Towards an understanding of production costs at Australia’s underground gold mines

Sam Ulrich, MAusIMM\textsuperscript{12}
Allan Trench, FAusIMM\textsuperscript{134}
Steffen Hagemann\textsuperscript{1}

1. Centre for Exploration Targeting, The University of Western Australia
2. CSA Global, Perth
3. Business School, The University of Western Australia
4. CRU Group, United Kingdom
Introduction

- Reported Mining Costs
- History of Studies
- Snapshot at 2017 Q2
  - Cost Curves, Grade Curves
- Time Series 2014 Q1 to 2017 Q2
  - Grade v Costs
- Conclusions & Implications
Reported Mining Costs
Reported Mining & Production Costs

“A gold mine is a hole in the ground with a liar standing on top of it.” origin unverified

- Comparing costs on $/oz basis since at least 1940
- Gold Institute – Cash Costs, Total Cash Costs
- Brook Hunt – C1, C2, C3
- Company Specific – CAS, NCE
- World Gold Council – AISC, AIC
- By-products v Co-products
- Voluntary & Unregulated
- Non-GAAP

This study using All-in Sustaining Costs (AISC)
History

Study Context
A Really Brief History

Testing the hypothesis grade is king

Initial study by Kanakis (2014) on 2013 Q4 data for all Australian and New Zealand gold mines showed there are linkages between costs and geology:

- Mineralisation style – distributed ✓ vs discrete
- Mineralisation geometry – planer vs cylindrical shoots vs equidimensional ✓
- Host rock – nothing clear
- Refractory mineralisation – important ✓ ??? (needs further work)
- Grade is king hypothesis – not as simple as it sounds

Initial study weakness: Not big enough

A follow-up study by Ulrich et al. (2016) on 2016 Q1 data confirmed Kanakis finding on grade is king.
Towards an understanding of production costs at Australia’s underground gold mines

The Grade is King Hypothesis

- Lower grade = higher cost mines
- Higher grade = lower cost mines

Source: Kanakis 2014
Towards an understanding of production costs at Australia’s underground gold mines

History Cont...

Grade v Costs Relationship Not That Simple at Industry Level

2013 Q4 – Kanakis (2014)

2016 Q1 – Ulrich et al. (2016)
Snapshot of Australian Gold Mining
Quarter Ending 30 June 2017

Towards an understanding of production costs at Australia’s underground gold mines
Cost Curve – AISC (Reported)

2017 Q2
Reported AISC

1st Ernest Henry - A$432/oz

1st Quartile ≤ A$886/oz

Median = A$1,054/oz

4th Quartile > A$1,256/oz

Towards an understanding of production costs at Australia’s underground gold mines

Slide 10 of 25

AusIMM UG Operators Conference, Gold Coast, Australia

16 Oct 2017
Cost Curve – Co-AISC (Adjusted)

2017 Q2
Adjusted Co-AISC

1st Fosterville A$517/oz

Gold-plus mines
• Ernest Henry
• Cadia
• Mt Carlton
• Boddington
• Hera
• Peak
• Beta Hunt

Towards an understanding of production costs at Australia’s underground gold mines

Slide 11 of 25
AusIMM UG Operators Conference, Gold Coast, Australia
16 Oct 2017
Grade Curve – Ave Feed/Head Grade

2017 Q2
Reported Ave Feed Grade (g/t)

Highest – Fosterville
High quartile $\geq 5.35 \text{ g/t}$
Median $= 2.19 \text{ g/t}$
Low quartile $\leq 1.24 \text{ g/t}$
Lowest – Ernest Henry & Cadia

Towards an understanding of production costs at Australia’s underground gold mines
Time Series Analysis
Australian Gold Mining
1 January 2014 to 30 June 2017
Time Series Study Period

- Relatively stable study period – no evidence for cost escalation

Towards an understanding of production costs at Australia’s underground gold mines

Slide 14 of 25  AusIMM UG Operators Conference, Gold Coast, Australia  16 Oct 2017
Reported Grade v AISC
- Still a scatter
- Industry trends emerging
- Gold-plus mines problematic
Towards an understanding of production costs at Australia's underground gold mines

Grade v AISC

Underground gold mines – Overall grade cost relationships

- Non-linear Relationship
  - As grade increases, AISC decreases, but decay rate less than growth rate of AISC, if grade decreases

Note: excludes underground gold-plus operations

Towards an understanding of production costs at Australia’s underground gold mines

Slide 16 of 25  AusIMM UG Operators Conference, Gold Coast, Australia  16 Oct 2017
UG Mines - Grade v Processing Costs

Note: excludes underground gold-plus operations

- Strong negative relationship between processing costs and grade
Costs dominated by 3 mines

Note: excludes underground gold-plus operations

- Considerably less of a cost difference with changing grade
- Factors affecting what is being mined most important
  - Geology, geometry etc

Towards an understanding of production costs at Australia’s underground gold mines

Slide 18 of 25  AusIMM UG Operators Conference, Gold Coast, Australia  16 Oct 2017
Individual Mines - Grace v AISC

Non-linear relationship

Towards an understanding of production costs at Australia’s underground gold mines

Slide 19 of 25  AusIMM UG Operators Conference, Gold Coast, Australia  16 Oct 2017
Individual Mines - Grace v AISC cont...

Non-linear relationship

Towards an understanding of production costs at Australia’s underground gold mines

Slide 20 of 33  AusIMM UG Operators Conference, Gold Coast, Australia  16 Oct 2017
Individual UG Mines Grade v AISC

Non-linear relationship
Power function i.e. $y=ax^{-b}$

- Individual mines have different grade-cost relationships
- Individual grade cost relationships different to overall industry relationship

Towards an understanding of production costs at Australia's underground gold mines
Conclusions & Implications
Conclusions & Implications

• “Grade is King”
  • Yes - for individual UG gold mines
  • Not that simple when comparing all UG gold mines

• Grade v costs – strong negative relationships
  • Quantifiable for most individual UG mines

• Different grade-cost profiles between mines
  • Different rates of growth or decline in AISC as grade changes
  • Therefore, grade is not a direct indicator of quality
  • What’s driving this? – More study required
    • geology (mineralisation style, structure etc)
    • geometry
    • ???
Conclusions & Implications Cont...

• Mine owner implications
  • Declining grades or high grade opportunities on AISC
  • Ore Reserve grades varying to recently processed grades

• Implications for M&A
  • Opportunities and risks of varying grades at mines with different grade-cost profiles.
  • Which mine might be a better buy for your company’s risk profile?

• The Future – Could one potentially determine a grade-cost profile at the resource stage or earlier, by knowing and understanding the fundamental attributes that drive costs?
Towards an understanding of production costs at Australia’s underground gold mines

Contact Details
Sam Ulrich: sam.ulrich@research.uwa.edu.au
Allan Trench: allan.trench@uwa.edu.au
Steffen Hagemann: steffen.hagemann@uwa.edu.au

Further Reading
• Kanakis, M.D. 2014. Geological Factors that Influence the Cost of Production in Currently Operating Gold Mines within Australia and New Zealand. BSc (Mineral Geoscience) Honours Thesis. The University of Western Australia.

Acknowledgments
The supportive mining companies

Towards an understanding of production costs at Australia’s underground gold mines