of the real world problem.[128]

7.2 Summary: Multiples, DCF and Real Options

Mining companies have volatile earnings, with the volatility coming from macroeconomic factors that are not in the control of these companies. As the economy weakens and strengthens, mining companies see their earnings and cash flows track the commodity price.

In multiples valuation, we estimate the value of an asset by looking at how similar assets are priced. To make this comparison, we convert prices into multiples and then compare these multiples across firms that we define as comparable. The allure of multiples remains their simplicity. However, the relationship to a firm's financial fundamentals is often ignored, leading to significant errors in application.

Real option valuation (ROV) is one of the modern evaluation methods that provide a tool to adapt and revise mining projects under uncertainty and future variable movements.

The main findings of most previous work in real options applications to valuing mining investments can be summarized as follows:

- The value of a project estimated by the ROV is greater than that estimated by the DCF method. In other words, the DCF tends to undervalue mining investments.
- The ROV is better than the NPV method in dealing with uncertainty and operating flexibility.
- The difference between the ROV and the DCF estimates represents the value of operating or management flexibility, and that difference depends on the uncertainty level and the project profitability.

[126] Eeden, January 2006, found at http://www.paulvaneeden.com/Valuing.an.exploration.company, accessed date 6.06.2010
[127] CIM, 2009, p. 623-628
[128] Samis/ Davis, 2003

- The ROV and the DCF method differ fundamentally in the way they discount future cash flows and in the way they deal with management flexibility.[129]

ROV and DCF may still be complementary techniques, with DCF being suitable for basic replacement decisions.[130]

Some of the reasons that the methods give different fair values are:

- Multiples depend on current market prices, so, if the market is undervalued, all assets will be undervalued;
- As for DCF and Real Options, one reason for the difference is related to the time assumptions used;
- Options become more valuable as their time to expiry increases.[131]

8 Valuation of a mining company with different methods

8.1 Introduction

This chapter presents the results from the empirical study and shows proceeding of the valuation of a mining company in the praxis. Also analysis is included of the data in this chapter. It will be investigated as well, whether methods presented in this paper are effectively applied and above all in what way the special features of mining and metals companies are taken into account.

Antofagasta, a Chilean-based copper mining group, will be taken as an example for valuation. More details to Antofagasta will be provided in the Chapter 8.2.

The banks and financial companies which commonly make the reviews of the companies usually make every year or two a detailed report with exact derivation of the valuation and work out some additional specific information. When some important events occur (for example, a presentation of a half-year report or an announcement of an acquisition), these will be updated in short "Updates", which usually do not conclude exact calculations. The following statements are based on the reports and news from homepage of Antofagsta and several researches of banks and capital companies such as Merrill Lynch from March 10, 2010, Raymond James from March 10, 2010, FD Capital from March 30, 2010 and Lusight from 22 March 2010. Since these detailed reports are based on the annual Report 2009 of Antofagasta, they are based on the same data und information. Hence, it is possible to compare the valuation directly.

[129] Dimitrakopoulos/ Sabour, 2007, found at http://cosmo.mcgill.ca/research/pdf/strat/STRAT_%5B2007%5DDIM_ABDEL_SABOUR_Evaluating_mine_plans.pdf, access date 15.05.2010
[130] Cobb/ Charnes, 2007, found at http://www.informs-sim.org/wsc07papers/018.pdf, access date 3.06.2010
[131] Tang, found at http://magazine.mining.com/issues/1003/Vol03-02-DeterminingTheRealValueOfJnrMiningCcompanies-08-10.pdf, accessed date 7.05.2010

8.2 Facts to Antofagasta[132]

Antofagasta's activities are mainly concentrated in Chile, in one of the main copper mining districts in the world, where it owns and operates three copper mines: Los Pelambres, El Tesoro and Michilla, with a total production in 2009 of 442,500 tonnes of copper in cathode and concentrate and 7,800 tonnes of molybdenum in concentrate. The average cash cost were 96.3USc/lb[133] in 2009 compare to the average copper price of 232USc/lb. The company is a low-cost producer.

The fourth mine – Esperanza is expected to complete construction and begin commissioning by the end of 2010. Over its first 10 years of operation it is expected to produce on average 191,000 tonnes of payable copper in concentrate containing 215,000 ounces of payable gold annually. Antofagasta also has four potential development mines: Sierra Gorda District, Los Pelambres District, Reko Diq and Antucoya. Table 10 summarize detailed information of Antofagasta`s operations:

Table 10: Operations of Antofagasta

	Los Pelambres	***El Tesoro***	***Michilla***	***Esperanza*** ***(production start in the end of 2010)***
Location	Chile's Coquimbo Region, 240km northeast of Santiago	Chile's Antofagasta Region, 1,350 km north of Santiago	Chile's Antofagasta Region, 1,500 km north of Santiago	Chile's Antofagasta Region, 4km south of El Tesoro Mine
Shareholders	60% Antofagasta plc 40% Japanese Consortia	70% Antofagasta plc 30% Marubeni Corporation	74% Antofagasta plc 26% other Chilean investors	70% Antofagasta plc 30% Marubeni Corporation
Process	Milling and flotation to produce copper concentrate (containing gold and silver) and molybdenum concentrate	Heap-leaching and solvent extraction-electro winning to produce copper cathode	Heap-leaching and solvent extraction-electro winning to produce copper cathode	Heap-leaching and solvent extraction-electro winning copper cathode to produce
Production	311,600 tonnes payable copper 6165 tonnes molybdenum	90,200 tonnes LME grade A copper	40,600 tonnes copper	97000 tonnes copper 2100 tonnes molybdenum (in 2015)
Cash costs	80.4 cents per pound (116.5 cents per pound excluding by-products)	123.4 cents per pound	157.6 cents per pound	157.6 cents per pound
Workforce	697 employees	534 employees	524 employees	524 employees
Safety index	1.3 accidents with lost time per million	2.0 accidents with lost time	4.4 accidents with lost time	4.4 accidents with lost time
(LTIFR)	hours worked	per million hours worked	per million hours worked	per million hours worked
Mine life	28 years remaining	10 years remaining	8 years remaining	16 years remaining
Reserves	1,503m tonnes @ 0.64% copper, 0.018% molybdenum and 0.033 g/tonne gold	212m tonnes @ 0.57% copper (inc. Esperanza ROM oxides)	10m tonnes @ 1.35% copper	583m tonnes @ 0.54% copper, 0.01% molybdenum, 0.223g/t gold
Resources	6165m tonnes @ 0.52% copper and 0.011% molybdenum	270m tonnes @ 0.56% copper (inc. Esperanza ROM oxides)	43m tonnes @ 2.27% copper	1204m tonnes @ 0.45% copper, 0.011% molybdenum, 0.147g/t gold

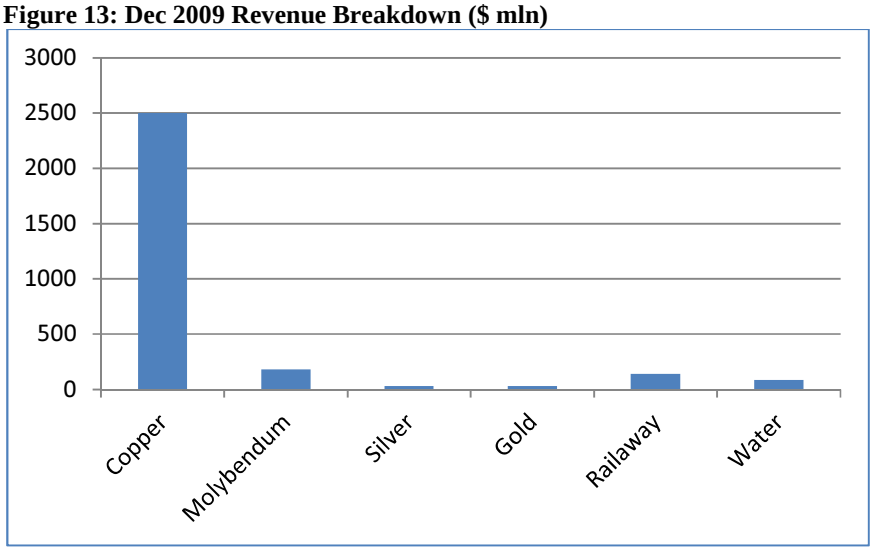
Source: Company Date

[132] Antofagasta, found at www.antofagasta.co.uk, accessed date 27.03.2010

[133] c/lb = cents per pound, 1lb = 0.4536 kg, 1 lb = 16 oz, 1 tonne=2204,62262 lb, Conversion Table, found at http://www.taylormade.com.au/billspages/conversion_table.html, accessed date 4.06.2010

Antofagasta's operations are broken down into five divisions; Copper production, Molybdenum production, Gold & Silver production, Water Facilities and Railway Transportation. Copper is by far the largest contributor to company sales (See Figure 13) with approximately 85% of revenue stemming from this area. Molybdenum, Gold & Silver are by-products of the copper mining function while the company's water and railway businesses are ancillary operations that are now divisions in their own right.

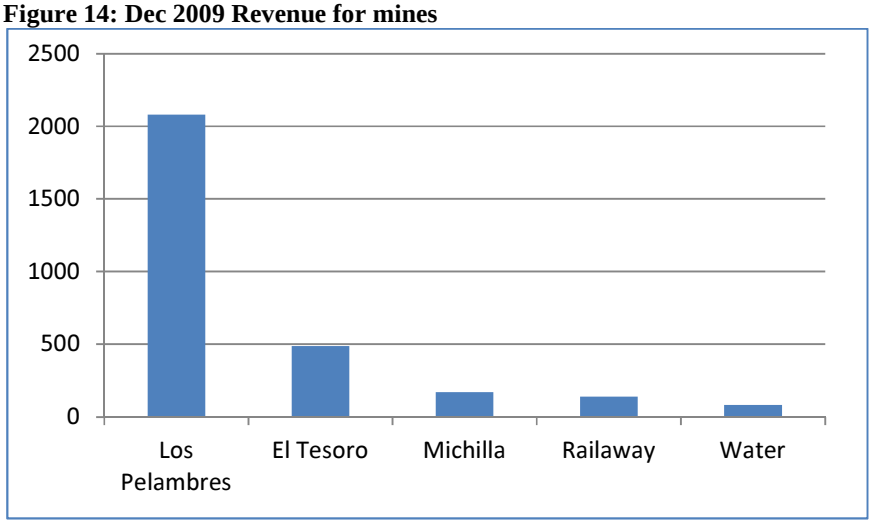
Figure 13: Dec 2009 Revenue Breakdown ($ mln)



Source: Company Date

Los Pelambres is by far the largest contributor to company revenues (See Figure 14) with approximately 70% of revenue. Heavy dependence on a single operation and single metal are the weaknesses of Antofagasta.

Figure 14: Dec 2009 Revenue for mines

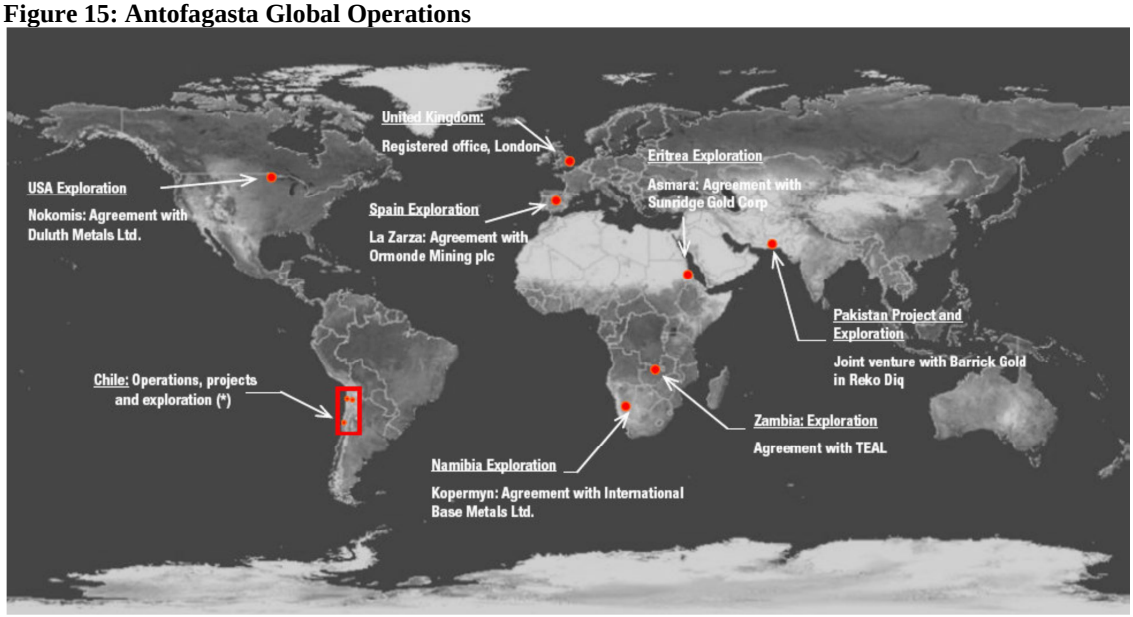


Source: Company Date

Antofagasta has a strong balance sheet with net cash of $1.6bn estimated for the end of 2009. This leaves significant room to maneuver in relation to existing and future expansion projects.

Antofagasta's producing assets are located in Chile; however, trying to reduce the risk of single country, the company has looked abroad (See Figure 15) to secure its future production by acquiring interests in North America, Asia, Africa and Europe. The stock is a member of the FTSE 100[134] and Chile's Luksic family holds a majority stake in the company since 2004. Thus Antofagasta is unlikely to be a target in ongoing sector consolidation.

Figure 15: Antofagasta Global Operations



Source: http://www.antofagasta.co.uk/interior/about/f_geo.html

Currently all of Antofagasta's productions are in Chile which carries low political risk. Fox-Davies sees this situation continuing for at least the next twelve months and possibly longer. It is all dependent on what happens at Reko Diq in Pakistan, which is undoubtedly a high risk operation.

8.3 DCF Valuation of Antofagasta (Anto)

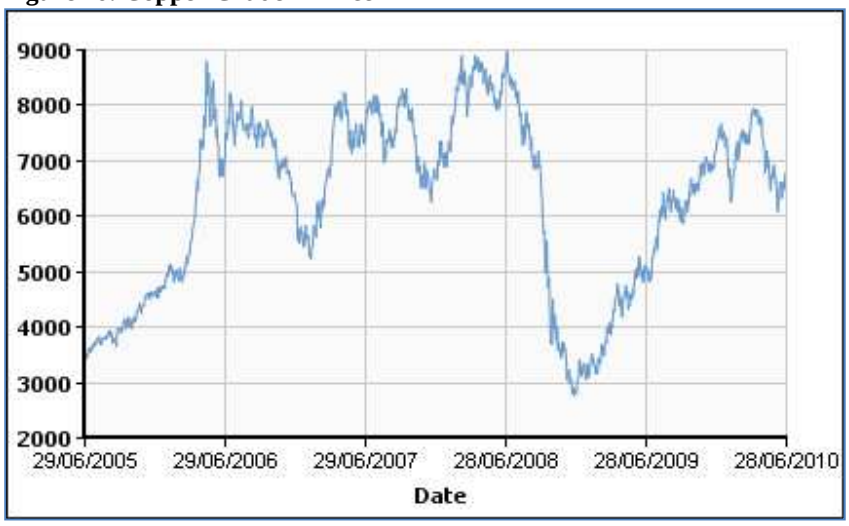
Copper Market Demand and Supply

With the copper price currently sitting at US $6510/tonne (June 30, 2010) up over 100% from 2009 (and 2004) it has become quite difficult to forecast short to mid-term targets for

[134] This index comprises the 100 most highly capitalized blue chip companies, representing approximately 81% of the UK market. It is used extensively as a basis for investment products, such as derivatives and exchange-traded funds, found at http://www.ftse.com/Indices/UK_Indices/index.jsp, accessed date 4.06.2010

the commodity (see figure 16). For the valuation of Antofagasta long-term copper prices are used which are mainly driven by its demand and supply.

Figure 16: Copper Grade A Price



Source: LME

Copper market supply and demand fundamentals are extremely supportive of current copper prices as demand is expected to outpace supply over the coming years. This will mean that copper producers with high grade deposits and consistent production like Antofagasta will have a positive impact on earnings over the coming years.

Reasons for the tightness from the supply side:

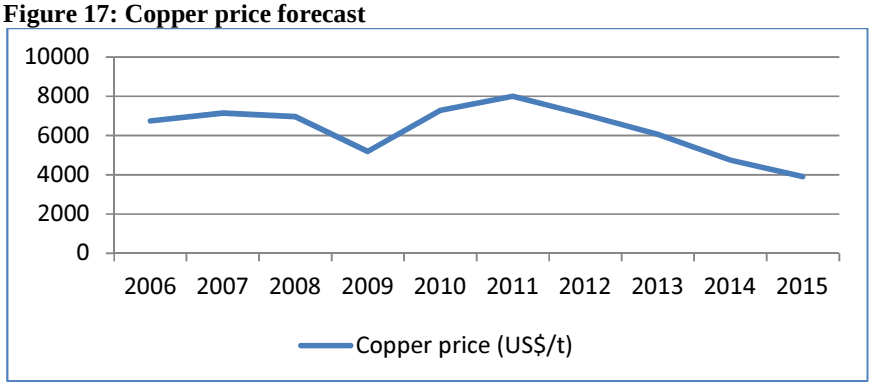
- deficit is an underinvestment in capital expenditure by the miners themselves. In an effort to protect balance sheets during the economic crisis, large miners slashed capital expenditure budgets resulting in a slowdown in the development of new assets.
- decline in the quality of copper ore being mined. This is a function of the type of mining techniques being utilized and the maturity of a number of the world's largest copper mines.
- Strikes and the threat of new strikes also continue to support the copper price.

Driving factors on the demand side:

- the process of urbanisation taking place in emerging economies like China, India and Brazil. Dolmen Daily expect this trend continues to gather momentum and demand for industrial metals like copper will remain
- a recent trend is that developed economies also strengthen demand

Nevertheless, the reversion to the mean will be used in order to forecast copper prices. To remember, the idea of this method is that both, high and low prices are temporary and that a price will tend to have average price inflation adjusted, over time. Figure 17 shows price assumptions for valuation of Antofagasta.

Figure 17: Copper price forecast



Source: Merrill Lynch

Production Expansion

Antofagasta expects to produce 543,000 tonnes of copper in 2010, a 23% increase from 2009. With the completion of the expansion project at Los Pelambres, Antofagasta expects to reach the 700,000 tonnes of copper target by 2011. The Esperanza project is on track and expected to produce its first copper in Q4/10. In the next years the company expects to produce an average of 698,000 tonnes of copper, 9,000 tonnes of molybdenum and 215,000 ounces of gold. Thus, in the near term, higher revenues are expected driven by higher copper production and additional revenue from the sale of gold from the Esperanza mine (gold revenues in the DCF sheet are included in the category "other revenue").

Solid water and transport volumes will stay stable over time.

Balance Sheet

Antofagasta commands one of the strongest balance sheets in the specialist mining sector. At the end of 2009 the company had a net cash position of $1.6bn. This figure fell substantially during 2009 as a result of the company pressing forward with the capital expenditure projects at Los Pelambres and Esperanza which will provide Antofagasta with a competitive advantage over its peers during the next number of years.

Costs

Group cash costs for 2009 were 96.3USc/lb compared with 87.3USc/lb in 2008. The increase in cash costs compared to 2008 was mainly due to significantly lower by-product credits (reflecting lower molybdenum prices) partially offset by a decrease in on-site and shipping costs. In the next years the company expects cash costs to increase mainly due to higher energy and labor costs. One more reason for increasing operating costs may be the price decrease of by-products in these years.

Therefore it is assumed that operating costs will increase in the years 2012-2014 at 5% per year. Depreciation and amortization, exploration and royalty, and other costs will stay constant over time.

Capital Structure and Free Cash Flow (FCF)

Debt/Equity last year increased significantly as the company increased its debt position to finance the Esperanza mine project. Going forward, Debt/Equity is expected to fall as equity increases over the next three years, driven by higher earnings.

In 2010, operating Cash Flow should increase mainly due to higher operating profit. As the company completes its main projects, we can expect FCF to increase favored by lower capital expenditures and rising earnings.

Cost of Capital (WACC)

In order to establish the firms cost of capital and the discount rate, the capital structure has to be considered. A high leverage, debt/equity ratio, generally results in a lower cost of capital since debt is cheaper to raise than equity. However, a too high debt/equity ratio results in an elevated cost of debt since the firm's credit rating will deter. Antofagasta has more cash than debt on its balance sheet. To calculate WACC the other inputs should be defined (see table 11):

Table 11: Antofagasta cost of capital

Risk free rate 10 year G-Bond	2.75%
Equity Beta	1.40
Market Risk Premium	7.0%
Cost of Equity	**12.6%**
Net Debt	0
Interest paid on Debt	0
Cost of Debt (risk free rate + 500bp)	**7.75%**
Cost of Equity	12.6%
Cost of Debt (risk free rate + 500bp)	7.75%
Marginal Tax rate	21.0%
Equity Ratio	100%
Debt ratio	0%
WACC	**12.6%**

Source: own presentation

- an average of US and Germany 10 years bonds should be considered as the risk free rate
- stock beta is equal to 1.40 (source: Bloomberg)
- the solid cash position of Antofagasta, good positioning of the company among other mining companies and low country risk of Chile allow to assume a risk premium about 7%
- Since Antofagasta has no net debt, the WACC is equal to the cost of equity; hence the free cash flow generated from the operations will be discounted by 12.6%

Table 12 presents the DCF valuation of Antofagasta. Profit and loss calculation, Balance Sheet, cash costs and capital expenditure information are attached in the Appendix 6.

Table 12: DCF Valuation of Antofagasta

DCF	2008A US$	2009A US$	2010F US$	2011F US$	2012F US$	2013F US$	2014F US$	2015-2040F US$
Revenues	3'498'119'008	2'962'656'192	4'203'020'480	5'576'660'800	5'556'217'600	5'287'266'400	4'660'016'000	
Growth (%)	*-9%*	*-15%*	*42%*	*33%*	*-0.4%*	*-5%*	*-12%*	
EBIT	**2'543'919'008**	**1'463'556'192**	**2'419'120'480**	**3'577'760'800**	**3'412'317'600**	**3'058'366'400**	**2'341'866'000**	
LessTax	521823801.6	287531238.4	477644096.0	711312160.0	708083520.0	668273280.0	524973200.0	
Tax Rate (%)	*21%*	*20%*	*20%*	*20%*	*21%*	*22%*	*22%*	
NOPAT	**2'022'095'206**	**1'176'024'954**	**1'941'476'384**	**2'866'448'640**	**2'704'234'080**	**2'390'093'120**	**1'816'892'800**	
Growth (%)	*-25%*	*-42%*	*65%*	*48%*	*-5.7%*	*-12%*	*-24%*	
Depreciation & Amortisation	186'900'000	217'500'000	270'700'000	266'700'000	267'100'000	267'100'000	267'100'000	
Gross Cash Flow	**2'208'995'206**	**1'393'524'954**	**2'212'176'384**	**3'133'148'640**	**2'971'334'080**	**2'657'193'120**	**2'083'992'800**	
Capital Expenditure	1'189'600'000	1'335'300'000	700'000'000	500'000'000	400'000'000	400'000'000	400'000'000	
Change in NWC	-625'000'000	566'600'000	-61'867'500	106'485'000	-1'557'750	-20'824'250	-20'243'000	
Free Cash Flow	**1'644'395'206**	**-508'375'046**	**1'574'043'884**	**2'526'663'640**	**2'572'891'830**	**2'278'017'370**	**1'704'235'800**	**54'512'842'616**

Reserves of Antofagasta's mines are estimated for about 30 years. As we already know, mining is a finite business; therefore, no terminal value is included in the valuation. Instead of this, free cash flows are calculated for the mine life by assuming 1.5% annual growth of for the years 2014-2040.

Based up on the calculations illustrated above, a free cash flow for the analyzed company has been produced:

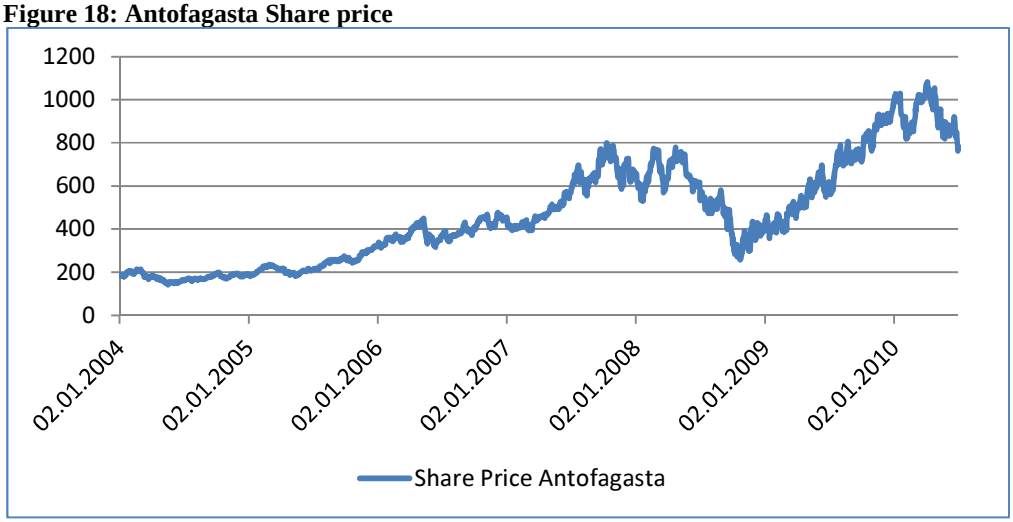
	2010F US$	2011F US$	2012F US$	2013F US$	2014F US$	2015-2040F US$
Free Cash Flow	1'574'043'884	2'526'663'640	2'572'891'830	2'278'017'370	1'704'235'800	54'512'842'616
WACC	12.6%	12.6%	12.6%	12.6%	12.6%	12.6%
Discounted FCF	**1'398'472'637**	**1'994'443'347**	**1'804'400'500**	**1'419'402'543**	**943'442'353**	**8'073'196'809**

Sum discounted FCF	**15'633'358'190**
Minorities	452'200'000
Cash & Cash Equivalents	3'222'300'000
Debt	1'626'600'000
Total	**16'776'858'190**
Number of shares	985'856'695
DCF per share (in US$)	**17.0**
Exchange Rate USD/GBP	0.6643
DCF per share (in £)	**11.3**

At a discount rate of 12.6%, the present value of all free cash flow until 2040 less minorities and debt, plus cash is $16'776'858'190.

Current share price of Antofagasta is about £8 (see figure 18). Thus, assuming our DCF valuation, the stock is currently trading at 41.25% discount.

Figure 18: Antofagasta Share price



Source: Bloomberg

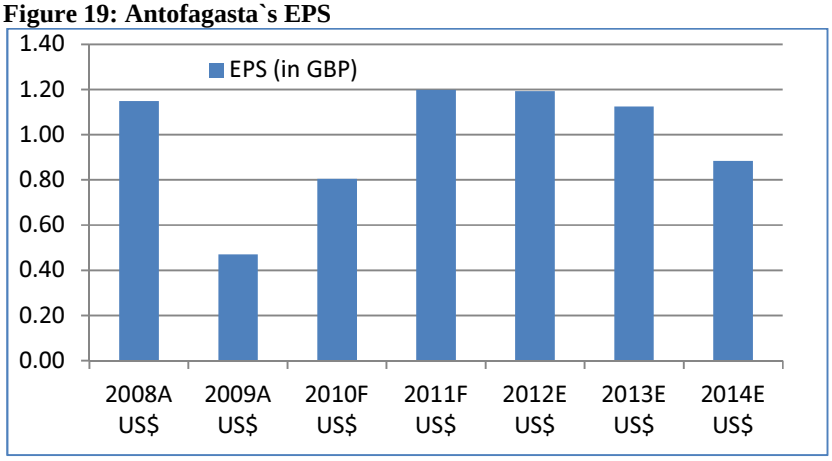
8.4 Multiples Valuation of Antofagasta

Based on calculations illustrated in chapter 8.3, Antofagasta`s earnings per share (EPS) has been produced:

	2008A US$	2009A US$	2010F US$	2011F US$	2012E US$	2013E US$	2014E US$
EPS (in USD)	1.73	0.71	1.21	1.80	1.80	1.69	1.33
EPS (in GBP)	1.15	0.47	0.80	1.20	1.19	1.13	0.88

Figure 19 shows EPS of Antofagasta spread over the years:

Figure 19: Antofagasta`s EPS



Source: own presentation

For determining the current value of Antofagasta with multiples method, we will examine and compare PERs and EV/EBITDA with those of similar companies, and it is generally the starting point in peer comparison analysis.
Two peer groups were chosen (see Table10 and Table11): the most comparable with Antofagasta copper mining companies (Copper Stock) and biggest London-listed diversified mining companies (diversified). We use the group to find average valuations. Among the companies listed in Table 13, we see that Antofagasta is valued at high PERs and low EV/EBITDA than the rest of the group. Comparing the average of multiples of copper peer group and the average diversified peer group with those of Antofagasta`s we can see that Antofagasta`s PERs have premium and EV/EBIDTA ratios a discount in both cases.

Table 13: Peer Group Comparison (Copper Stock)

Company	Currency	Price	PE 10E	PE 11E	EV/EBITDA 10E	EV/EBITDA 11E
Copper Peer Group						
Freeport McMoRan	USD	60.80	7.6	6.8	3.6	3.3
Kazakhmys	GBP	994.00	5.5	4.7	5.2	4.8
First Quantum	CAD	55.59	5.2	4.3	3.0	2.5
Equinox	CAD	3.69	9.7	5.9	6.0	4.0
Oz Minerals	AUD	0.96	9.1	8.1	3.6	3.4
Quadra FNX	CAD	10.07	6.3	4.0	3.6	2.1
Antofagasta	GBP	786.5	9.7	6.5	3.9	2.8
Average Copper Peer Group			**7.6**	**5.8**	**4.1**	**3.3**
Premium/Discount on Antofagasta shares to Average Copper Peer Group			28%	13%	-5%	-15%
Diversified						
BHP Biliton	GBP	1'754.50	10.7	6.7	6.9	4.5
Rio Tinto	GBP	2'968.50	6.5	5.5	4.9	4.4
Xstrata	GBP	886.80	6.6	5.3	4.4	3.7
Anglo American	GBP	2'350.50	8.3	6.2	5.1	4.1
Antofagasta	GBP	786.50	**9.7**	**6.5**	**3.9**	**2.8**
Average Diversified			**8.4**	**6.1**	**5.1**	**3.9**
Premium/Discount on Antofagasta shares to Average Diversified Peer Group			16%	8%	-22%	-29%

Now we can value Antofagasta corresponding to average copper peer group multiples (in GBP) and to average diversified peer group multiples (in GBP). The results are presented in the Table 14. Adding 10% premium to calculate the fair value of Antofagasta we come to value of £9.46, an upside potential of 18.25% to the current share price of £8. We believe a premium is warranted due the fact that Antofagasta has its main operations in Chile, one of the countries with the lowest risk premium (see figure 1, p. 12), has a strong balance sheet (net cash $ 1.6bn), a proven management track record and very low cost long-live operations.

Table 14: Peer Group Comparison (Diversified)

Company	PE 10E	PE 11E	EV/EBITDA 10E	EV/EBITDA 11E
Corresponding valuation of Anto to average copper peer group multiples (in GBP)	6.13	9.08	9.08	10.01
Corresponding valuation of Anto to average diversified peer group multiples (in GBP)	6.76	10.86	10.86	11.74
Average comparison-based valuation of Antofagasta in GBP				**8.60**
Justified premium / discount of Antofagasta relative to Sector				*10.0%*
Fair value of Antofagasta based on peer group valuation (in GBP)				**9.46**
Upside / downside potential to current share price (%)				18.25%

8.5 DCF and Real Options Valuation of Antofagasta

The mining assets which will only be developed in the future, conditional on whether or not the assets have a positive net present value at the decision date, cannot be valued using traditional DCF method. However, DCF and ROV can be combined, in order to receive better estimates as ROV will provide an additional value to DCF. This chapter demonstrates how the methods can complement each other on a simplified example: a development project of Antofagasta – Antucoya, which will be valued with real options method.

The value of Antofagasta will be calculated in this way:

Value of Developed Reserves (DCF Valuation of producing assets)
+
Value of Undeveloped Reserves (Option Valuation: Option Value of Antucoya)

= Value of Antofagasta

The Antucoya deposit is located around 45km from Antofagasta's Michilla mine. The prospect is an oxide deposit, and following drilling during 2008 and 2009, there is now a resource of estimated 1.5 billion tonnes grading 0.27% copper with a cut off grade of 0.10% copper.

In April 2008, Antofagasta became 100% owners of the exploration area after purchasing a final 49% stake in Antomin Ltd from Mineralinvest. The final consideration payable was $243m after interest.

A feasibility study on the property was initiated in February 2008, which is examining a number of processing options, including producing an enriched copper solution for processing at the company's SX-EW plant at Michilla, as well as a standalone SX-EW plant on-site to produce around 30,000 tonnes of copper cathodes per year. The study was due to be finished in the second half of 2009, but the project has now

been expanded to include a test pit and the result of the feasibility study is not expected until mid 2011. Due to the low grade of the deposit, future development will be very sensitive to operating costs and future copper prices.[135]

Table 15 presents estimated resources at Antucoya mine. For real options valuation inferred resources will not be taken into account since this is the most uncertain category among resources. In order not to over- or undervalue the project, an average price of copper for the years 2000-2009 was calculated. It is by 4'017US$/t; the marginal cost per unit of extracting the natural resource is by 2'157.12US/t.

Table 15: Resources summary at Antucoya of 31 December 2009

TYPE OF RESOURCE	TONNES (MT)	CU (%)	THE CHANCE THAT MINERALIZATION IS THERE	POTENTIAL COPPER (T)
Measured	497.3	0.31	is 90 % or greater	1'387'467
Indicated	656	0.26	is 50 % or greater	852'800
Inferred	355.7	0.24	is 10 % or greater	85'368
Total	**1509.1**	**0.27**		**2'325'635**

Source: Company data and own calculation

Antucoya will be producing copper cathodes; therefore it is necessarily to convert the copper resources to expected amount of cathodes produced. In order to determine Antucoya value, the inputs of real options model should be defined (see table 16).

Table 16: Inputs (for Antofagasta) for Real Option Model

BSM Parameter	Antucoya	Inputs into valuing Natural Resources Option
Value of underlying asset, S_t	(1'387'467+852'800)*90%*30%*(4017-2157.12)=1'124'989'503US$	Estimated value of natural resources. Estimated as the quantity of resources times recovery rate of Cu concentrate times copper content times the current price of Cu cathodes less costs
The exercise or strike price, K	The cost of developing has not been fixed yet as the feasibility study of the project is not complete. Therefore, it is assumed that the cost of developing are 1'000'000'000US$	Cost of developing the reserve. Generally assumed to be known and fixed
The volatility of the underlying asset, σ	40%	the volatility in price of natural resources
The time of expiration, T	((1'387'467+852'800)*90%*30%) / 30'000t = 20 years	The number of years of production it would take to exhaust the estimated reserve.

[135] FD Capital from March 30,2010

Dividend rate, δ	0.92% (after-tax cash flow are assumed by 40'000'000US$)	Annual after-tax cash flow as a percentage of the value of the underlying asset. Once the reserve becomes viable, this is what the firm is losing by not developing the reserve (also cost of delay)
Risk-free interest rate, r	2.75%	Risk-free interest rate

By setting in the inputs in Black-Scholes-Merton model and calculating the value using an excel spreadsheet tool for real options valuation, we become the value of the natural resource option equal to $342'994'626 (see table 17).

Table 17: Valuing a Long Term Option

$$C(S_t, T-t) = S_t \times N(d_1) - K \times e^{-r\times(T-t)} \times N(d_2)$$

St=	**$1'124'989'503**	r =	**2.75%**
K=	**$1'000'000'000**	σ =	**0.16**
T=	**20**	δ =	**0.96%**
d1 =	0.870197135		
N(d1) =	0.807903659		
d2 =	-0.918657247		
N(d2) =	0.179137439		
Value of the natural resource option =			**$342'994'626**

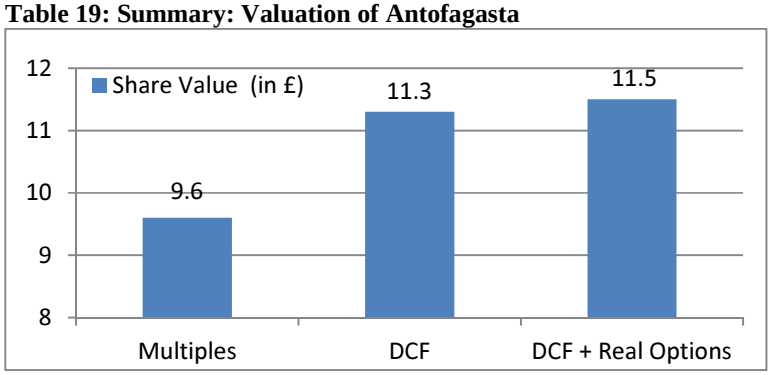
Consequently, if we include the option value of undeveloped reserves of Antucoya in the company valuation, the value per share of Antofagasta increases up to £11.5 (see Table 18). The additional value is £0.2 per share or 1.80% more than previous value (DCF value was £11.3).

Table 18: Antofagasta share price value with included option

Sum discounted FCF	**15'633'358'190**
Option Value	**342'994'626**
Minorities	452'200'000
Cash & Cash Equivalents	3'222'300'000
Debt	1'626'600'000
Total	**17'119'852'816**
Number of shares	985'856'695
Value per share (in US$)	**17.4**
Exchange Rate USD/GBP	0.6643
Value per share (in £)	**11.5**

Table 19 presents final results of Antofagsta`s valuation.

Table 19: Summary: Valuation of Antofagasta



Source: own presentation

This example illustrates that DCF generally undervalue the natural resources companies, because it ignores the value of the option - the additional value of flexibility in the face of future uncertain events. However, the required assumptions for this method are of subjective nature and simplify the real world problems. Therefore, there exists the risk that the company's value is manipulated.

Conclusion

All valuations of companies today differ from each other, not only because the companies are differently but also because different people with different knowledge and backgrounds do the valuations. Especially in valuing mining companies, it is immensely difficult to estimate production figures of the coming years since they are very uncertain.

The price forecasts of the underlying commodity, in this case copper, is also very difficult to predict and will differ even between professional analysts. Also other input's forecasts, like discounted factor, costs and methodology used vary from analyst to analyst.

No valuation method can be said to be right, but no method is wrong either. The three methods: Multiples, Discounted Cash Flow and Real Options, should not be viewed as being independent of each other. The underlying idea is that they should complement the findings of each other.

The company valuation which is done in practical part of this paper is only one possible forecast for a company and hopefully gives a good indication of the future. Though, with in time it could be proven to be wrong. However, the theory behind the valuation and the basic models can be followed since it is only the estimations that will differ.

Final aspect is that, when some events in the world occur, such as impositions of a new 40% tax on resource in Australia, China's destocking or the Greek/ EU debt crisis, valuation of mining companies seriously be distorted in the short-term.

References

Bank of America, Merryll Lynch: *Metals and Mining Industry primer*, April 2010

Black, Fischer/ Scholes, Myron: *The pricing of options and corporate liabilities*. Journal of Political Economy 81, 1973 p.637-654

Brebner, Daniel/ Tanners, Timna/ Snowdowne, Andrew: *UBS Investment research, Mining and Steel Primer*, June 2008

Canadian Institute of Mining (CIM), Metallurgy and Petroleum: *Mineral Resources/ Reserves and Valuation Standards*, 2009

Citygroup: Fitzpatrick, Liam/ Sainsbury, Craig/ Jansen, Heath R.: *The World of Metals & Mining*, August 2007

Damodaran, Aswath: *Investment Valuation. Tools and Techniques for Determining the Value of Any Asset*, 2nd Edition, 2002.

Damodaran, Aswath: *The Dark Side of Valuation*, Second Edition, 2010, p. 417-449.

Drieza, J A/ Kicki, J and Saluga, P.:*Real options in mine project budgeting – Polish mining industry example, in Risk Analysis I*, 2002

Hull, John C.: *Options, Futures and Other Derivatives*, 6th Edition, 2005

Kernot, Charles: *Valuing mining companies*, 2006.

Kruschwitz, Lutz/ Löffler, Andreas: *Discounted Cash flow*, 2005

Ludeman, Frank L.: *A Decade of Deals: Gold & Copper Ore Reserve Acquisition Costs, 1990-1999*, Three Volumes. Castle Rock, Colorado, 2000

Mc Kinsey & Company, Inc. Copeland, Tom; Koller, Tim; Murrin, Jack: *Valuation Measuring and Managing the Value of Companies*, Third Edition, 2000.

Merton, Robert King: *The Theory of Rational Option Pricing*, Bell Journal of Economics and Management Science 4, 1973, p.141-183.

Ocean Equities Ltd: *Ferrous Resources Limited*, May 2010

Oliver, Helen/ Roscoe Willian E. / Chamois, Paul (Scott Wilson Copanie): *Valuation of the Exploration Properties of Kivu Gold Corporation*, December 2008

Truscott, S. J. / Russell, James: *Mine Economics*, 3rd Edition, 1984, p. 175-187

Viebig, Jan/ Poddig Thorsten / Varmaz, Armin: *Equity Valuation*, 2008

References from Internet

Antofagasta, found at www.antofagasta.co.uk, accessed date 27.03.2010

Basinvest AG: *A World Hungry for Commodities*, 2010, found at www.basinvest.ch, accessed date 10.03.2010

BHP Billiton found at www.bhpbilliton.com, accessed date 17.05.2010

Bruce, Christopher: *Ontario's Mandated Discount Rate - Rule 53.09(1)*, august 2000, found at http://www.economica.ca/ew05_3p2.htm, accessed date 1.06.2010

Business with The Wall Street Journal: *State royalty payments may increase, South Australia Warns Miners*, May 2010, found at http://www.theaustralian.com.au/business/in-depth/state-royalty-payments-may-increase-south-australia-warns-miners/story-fn5eo6td-1225861497831, accessed date 10.05.2010

Cobb, Barry R. / Charnes, John M.: *Real Options Valuation*, 2007, found at http://www.informs-sim.org/wsc07papers/018.pdf, accessed date 3.06.2010

Conversion Table, found at http://www.taylormade.com.au/billspages/conversion_table.html, accessed date 4.06.2010

Davis, Graham A.: *Economic Methods of Valuing Mineral Assets*, August 2002, found at http://www.bvappraisers.org/contentdocs/Conference/Graham_Davis_Economic_Method.pdf, accessed date 25.05.2010

Dimitrakopoulos, Roussos G. / Sabour, Sabry A. Abdel: *Evaluating mine plans under uncertainty: Can the real options make a difference?* 2007, found at http://cosmo.mcgill.ca/research/pdf/strat/STRAT_%5B2007%5DDIM_ABDEL_SABOUR_Evaluating_mine_plans.pdf, accessed date 15.05.2010

Domingo, Estrella V. / Lopez-Dee, Edward Eugenio P.: *Valuation Methods of Mineral Resources*, March 2007, found at http://unstats.un.org/unsd/envaccounting/londongroup/meeting11/LG11_14a.pdf, accessed date 10.05.2010

Eeden, Paul van: *Valuing an Exploration Company*, January 2006, found at http://www.paulvaneeden.com/Valuing.an.exploration.company, accessed date 6.06.2010

Encarta, dictionary, found at: http://encarta.msn.com/encnet/features/dictionary/DictionaryResults.aspx?lextype=3&search=metallurgy, accessed date 11.03.2010

FTSE, found at http://www.ftse.com/Indices/UK_Indices/index.jsp, accessed date 4.06.2010

Hacettepe University Department of Mining Engineering, Dictionary, found at: http://www.maden.hacettepe.edu.tr/dmmrt/, accessed date 11.03.2010

Hacettepe University Department of Mining Engineering, found at http://www.maden.hacettepe.edu.tr/dmmrt/, accessed date 2.04.2010

Infomine, found at www.infomine.com/publications/docs/Evans2007.ppt, accessed date 25.05.2010

Jacks, David S. / Fraser, Simon/ Williamson, Jeffrey G.: *Commodity Price Volatility and World Market Integration since 1700*, 2009, found at http://www.economics.harvard.edu/faculty/williamson/files/CommodityPriceVolatility.pdf, accessed date 10.06.2010

Lattanzi, Christopher R.: *Discounted Cash Flow Analysis Input Parameters and Sensitivity*, found at http://www.cim.org/mes/pdf/VALDAYChrisLattanzi.pdf, accessed date 31.05.2010

Lawrence, Devon Smith: *Discounted Cash Flow Analysis Methodology and Discount Rates*, found at http://www.cim.org/mes/pdf/VALDAYLarrySmith.pdf**,** accessed date 30.05.2010

London Metal Exchange (LME), found at www.lme.com, accessed date 15.04.2010

MVENMYN, found at www.infomine.com/.../docs/ValuationMethodsMineralProjects.ppt, accessed date 10.04.2010

OracleThinkQuest, found at http://library.thinkquest.org/05aug/00461/open.htm, accessed date 5.04.2010

Otto, James: Mining Taxation, 2006, found at www.siteresources.worldbank.org/INTOGMC/.../miningtaxationotto.ppt, accessed date 2.06.2010

Quantec Geoscience, found at http://www.quantecgeoscience.com/Minesite/index.php, access date 15.06.2010

Real Options in Petroleum, found at http://www.puc-rio.br/marco.ind/revers.html, accessed date, 14.06.2010

Rio Tinto, found at www.riotinto.com, accessed date 26.05.2010

Roberts, Craig: *The Valuation of Advanced Mining Projects & Operating Mines: Market Comparable Approaches*, found at http://www.infomine.com/publications/docs/Roberts2006.pdf, accessed date 15.05.2010

Roscoe, William E.: *Valuation of Mineral Exploration Properties Using the Cost Approach*, found at: http://www.cim.org/mes/pdf/VALDAYBill_Roscoe.pdf, accessed date 3.04.2010

South African Mineral Resource Committee (SAMREC): *South Africa Code for Reporting of Mineral Resources and Mineral Reserves*, March 2000, found at: http://www.geolsoc.org.uk/webdav/site/GSL/shared/pdfs/Fellowship/South%20Africa%20Code.pdf, accessed date 13.03.2010

Southwest Environmental Limited, found at http://www.desktop-study.co.uk/, accessed date 30.03.2010

Tang, Brian: *Determining the Real Value of Junior Mining Companies*, March-April 2010, found at http://magazine.mining.com/issues/1003/Vol03-02-DeterminingTheRealValueOfJnrMiningCompanies-08-10.pdf, accessed date 7.05.2010

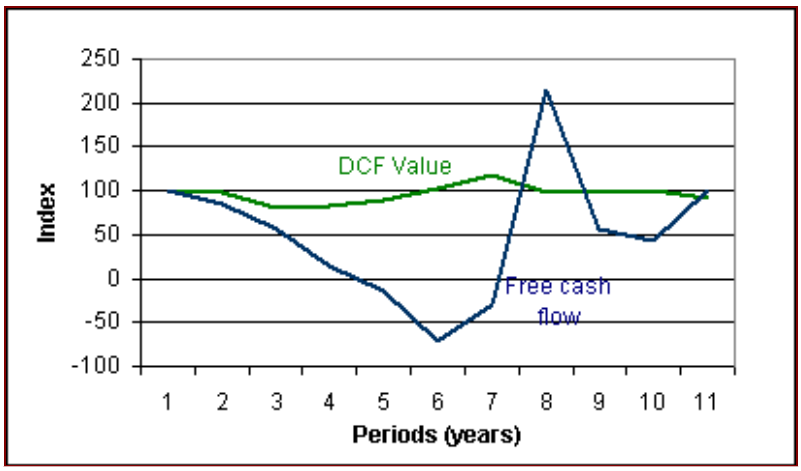
The JORC Code and Guidelines, found at http://www.jorc.org/jorc_code.asp, accessed date 12.06.2010

The World Bank: *Mining Royalties*, 2006, found at http://siteresources.worldbank.org/INTOGMC/Resources/336099-1156955107170/miningroyaltiespublication.pdf, accessed date 25.05.2010

Thompson, Ian S.: *A Critique of Valuation Methods for Exploration Properties And Undeveloped Mineral Resources*, found at: http://www.cim.org/mes/pdf/VALDAYIanThompson.pdf, accessed date 21.04.2010

Appendix

- **Appendix 1: The Long-Term View: Free Cash Flow and DCF Volatility**



The Long-Term View: Free Cash Flow and DCF Volatility

1 **Free cash flow pattern, Company A ($million)**

Period (years)	0	1	2	3	4	5	6	7	8	9	10
After-tax operating profit	10	9	6	3	0	-2	3	18	7	6	10
Net investment	3	3	2	2	1	3	5	3	3	3	3
Free cash flow	7	6	4	1	-1	-5	-2	15	4	3	7

Cash flows valued from any one year forward

2

DCF Value	34	33	27	28	30	35	40	33	33	34	31

Index

DCF Value	100	97.05882	79.41176	82.35294	88.23529	102.9412	117.6471	97.05882	97.05882	100	91.17647
Free cash flow	100	85.71429	57.14286	14.28571	-14.2857	-71.4286	-28.5714	214.2857	57.14286	42.85714	100

3 **Free cash flow and DCF value patterns**

- **Appendix 2: Definitions of Resources and Reserves**

Inferred Mineral Resource is that 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 that 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 that part of a Mineral Resource for which quantity, grade or quality, densities, shape, 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 Reserve is the economically mineable part of a Measured or Indicated Mineral Resource demonstrated by at least a preliminary feasibility study. 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. 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. This study must include adequate information on mining, processing, metallurgical, economic, and other relevant factors that demonstrate that economic extraction can be justified.

Proven Mineral Reserve the economically mineable part of a *measured mineral resource* demonstrated by at least a preliminary feasibility study. This study must include adequate information on mining, processing, metallurgical, economic, and other relevant factors that demonstrate that economic extraction can be justified.

- **Appendix 3: Low and High Cost Producers**

Let's assume that we have high and low cost producer, as presented in the table below. We can see that the margin of low cost producer is substantially higher than the margin of low cost producer.

Initial position	**Price 1, $**	**Cost, $**	**Margin 1, $**
High Cost producer	1000	900	100
Low Cost Producer	1000	500	500

Scenario 1:
If the price of commodity increase to 1100$ (see the table below), obviously, both companies have positive margins. The difference is that margin 1 of high cost producer has increased by 100% and the margin 1 of low cost producer has increased by 20%. We can see a leverage effect on the side of high cost producer. In this scenario leverage is equal to 5 (100/20).

Scenario 1	Price 2, $	Cost, $	Margin 2, $	Margin 1 increased um
High Cost producer	1100	900	200	100%
Low Cost Producer	1100	500	600	20%

Scenario 2:
If the price of commodity decrease to 900$ (see the table below) the margin of high cost producer decreases by 100% and of low cost producer by 20%. Again we see the leverage effect and the related risk of downturn in commodity prices.

Scenario 2	Price 3, $	Cost, $	Margin 3, $	Margin 1 decreased um
High Cost producer	900	900	0	100%
Low Cost Producer	900	500	400	20%

- **Appendix 4: Black-Sholes-Merton Model**[136]

In the financial world, options are types of contracts that generally include the right, but not the obligation, to buy or sell a share, currency or commodity.

A *call option* gives the buyer the right to buy a tradable commodity or currency at a predetermined price for a specified period of time. For the owner of call options, they become more valuable as the price of the underlying commodity increases. For the seller of call options, these options become an increasing liability as commodity prices rise, since there is the obligation to sell the commodity at a predetermined (perhaps lower-than-market) price.

A *put option* gives the buyer of the option the right to sell a tradable commodity or currency at a predetermined price for a specified period of time. Put options therefore increase in value as the price of the commodity drops.

In the year 1973 Fischer Black and Myron Scholes published a description of a financial model for valuing options which has become widely accepted in the financial world for valuing and pricing financial and other types of options contracts. In the same year Merton adapted the model to include options on dividend paying stocks.

The Black-Scholes-Merton (BSM) model is used to calculate a theoretical call and put price using the six key determinants of an option's price: the current price (S_t), the exercise or strike price (K), the volatility of the underlying asset (σ), the time of expiration (T) (expressed as a percent of a year), risk free interest rate (*r*) and the dividend rate (δ).

The Black-Scholes-Merton (BSM) price for a European call option trading at time *t* is:

$$C(S_t, T-t) = S_t \times N(d_1) - K \times e^{-r\times(T-t)} \times N(d_2) \qquad (1)$$

[136] Black / Scholes, 1973 p.637-654, Merton, 1973, p.141-183

Where:

$$d_1 = \frac{\ln(\frac{S_t}{K}) + (r - \delta + \frac{\sigma^2}{2}) \times (T - t)}{\sigma \times \sqrt{t}} \quad (2)$$

$$d_2 = d_1 - \sigma \times \sqrt{(T - t)} \quad (3)$$

The variables not mentioned above are:

ln = natural logarithm
N(x) = standard normal cumulative distribution function
e = the exponential function

The BSM price for a European put option trading at time t is:

$$C(S_t, T - t) = -S_t \times N(-d_1) + K \times e^{-r \times (T-t)} \times N(-d_2)$$

where d1 and d2 are given by expressions (2) and (3) above

Appendix 5: Normalized Valuations

What are normal numbers?

If a company's current financial statements answer our question about how much earnings, reinvestment, and cash flow would this company have generated in a normal year? Normal year would be one in which commodity prices reflect the intrinsic price of the commodity, reflecting the underlying demand and supply.

The volatility appears because of the price of the commodity. It impacts not only revenues and earnings but also reinvestment and financial costs. Consequently, normalization with commodity companies has to be built around a normalized commodity price.

Normalized commodity price

1. Approach: commodity companies have a long trading history. We can use the historical price date to come up with an average, which we can then adjust for inflation.
2. Approach: is more complicated than approach 1. Since the price of the commodity is a function of demand and supply for that commodity, we can assess the determinants of that demand and supply and try to come up with the intrinsic value for the commodity.

After we have normalized the price of the commodity, we can assess what the revenues, earnings, and cash flows would have been for the company being valued at that normalized price.

Appendix 6: DCF Valuation of Antofagasta

Table 20: Balance sheet of Antofagasta

Balance Sheet	2008A US$m	2009A US$m	2010F US$m	2011F US$m	2012E US$m	2013F US$m	2014E US$m
Cash and Deposits	3358.0	3222.3	2756.6	4113.3	5378.1	6737.3	7365.8
Trade and ither receivables	313.8	608.6	500.0	500.0	500.0	500.0	500.0
PPE (Property, Plant & Equipment)	3679.7	4873.2	5764.5	5415.7	4995.7	4614.5	4257.4
Exploration	0.0	0.0	34.0	86.1	154.5	216.9	279.3
Other Assets	603.4	806.4	365.5	365.5	365.5	365.5	365.5
Total Assets	**7954.9**	**9510.5**	**9420.6**	**10480.6**	**11393.8**	**12434.2**	**12768.0**
Current borrowings	319.0	431.8	6.6	0.0	0.0	0.0	0.0
Non-Current borrowings	119.9	1194.8	763.0	331.2	-100.6	-100.6	-100.6
Other liabilities	1083.4	1266.5	1270.4	739.9	173.1	-432.2	-1019.5
Total Liabilities	**1522.3**	**2893.1**	**2040.0**	**1071.1**	**72.5**	**-532.8**	**-1120.1**
Total Shareholders Equity	**6432.6**	**6617.4**	**7389.6**	**9409.6**	**11321.3**	**12958.0**	**13888.1**
Total	**7954.9**	**9510.5**	**9429.6**	**10480.7**	**11393.8**	**12425.2**	**12768.0**

Source: FD Capital

Table 21: Profit and Loss of Antofagasta

Profit & Loss	2008A US$	2009A US$	2010F US$	2011F US$	2012E US$	2013E US$	2014E US$
Copper produced (tonnes)	477'000	442'500	543'000	700'000	800'000	800'000	800'000
Copper price (USc/lb)	315	234	334	345	300	285	250
Copper Revenue	**3'360'369'600**	**2'318'416'800**	**4'060'076'160**	**5'409'600'000**	**5'376'000'000**	**5'107'200'000**	**4'480'000'000**
Molybdenum produced (tonnes)	7'800	7'800	6'200	8'000	9'000	9'000	9'000
Molybdenum price (Usc/lb)	28.9	11.1	14	11.5	11	10.3	10
Molybdenum Revenue	**5'049'408**	**1'939'392**	**1'944'320**	**2'060'800**	**2'217'600**	**2'066'400**	**2'016'000**
Water & Transport (US$m)	92'700'000	86'000'000	91'000'000	95'000'000	98'000'000	98'000'000	98'000'000
Other revenues	40'000'000	556'300'000	50'000'000	70'000'000	80'000'000	80'000'000	80'000'000
Total Revenue	**3'498'119'008**	**2'962'656'192**	**4'203'020'480**	**5'576'660'800**	**5'556'217'600**	**5'287'266'400**	**4'660'016'000**
Operating Costs	1'737'300'000	1'287'800'000	1'350'000'000	1'550'000'000	1'700'000'000	1'785'000'000	1'874'250'000
EBITDA (Gross Operating Proft)	**1'760'819'008**	**1'674'856'192**	**2'853'020'480**	**4'026'660'800**	**3'856'217'600**	**3'502'266'400**	**2'785'766'000**
Depreciation & Amortisation	186'900'000	217'500'000	270'700'000	266'700'000	267'100'000	267'100'000	267'100'000
Exploration & Royalties	54'900'000	67'100'000	145'200'000	164'200'000	158'800'000	158'800'000	158'800'000
Other	-1'024'900'000	-73'300'000	18'000'000	18'000'000	18'000'000	18'000'000	18'000'000
EBIT	**2'543'919'008**	**1'463'556'192**	**2'419'120'480**	**3'577'760'800**	**3'412'317'600**	**3'058'366'400**	**2'341'866'000**
Less Net Interest Expense	-65'200'000	25'900'000	30'900'000	21'200'000	-128'100'000	-283'000'000	-283'000'000
EBT (Profit before tax)	**2'609'119'008**	**1'437'656'192**	**2'388'220'480**	**3'556'560'800**	**3'540'417'600**	**3'341'366'400**	**2'624'866'000**
LessTax	521823801.6	287531238.4	477644096.0	711312160.0	708083520.0	668273280.0	524973200.0
Less Minorities	383300000.0	452200000.0	716'466'144	1'066'968'240	1'062'125'280	1'002'409'920	787'459'800
Net Profit	**1'703'995'206**	**697'924'954**	**1'194'110'240**	**1'778'280'400**	**1'770'208'800**	**1'670'683'200**	**1'312'433'000**

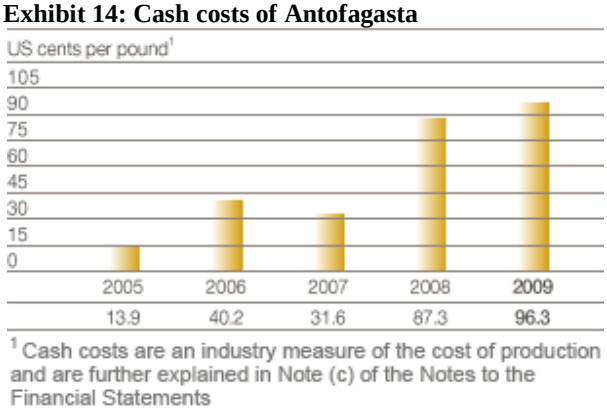
Source: Company date and own forecasts

Table 22: Change in Net Working Capital (NWC)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Revenues	**3870**	**3826.7**	**3498.1**	**2962.6**	**4'203**	**5'577**	**5'557**	**5'288**	**4'661**	**4'400**
Trade Debtors	425.5	403.5	80.2	401.9	399.285	529.815	527.9055	502.379	442.814	418
%	*11%*	*11%*	*2%*	*14%*	*9.50%*	*9.50%*	*9.50%*	*9.50%*	*9.50%*	*9.50%*
Inventories	120.3	130.3	155.9	240.1	189.135	250.965	250.0605	237.969	209.754	198
%	*3%*	*3%*	*4%*	*8%*	*4.50%*	*4.50%*	*4.50%*	*4.50%*	*4.50%*	*4.50%*
Trade Creditors	76.2	87.8	415.1	254.4	262.6875	348.5625	347.30625	330.5125	291.325	275
%	*2%*	*2%*	*12%*	*9%*	*6.25%*	*6.25%*	*6.25%*	*6.25%*	*6.25%*	*6.25%*
NWC	469.6	446	-179	387.6	325.7325	432.2175	430.65975	409.8355	361.243	341
Change in NWC		**-23.6**	**-625**	**566.6**	**-61.8675**	**106.485**	**-1.55775**	**-20.82425**	**-48.5925**	**-20.243**

Source: Company Date and own forecasts

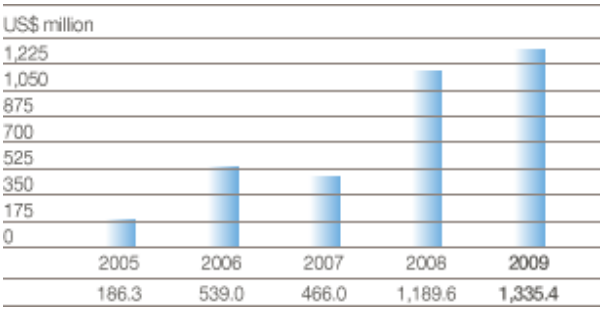
Exhibit 14: Cash costs of Antofagasta



[1] Cash costs are an industry measure of the cost of production and are further explained in Note (c) of the Notes to the Financial Statements

Source: Company data

Exhibit 15: Capital Expenditure of Antofagasta



Source: Company data