AUSTRALIAN INSTITUTE OF GEOSCIENTISTS

REAL OPTIONS VALUATIONS

A new way of valuing mining projects

By

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OBJECTIVES

- To consider weaknesses and bias inherent in Discounted Cash Flow (DCF) analysis
- To review recent developments in mineral project evaluation and
- To explore how real options valuation (ROV) methodologies may overcome some of these difficulties in the evaluation of mineral projects

INVESTMENT CRITERIA

- For resources projects with healthy Net Present Values (NPVs) and low volatility in their future cash flows, Discounted Cash Flow (DCF) analysis will continue to provide the dominant investment decision-making criteria

HOWEVER DCF EVALUATION CAN BE BIASED BECAUSE

- It applies a **single time- and risk-adjusted discount rate** to derive and compare the NPVs of:

1. **different projects with different risk characteristics**
2. the **same project under different development design scenarios**, e.g. different capital-intensity, operating leverage
3. Both the **riskier revenue and less risky cost functions** of their financial models biasing decisions against incurring expenditure now to save costs later

COMPARING THE RISK OF PROJECTS WITH DIFFERENT CAPITAL INTENSITY

Both company A and B produce the same CF. A is capital-intensive and B labour-intensive. Their CFs have very different levels of risk due to variability in demand

COMPANY	A	B			A		B	
	Capital	Labour			Capital		Labour	
	Intensive	Intensive			Intensive		Intensive	
Price $/t	3000		Demand volatility %	25.00%				
Production t * '000	30	30						
Revenue $'000	90000	90000		Sensitivity of CFs to changes in demand				
Variable cost of production $/t	1000	1666.667			30000		30000	
Annual fixed cost $'000	30000	10000		22.5	15000	22.5	20000	
Total annual cost of production $'000	60000	60000		30	30000	30	30000	
Gross annual cash flow $'000	**30000**	**30000**		37.5	45000	37.5	40000	
			Standard deviation of CFs $'000		12247		8165	
			Standard deviation of CFs %		**40.82%**		**27.22%**	

COMPARING THE RISK OF PROJECTS WITH DIFFERENT UNIT OPERATING COSTS

Company B with a higher unit cost must produce a larger annual tonnage to match company A's CF. The risk of the CF of company B as a function of price volatility is much higher

	Low	High			Low	High
Price $/t	3000		Price volatility % pa	25.00%		
Cost of production $/t	2000	2500		Sensitivity of gross CFs to price changes		
Annual production t * '000	30	60			30000	30000
Annual Revenue $'000	90000	180000		2250	7500	-15000
Annual operating cost $'000	60000	150000		3000	30000	30000
Annual gross cash flow $'000	30000	30000		3750	52500	75000
			Standard deviation of CF $'000		18371	36742
			Volatility of CF %		61.24%	122.47%
Price of risk = Percentage discount per 1% of CF volatility				0.10%	6.12%	12.25%

PRICE OF RISK AND DIFFERENT DISCOUNT RATES

- We **cannot be indifferent between the two projects because their single-discount, NPV is the same**, **unless** we have a take or pay contract or the commodity price and exchange rate have been **hedged**

- To make an **objective comparison** between un-hedged projects with such **large differences in CFs volatility** we would need to use **different discount rates**

- These could be derived by applying a **"prices of risk"**, i.e. a **common percentage of risk-discount per unit of CF volatility** in addition to the risk –free rate of discount which compensate for the timing of cash flows

OTHER CAUSES OF DCF BIAS

- DCF also applies a single time- and risk-adjusted discount rate to both components of Net Cash Flows irrespective of their very different risks e.g.:
  - Revenue as a function of risky output quantities and above all price risk and
  - Capital and operating costs which are known with greater certainty, can be controlled and are not subject to price risk
- If costs are less risky than revenue then using a single, high, risk-adjusted discount rate biases DCF/NPV against incurring appropriate levels of expenditure now to save costs later

OVERCOMING DCF BIAS USING ROV

- ROV can help overcome these biases about:
  - Trade-offs between capital and operating costs and
  - Trade-offs between costs and potential production rates
- By constructing models that separate and discount more realistically the inherently higher-risk revenue function of mineral and petroleum projects as compared to discounting their cost function using a risk-free rate

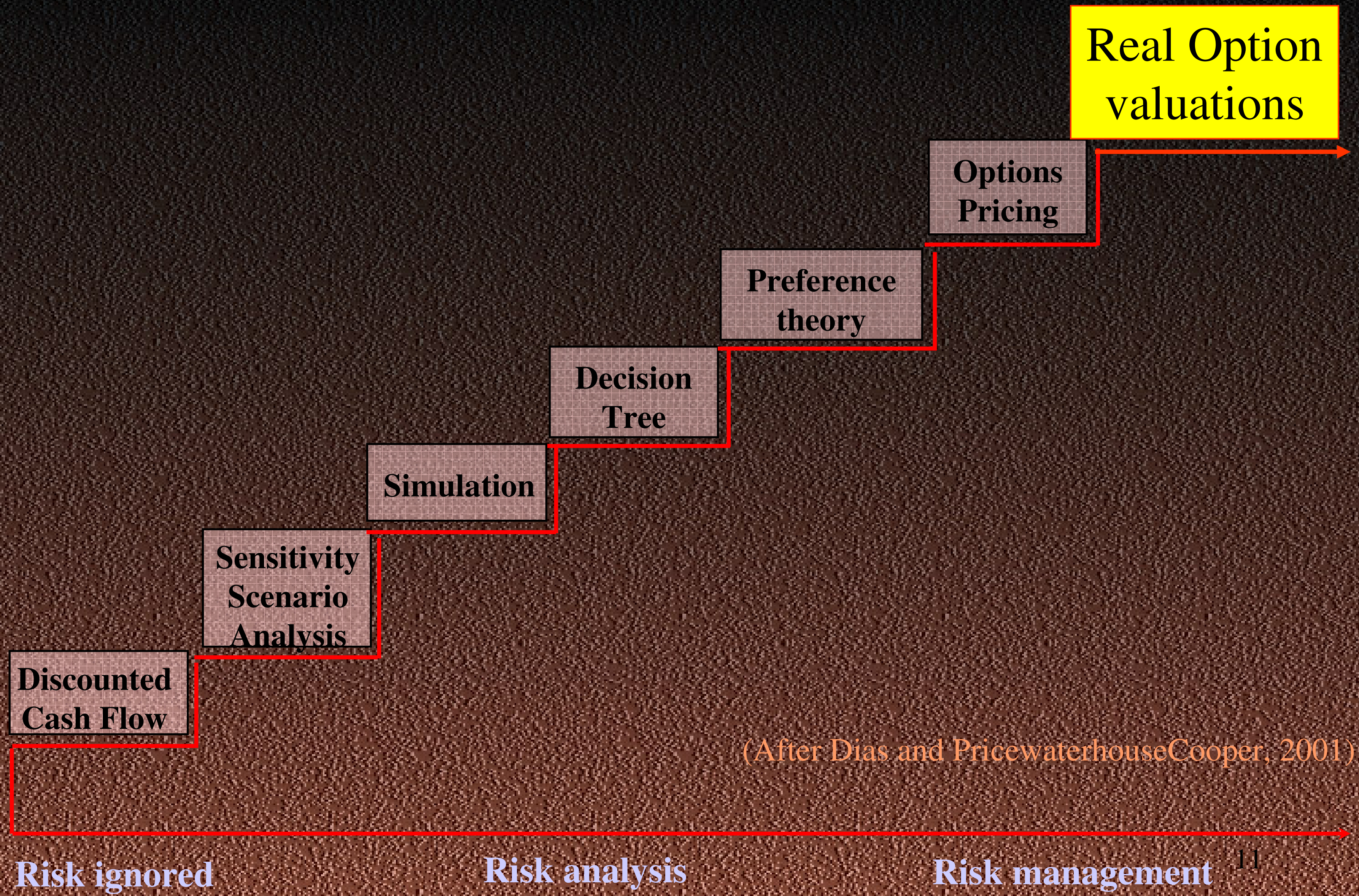
Salahor (1998) and Samis (2002) provide models to address these issues

REAL OPTIONS

- As the name implies Real Options Valuations (ROV) have to do with real assets, such as risky mining and petroleum projects, as opposed to financial securities and their derivatives

- The ROV methodology has evolved from advances in both the field of finance and decision analyses

FROM MODELLING UNDER ASSUMED CERTAINTY TO RISK ANALYSIS AND STOCHASTIC MODELS



VOLATILITY CAN BOTH ADD OR CONSUME VALUE

- The trick is in investing in or designing projects in a manner that provides **management flexibility** to take advantage of up swings (e.g. rising Ni prices) and to avoid or minimise the impact of down swings

- These are the fundamental factors that generate option value

EXPLORATION, R & D and PILOT STUDIES CREATE OPTIONS

- Exploration, R & D and pilot studies have the characteristics of real options, in that they **create opportunities but not obligations**
- Yet many of them continue to be penalised by DCF analysis and are often unwisely rejected
- This is due to investors not recognising and valuing management flexibility to keep their future options open to progressively adjust their actions as a project unfolds, depending on emerging circumstances and information

EXAMPLE OF DCF versus REAL OPTION LOGIC IN R & D AND PILOTING

DCF LOGIC

- **Evaluate investment opportunity in $100M project**
  - 50% chance of success (PV = $150M)
  - 50% chance of failure (PV= $10M salvage)

EV = 50%*($150M-$100M) + 50%*($10M – $100M) = -$20M

Decision: Reject

(After Searson, 2002)

REAL OPTION LOGIC

- **Invest $10M in pilot plant**
  - 50% chance that pilot will succeed

EV = 50%*($150M -$110M) + 50%*($0-$10M) = $15M

Decision: 1 -If pilot successful then invest $100M
2- If pilot fails do not proceed

THE STOCK MARKET PREMIUM

- The stock market supports “option creation” by valuing some non-dividend-paying companies holding sub-economic mineral deposits of commodities with volatile prices
- It does so on the basis of their growth potential even though the NPVs of their projects may be negative at current prices
- This result in a “market premium” between a company capitalisations and the the sum of the “fundamental valuations” (NPVs) of all its projects

EXAMPLE OF THE ROV OF AN EXPLORATION/DEVELOPMENT PROJECT

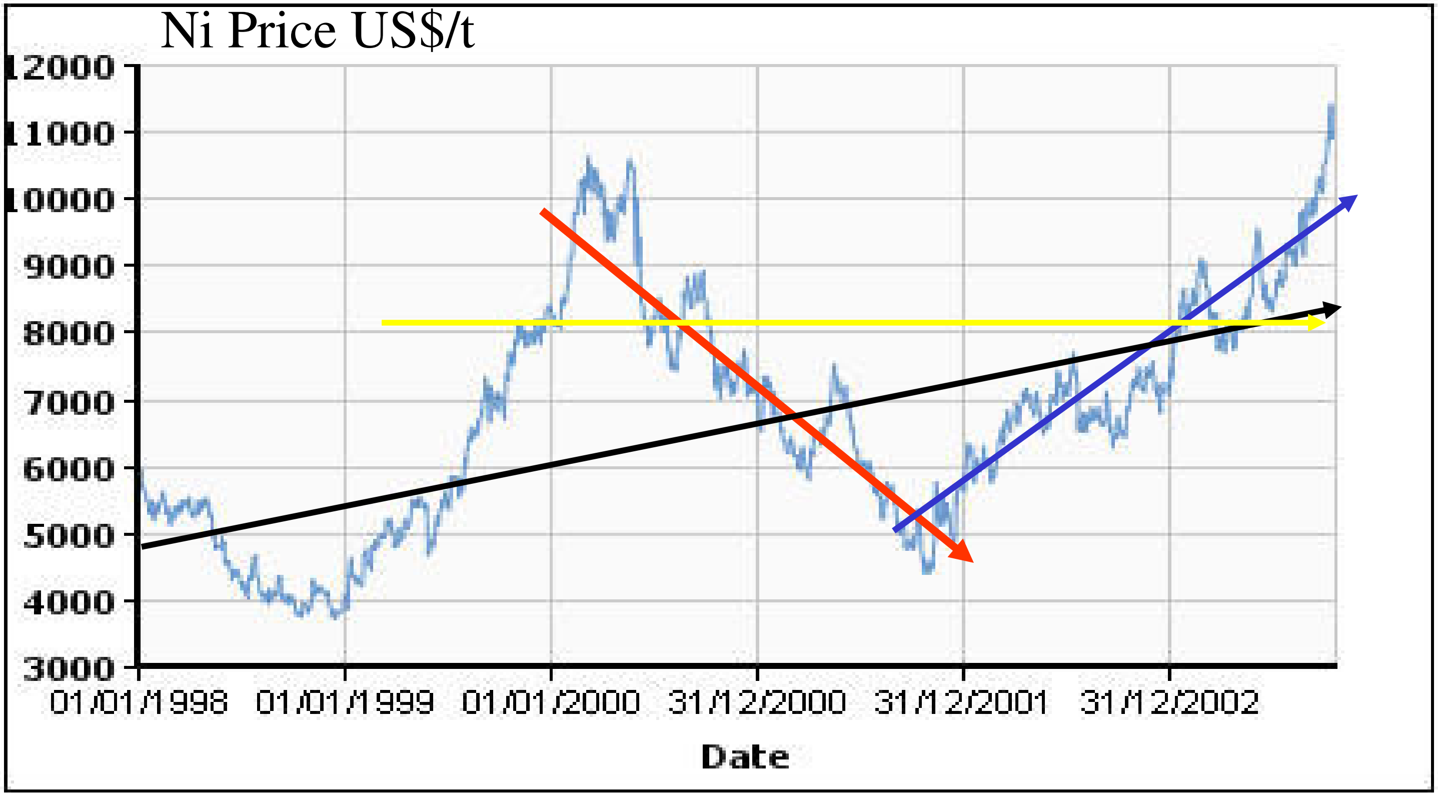
- In September 2001 the price of Ni was US$5000/t
- At this price the NPV of a 5-year, Ni-mining operation based on reserves of 3.4 Mt at a Ni equivalent of 2.32% (i.e. of the size of Sally Malay) would have been negative (-A$8.9 M)
- Yet following its IPO Sally Malay Mining Ltd. was capitalised at $12.2 M

NICKEL PRICE VOLATILITY

Investors in Sally Malay would have known that:

- The LME Ni prices show over 20% annual volatility
- Depending on what period is analysed, the historical mean price of Ni appears to be trending upwards
- Prices in September 2001 were close to historical lows and likely to revert to the long-term mean of around $7000/t over the following 3 to 4 years particularly with the onset of the next economic cycle

TREND IS SENSITIVE TO WHERE WE START AND STOP



LATTICE OF POSSIBLE REAL Ni PRICES

Each year real prices can either go up or down

		YEAR			
0	1	2	3	4	5
					$10,732
Up factor	**1.165**			$9,212	
Down factor	**0.809**		$7,907		$7,907
		$6,787		$6,787	
	$5,825		$5,825		$5,825
$5,000		$5,000		$5,000	
	$4,045		$4,045		$4,045
		$3,273		$3,273	
			$2,648		$2,648
				$2,142	
					$1,733

Up 5 times in succession

Down 5 times in succession

RELATED POSSIBLE NPVs

At any price the NPV can be either positive or negative, but if negative we are not compelled to develop the mine

		YEAR			
0	1	2	3	4	5
		A lot of upside			1241.5
				558.9	
			247.0		247.0
NPV A$M		95.7		95.7	
	21.8		21.8		21.8
-8.9		-8.9		-8.9	
	-59.0		-59.0		-59.0
		-129.4		-129.4	
			-187.8		-187.8
				-221.8	
					-236.4
		But also a lot of downside			

THUS THE PROJECT VALUE MUST BE GREATER THAN ITS STATIC NPV

As no development will take place unless the price improves, thus value of the project at each node = Max(NPVs or zero)

		YEAR			
0	1	2	3	4	5
					Mine
				Mine	
			Mine		Mine
		Mine		Mine	
	Develop		Develop		Develop
Delay		Delay		Delay	
?	Delay		Delay		Delay
		Delay		Delay	
			Delay		Delay
				Delay	
					Delay

What is the value of flexibility?

Downside is avoided by delaying development

TIMING OF A POSSIBLE DEVELOPMENT

- Given that the mining leases could have been kept in good standing at a low cost until their expiry a fair way into the future
- management had the option of deferring development until a possible rise in Ni price would make the project commercially viable, but no obligation to proceed with development

PROJECT AS A CALL OPTION

- Thus in September 2001 the Sally Malay project had all the characteristics of an American call option to:
  - Defer or proceed at the company's discretion with a $46M development = Exercise price (X)
  - At any time until the expiry date (t) of the mining leases, say 11 years
  - To derive a net benefit equal to the present value of all future net after-tax operating cash flows (S) (this is the equivalent of the spot price in normal derivatives) less that of the capital investment (X)
- As a consequence the project value would have been the Max(between S – X or zero), assuming the company was in a position to hung onto the leases at no cost

REAL OPTION VALUE (ROV) USING THE BLACK AND SCHOLES (B-S) FORMULA

Using simulation we calculate the volatility of future project cash flows to be 29% largely influenced by 20% Ni price volatility. S and X are derived from the DCF model

C = Value of real option (ROV) A$ million		**20.94**
SS = Spot price = PV of net after-tax operating CFs		41.12
X = Exercise price = PV of capital investments		46.00
t = Time to expiry (years)		11
SD = CF Volatility		29.00%
Risk-free interest %		5.00%
ENPV = Enhanced NPV = NPV + ROV A$ million	**= -8.9M+20.94M =**	**12.04**

NPV versus ENHANCED NPV (ENPV)

- The Enhanced NPV (or ENPV) = NPV + ROV
- In our example the ENPV = -$8.9M + $20.94M = $12.04M
- ENPV is close to the market value of the project at the time of the IPO, i.e. $12.2M
- ROV represents the "market premium", i.e. the difference between the static NPV of the project and the capitalisation of Sally Malay Mining Ltd. at the time

LIMITATIONS OF BLACK AND SCHOLES FORMULA

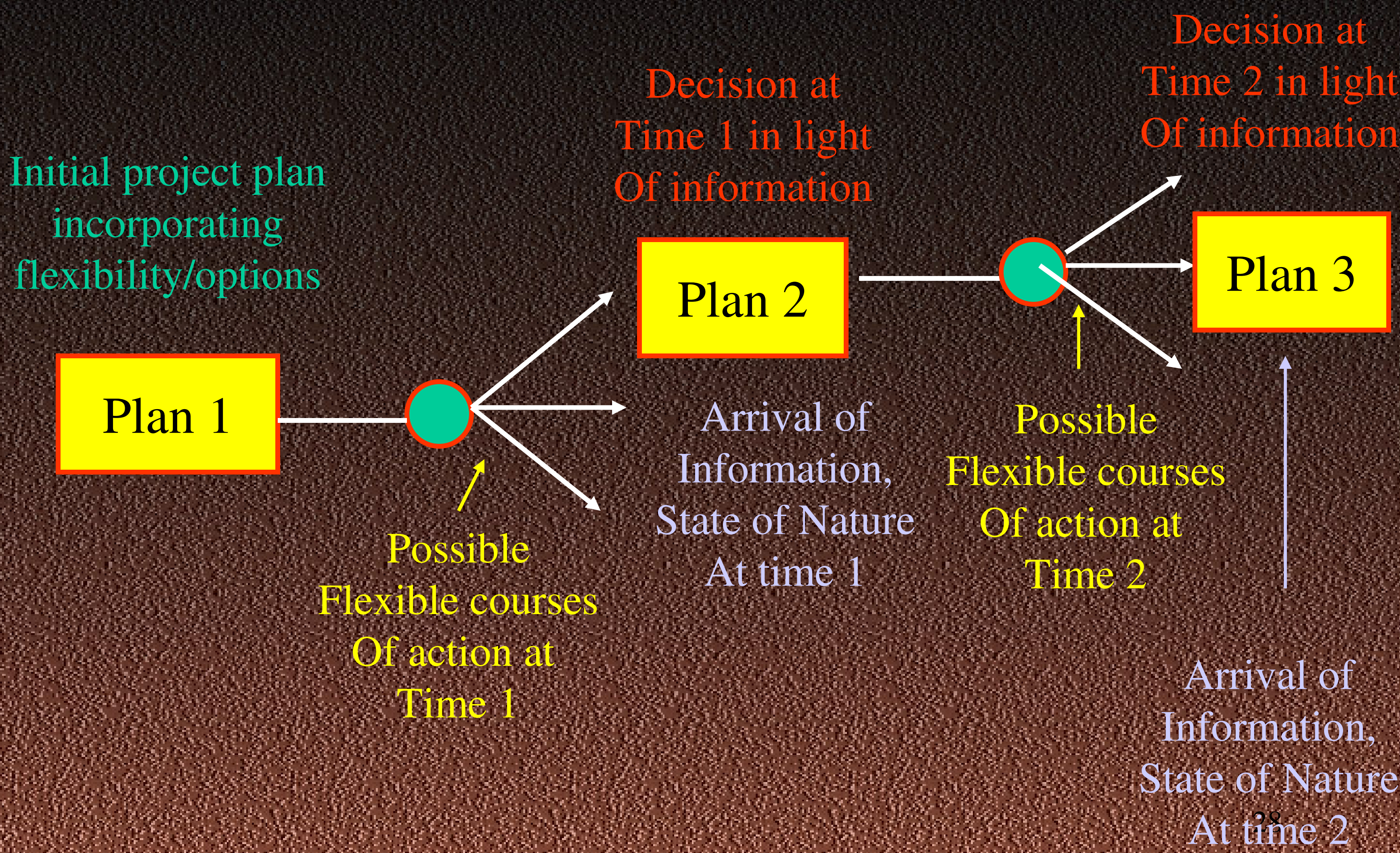
- **The Black and Scholes (B-S) equation** (normally used to calculate the value of an American call option for financial derivatives) gives a good approximation of the ROV of this highly simplified project model

- However, because of its restrictive assumptions, the B-S formula is unsuitable for more realistic and therefore complex, models of mining projects which frequently feature series of sequential and/or compound real options

DECISIONS WITH THE BENEFIT OF HINDSIGHT

- DCF models are static, i.e. they imply that investors are committed to the initial plans irrespective of emerging circumstances
- In reality most projects are dynamic and can be visualised as **a tree of possible scenarios** with nodes representing uncertain **"states of nature"**
- The arrival of new information progressively resolves this uncertainty making it possible for managers, with the wisdom of hindsight, to identify which, among the various "branches" representing possible actions, is the most advantageous one

THE FUTURE AS A TREE-LIKE STRUCTURE OF POSSIBLE SCENARIOS



EXPLORATION PROGRAMS AS SEQUENTIAL REAL OPTIONS

- At the conclusion of each successive exploration phase explorers have the option but not the obligation to:

1. progress to the next stage
2. defer further exploration, but retain the exploration license
3. farm-out or
4. abandon the project

- These are typical sequential/compound real options

CATPURING THE VALUE OF GRADE-TONNAGE TRADE-OFFS

- We often need to value mining projects with opportunities for grade-tonnage trade-offs
- JORC code-based valuations will only include proven and probable, run-of-the-mill ore
- Inadequate value may be attributed to managerial flexibility and the price leverage inherent in these reserves and surrounding lower-grade resources

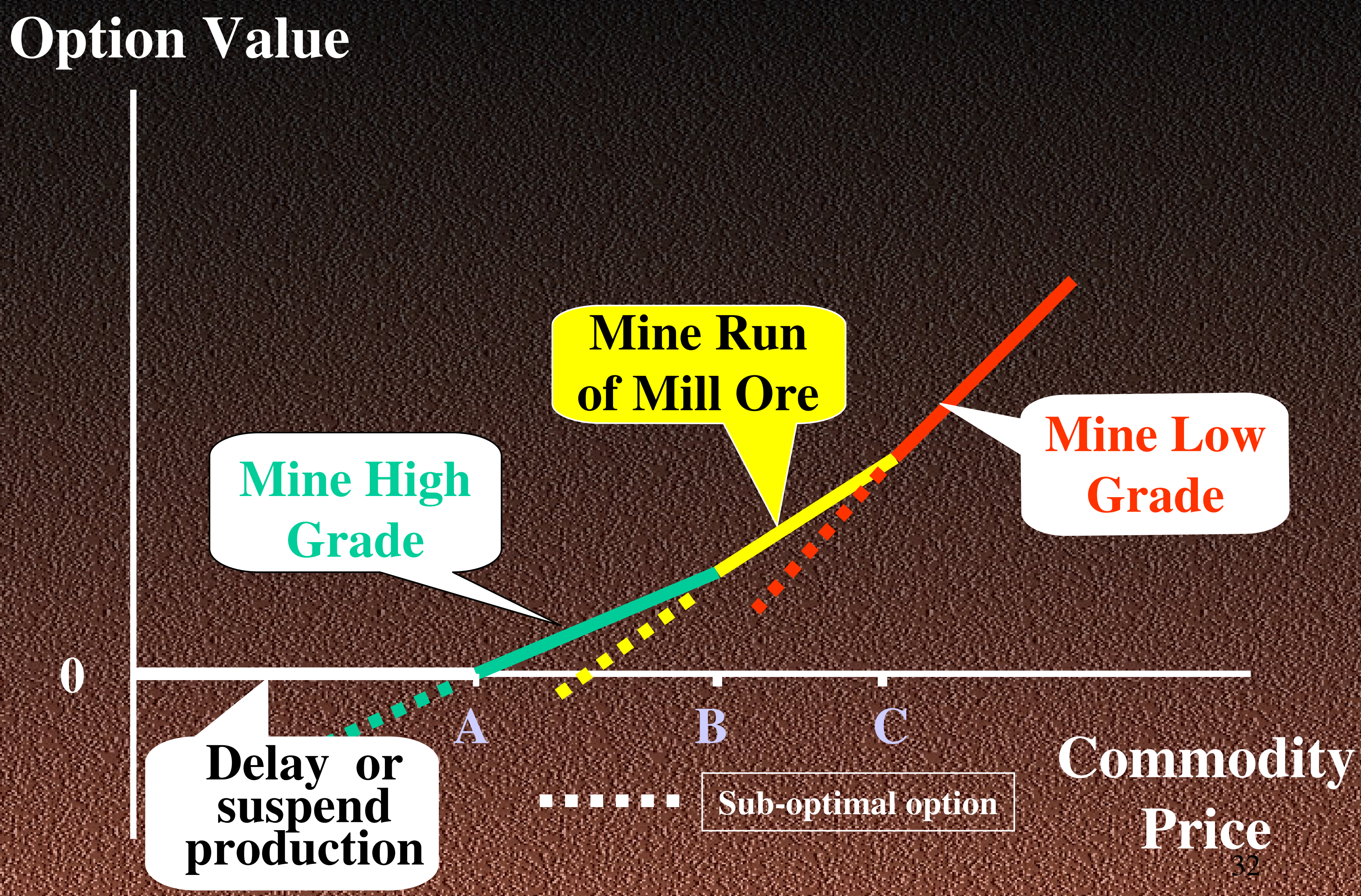
PROJECTS WITH GRADE-TONNAGE TRADE-OFFS CAN BE VIEWED AS A SERIES OF REAL OPTIONS TO:

1. Wait or defer an investment with a right but no obligation to invest later
2. Commence or stage development with revaluation and possible expansion or abandonment at each stage
3. Alter the operating scale e.g.:
   - **Expand/contract production**
   - **Shut down/restart**
4. Abandon

- The value of these options, which may be worth several times the discount rate, is not captured by and must therefore be added to the project static NPV

TYPE OF REAL OPTIONS IN MINING

(After Samis, 2002)



ROV MODELLING OF MULTIPLE OR COMPOUND OPTIONS CAN BE COMPLEX

- It entails:

1. Static DCF modelling of all possible scenarios
2. Simulation of expected NPV and volatility of net operating cash flows as real option model inputs
3. Identifying and modelling the project real options
4. Optimising the investment choice by applying an appropriate ROV analytical method, to **neutralise risk**

IDEAS BEHIND REAL OPTIONS VALUATIONS (Salahor,1998 and Bradley, 1998)

1. Cash flows can be considered as a commodity with criteria of value: Timing and Risk

2. Essentially frictionless financial markets with low barriers and transaction costs ensure:
   - **"value consistency"** = assets with the same CFs and similar risk should have the same price, i.e. there should be "no arbitrage" no "free lunches" and
   - **"value addictivity"** = CFs (e.g. revenue and costs), can be separated, appropriately discounted, evaluated and re-combined

PROJECTS AS CLAIMS ON FUTURE CASH FLOWS (Samis, 2002)

- Under "no-arbitrage" conditions, mining projects can be viewed as a set of "contingent claims" with the same cash flow consequences as those of a **replicating portfolio** composed of a series of:
  - **Mineral Forward contracts** with quantities and delivery dates matching the mineral production schedule of the mine, **equating to its Revenue Function** and
  - **Bonds to replicate Capital and Production Costs.** As these costs are known with a degree of certainty and can be controlled, their future value is analogous to servicing bonds with principal repayments of the same magnitude and maturing at the same time as the project costs

ARBITRAGE VALUATION "NEUTRALISES" RISK (Samis, 2002)

- As the forward price at various times in the future already incorporates discounting for risk, and
- The bonds are secured
- **ROV methodologies "neutralise" or manage risk** and
- **only risk-free rates of discount are used in ROV to compensate just for the time-value-of-money**

NET VALUE OF MINERAL PRODUCTION (Samis, 2002)

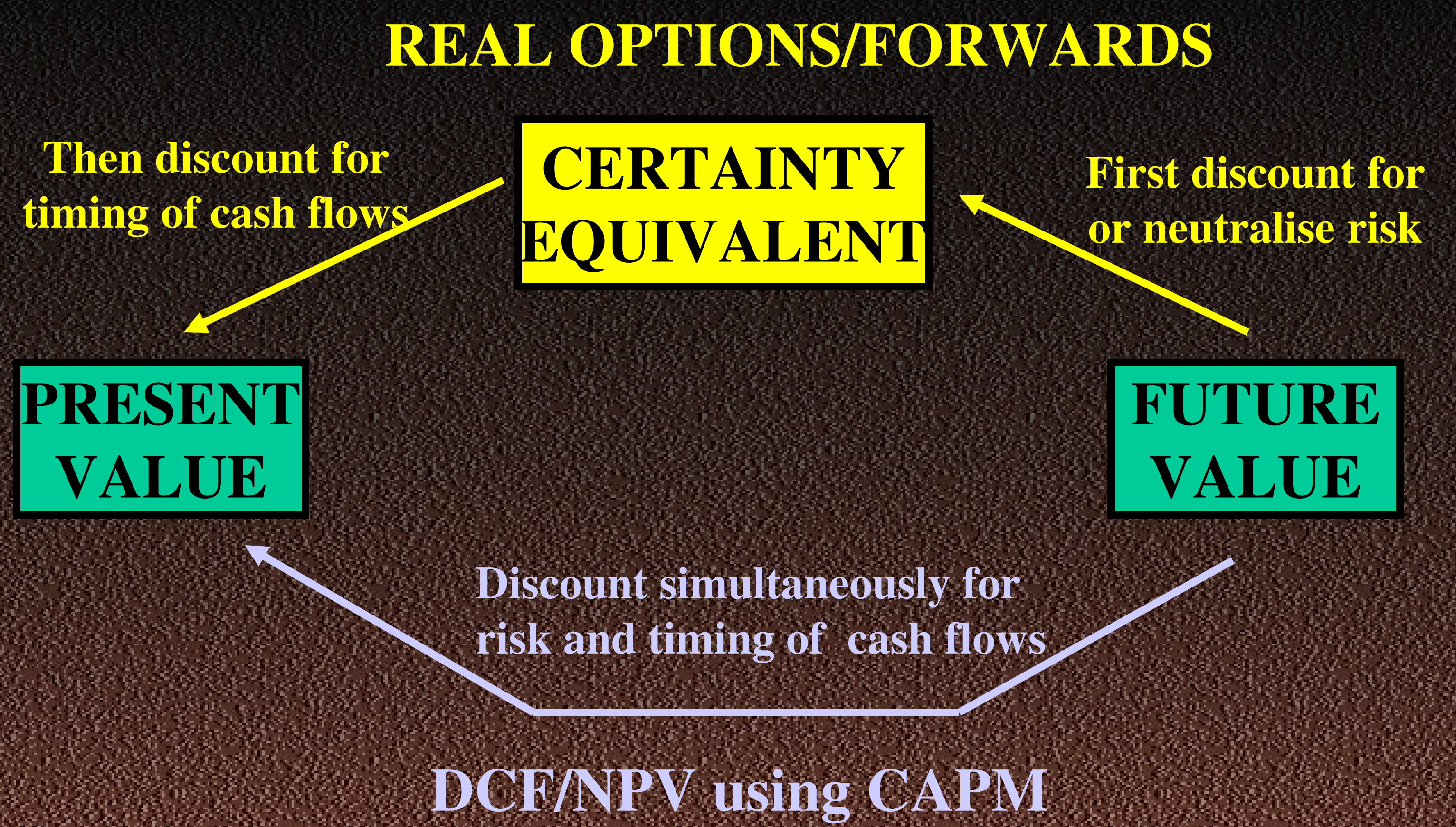
- **FV (Production,t) = Mineral produced$_t$*K$_{Mineral,t}$ – OPEX$_t$**

- **PV (Production,t) = (Mineral produced$_t$*K$_{Mineral,t}$ – OPEX$_t$)*e^{-rt}**

- **NPV (Mine) = $\Sigma_{t=0}{}^{T}$(Mineral produced$_t$*K$_{Mineral,t}$ – OPEX$_t$ - CAPEX$_t$)*e^{-rt}**

Where K$_{Mineral,t}$ is the forward price of the mineral at time t

DCF versus ROV DISCOUNTING



(After Dias, 2000)

HOW IS RISK NEUTRALISED?

- There are a number of ROV approaches:

  1. Close-form equations of which the **Black and Scholes (B-S) formula** is an example and

  2. The more friendly and versatile **binomial lattice** methods including the:
     - The **replicating portfolio** method
     - The **State Prices** method and
     - The **"Risk-free Probability"** method

- All these methods based on "contingency claims" and "no arbitrage" principles

IT ALL SOUNDS SIMPLE IN THEORY, BUT…..

- If forward prices are available for the length of the project life (which is unlikely beyond a few years) we can just use them.
- If not, they need to be forecast using complex stochastic simulation processes.
- This is only one of a number of statistical inputs of sources of CF volatility the estimation of which may be mathematically challenging

CONCLUSIONS

- The value of managerial flexibility to make successive decisions in light of emerging information resolving uncertainty is not captured by conventional DCF/NPV methodologies
- This "real option value" can be significant particularly in the case of projects with low NPVs but high variability of returns and time to embark into flexible alternative courses of action

CONCLUSIONS (Cont.)

- Project evaluation is continuing to advance rapidly in refining the concept of "Enhanced NPV = NPV + ROV", by transferring and building on the option valuation methodologies established for financial derivatives
- An order of magnitude of the value can be derived using the B-S formula, but more reliable estimates require more complex modelling and computational methodologies
- Estimates of the necessary model inputs are complex and sometimes inaccurate but, in spite of this, the combination of NPV and ROV is bound to support more realistic, hence sounder, investment comparisons and decisions