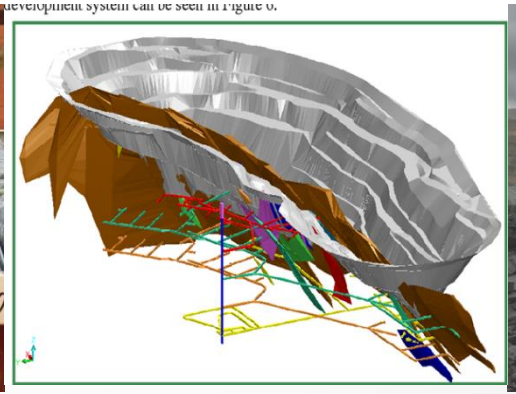
GGY 4119 – MINING GEOLOGY

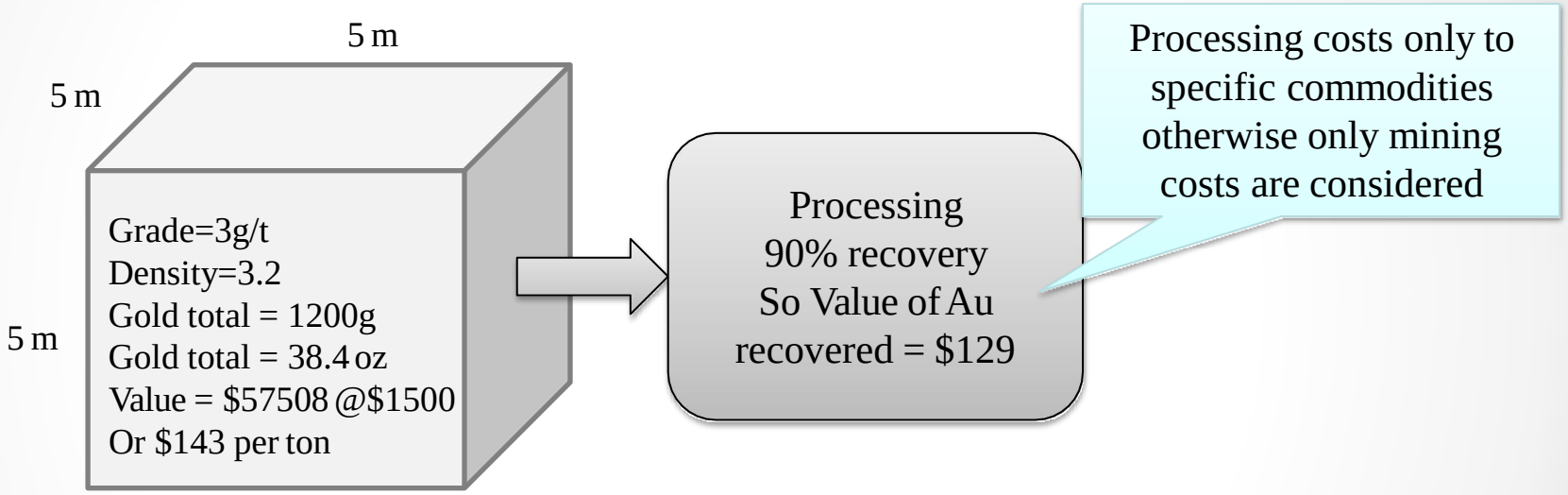
ECONOMIC FACTORS IN GRADE ESTIMATION

Cut-off grades



Why calculate a Cut-off Grade?

Mining is a commercial operation with an aim to maximize profits



During mining, if the mining, processing and other costs (overheads) per ton of material mined are less than $129, then it is economically viable to mine and process the block of material

Based on costs, optimum grade can be determined above which mining operation is profitable

Cut-off Grade

Cut-off grade – generally minimum grade of ore that can be mined without loss

Minimum amount of metal that one metric ton of material should contain before the material is sent to the processing plant

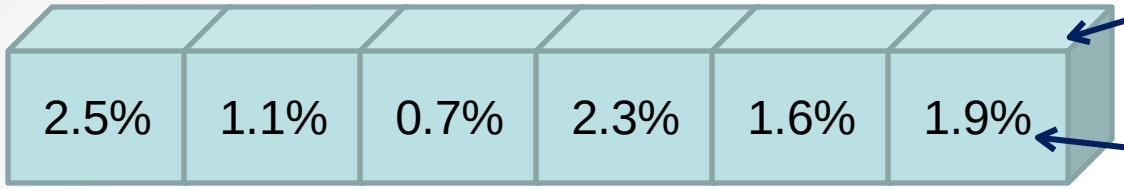
An economic threshold used to differentiate areas for mining

Depends on

- Operating costs (salaries, fuel, etc)
- Price of metal(s),
- Losses during mining and milling
- Mill and mine capacity

} Factors that change with time and definitely during a life of a mine

Simple Example Of Use Of Cut-off Grades



Selective Mining Unit (SMU)

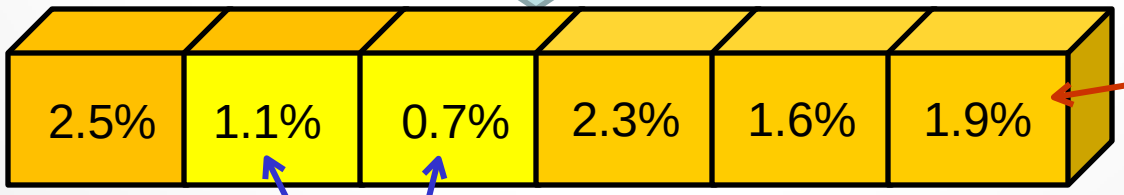
Estimated grade for SMU

?

On mining (hauling), which SMU load goes to Waste and which to Mill?

Need to determine cut-off grade which includes mining & mill operating costs, mill recovery, price of metal & corporate objectives

Example: Cut-off grade calculated = 1.4%



Haul to mill

Haul to waste

Type of Cut-off Grades

- **Geological** cut-off
  - Used to define a mineral deposit
- **Resource/reserve** cut-off
  - Used in resource/reserve calculations
- **Marginal** cut-off (mining and milling)
  - Grade required to cover treatment costs
- **Break-even** cut-off
  - Includes the cost of development (position of ore is important)
- **Incremental** cut-off grade
  - Grade required to cover the incremental costs of treating more material

(after Adam, 1990)

Parameters Required To Calculate Cut-off Grade

$$\textbf{Cut-off grade} = \frac{\textbf{Cost}}{\textbf{Revenue}}$$

Cost of mining (& transport) of tonne of ore = $\mathbf{M_c}$

Cost of mining waste to expose a tonne of ore = $\mathbf{W_c}$

Cost of treating a tonne of ore (or Processing costs) = $\mathbf{T_c}$

Overhead costs (other costs associated with mining) = $\mathbf{A_c}$

Recovery or metallurgical recovery factor (%) = **R**

Price of metal (per gram, pound etc) = **P**

Breakeven Cut-off Grade

- The grade at which the revenue acquired from treating a tonne of ore has to cover the cost of mining and processing the ore and the cost of mining the waste (to get to the ore)
- In calculating this cut-off grade, the POSITION of the ore is important

$$\text{Breakeven cut-off grade} = \frac{\mathbf{Mc + Wc + Tc + Ac}}{\mathbf{P \times R}}$$

Example Of Breakeven Cut-off Grade

$$\text{Breakeven cut-off} = \frac{Mc + Wc + Tc + Ac}{P \times R}$$

where Mc = $2t (cost of mining and transport per tonne of ore)
Wc= $1.6 t (total waste mining cost to expose tonne of ore)
Tc = $12/t (cost of treating each tonne of ore)
Ac = $6.2/t (overhead and administration costs per tonne)
P = $900 oz (price per unit at final sale)
R = 90% (metallurgical recovery factor)
Price per unit = 1g/31.1g/oz x $900 = $28.9/g
Strip ration = 5:1

$$\textbf{Breakeven cut-off} = \frac{2 + (5*1.6) + 12 + 6.2}{28.9 \times .90} = 1.08\ \text{g/t}$$

Marginal Mining Cut-off Grade

- The marginal **mining** cut-off grade is that which the revenue obtained from treating one tonne of ore is equal to the costs associated with producing the tonne of ore
- In calculating this cut-off grade, the LOCATION of the ore is not applicable and the cost of treating ore is accepted as an incremental cost

$$\text{Marginal Mining cut-off grade} = \frac{\mathbf{Mc + Tc + Ac}}{\mathbf{P \times R}}$$

Example Of Marginal Mining Cut-off Grade

$$\text{Marginal Mining cut-off grade} = \frac{\mathbf{Mc + Tc + Ac}}{\mathbf{P \times R}}$$

Where;

Mc = $2t (cost of mining and transport per tonne of ore)

Tc = $12/t (cost of treating each tonne of ore)

Ac = $6.2/t (overhead and administration cost per tonne)

P = $900 oz (price per unit at final sale)

R = 90% (metallurgical recovery factor)

Price per unit = 1g/31.1g/oz x $900 = $28.9/g

$$\textbf{Marginal cut-off} = \frac{\mathbf{2 + 12 + 6.2}}{\mathbf{28.9 \times .90}} = \mathbf{0.78\ g/t}$$

Marginal Milling Cut-off Grade

- In an operating mine, all blocks have to be mined
- In a situation, where costs associated with mining are zero, the only cost to produce the metal is the milling cost
- Marginal milling cut-off grade is determined by only using only treatment costs and any costs associated with transport of ore from pit or stockpile to mill
- In underground mines, cost of trucking ore to the surface need to be considered

$$\text{Marginal milling cut-off grade} = \frac{\mathbf{Tc + Transport}}{\mathbf{P \times R}}$$

CUT-OFF GRADE IMPACTS

- Affects profitability of mining and mine life
  - High cut-off grade can be used to increase short-term profitability of a mine but…
  - It can also decrease the mine life
- Increase mining capacity but forced to keep processing capacity constant
  - Lower grade material may be stockpiled to process at later date
- Affect the reserves of a mine and this is important for public reporting
  - Investors give values to a company based on public reserves and production costs...

Cut-off Grade Strategies

- Need to maximize cash flow early to reduce debt (if present) and money in hand now is better than in the future!
- Process highest feed grades in the early years of the mine and lower grades as the mine ages
- Strategy is fine in theory, but consider the following…
  - Difficulties in accessing high grade ore in early life
  - Costs generally increase with depth
  - Difficult to mine selectively

Cut-off Grade Application

Strategy: Process highest grade ore in early stages of operation and lower grade later (these do have practical difficulties such as access to high-grade ore in the early stages)

Accordingly, cut-off grades dictate management of stockpiles for processing and waste

Type	Cut-off grade	Description
High grade	>6%	High grade ore to be milled first
Medium grade	4-6%	Above breakeven grade – ROM pad
Low grade	1.5 – 4%	Above breakeven grade
Sub grade	.8-1.4%	Below current marginal milling grade
Waste	< 0.8	Below foreseable marginal grade