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

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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:

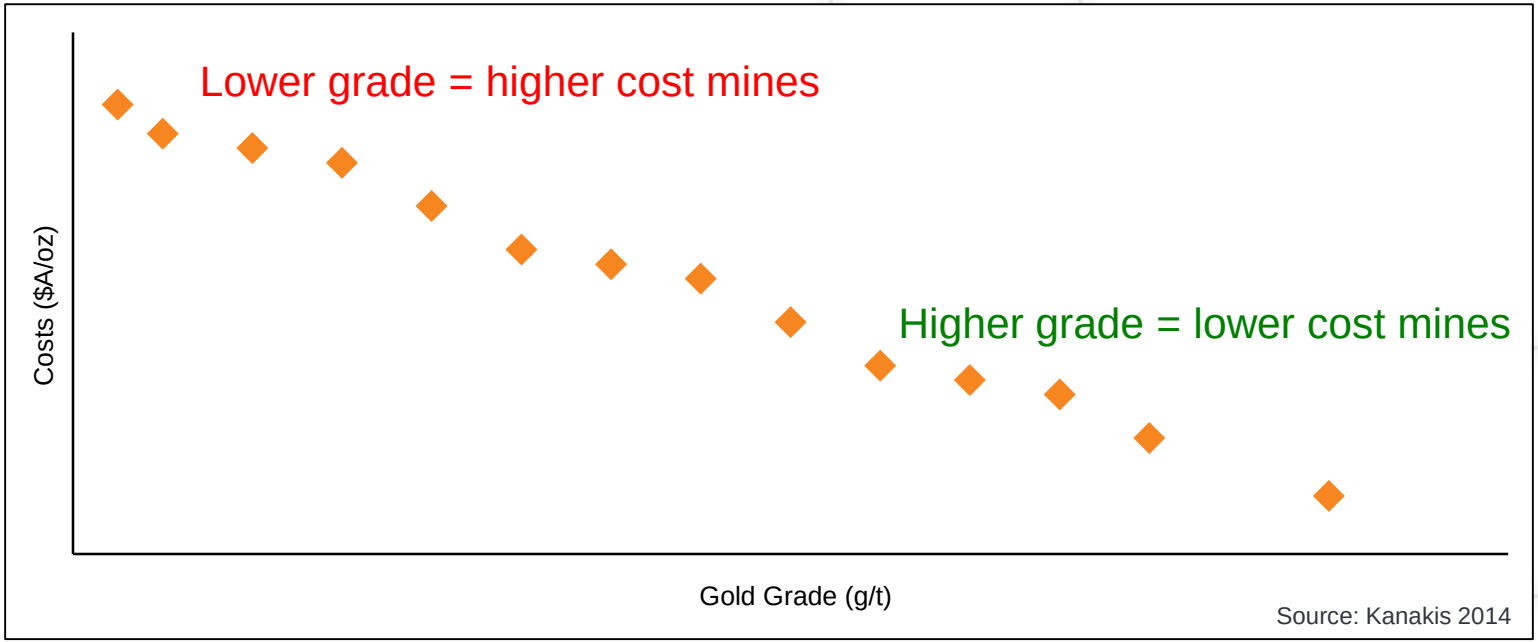
- Mineralisation style – distributed ✓ v discrete
- Mineralisation geometry – planer v cylindrical shoots v equidimensional ✓
- Host rock – nothing clear
- Refractory mineralisation – important ✓ ??? (needs further work)
- Grade is king hypothesis – not as simple as it sounds

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.

History cont…

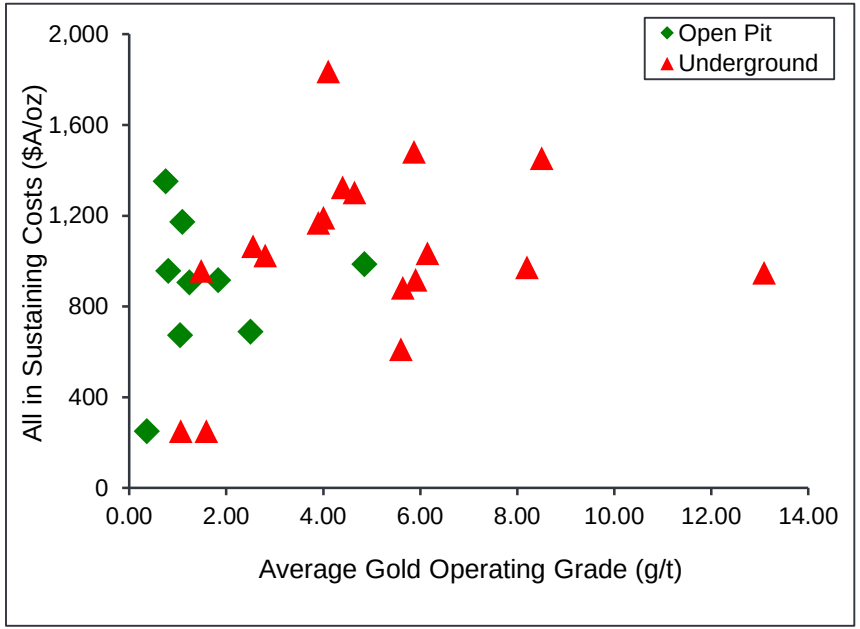
The Grade is King Hypothesis



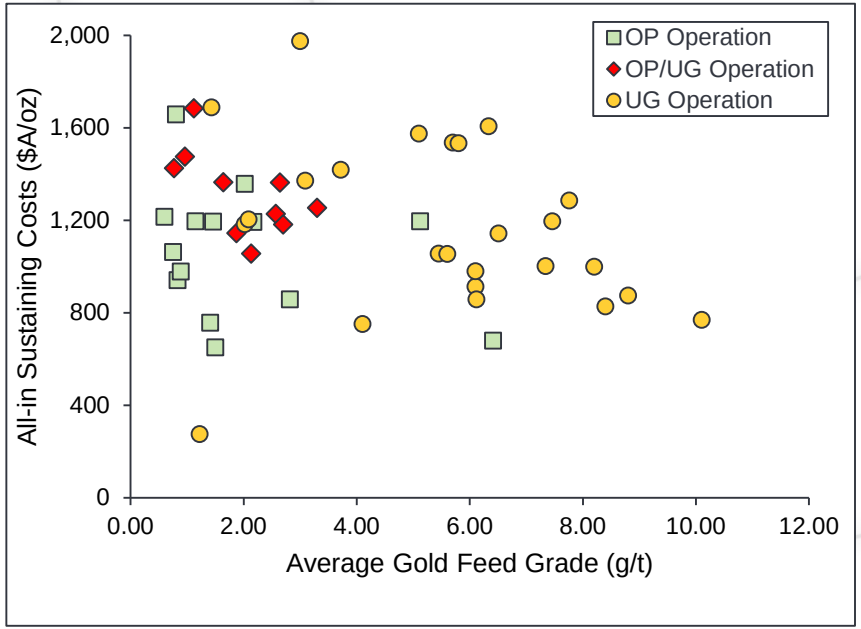
History Cont…

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

Cost Curve – AISC (Reported)

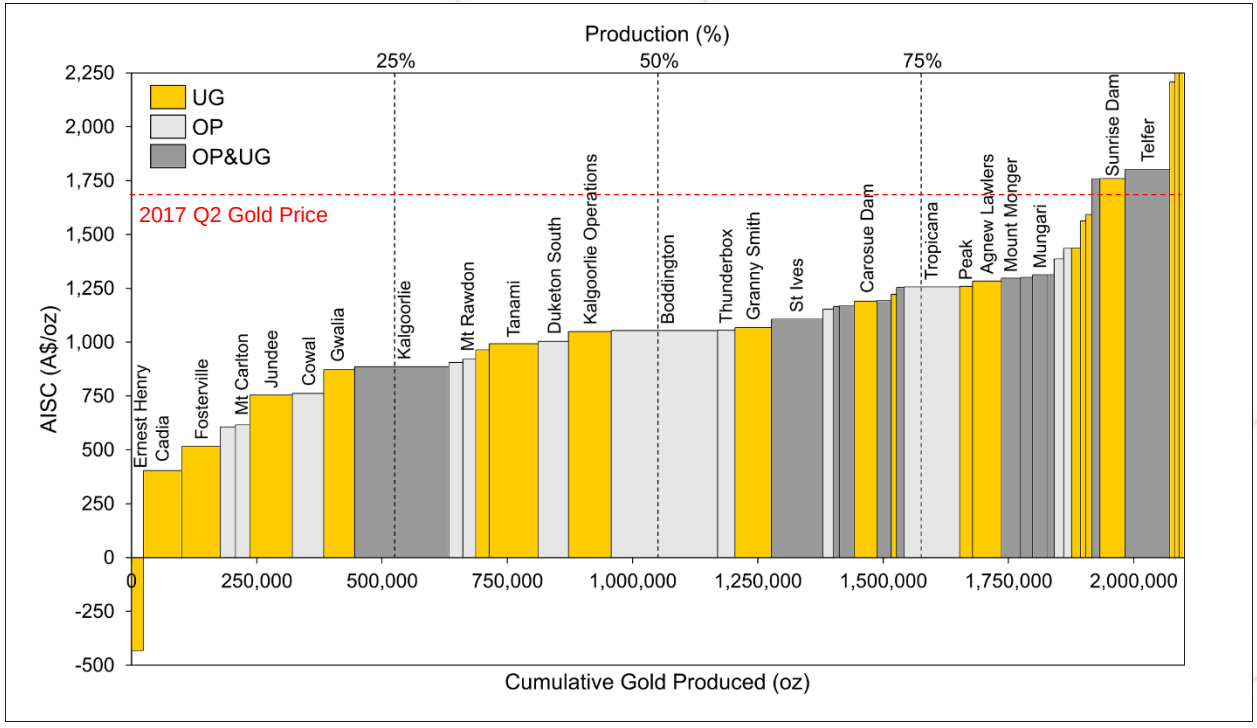
2017 Q2
Reported AISC

1st Ernest Henry -A$432/oz

1st Quartile ≤ A$886/oz

Median = A$1,054/oz

4th Quartile > A$1,256/oz

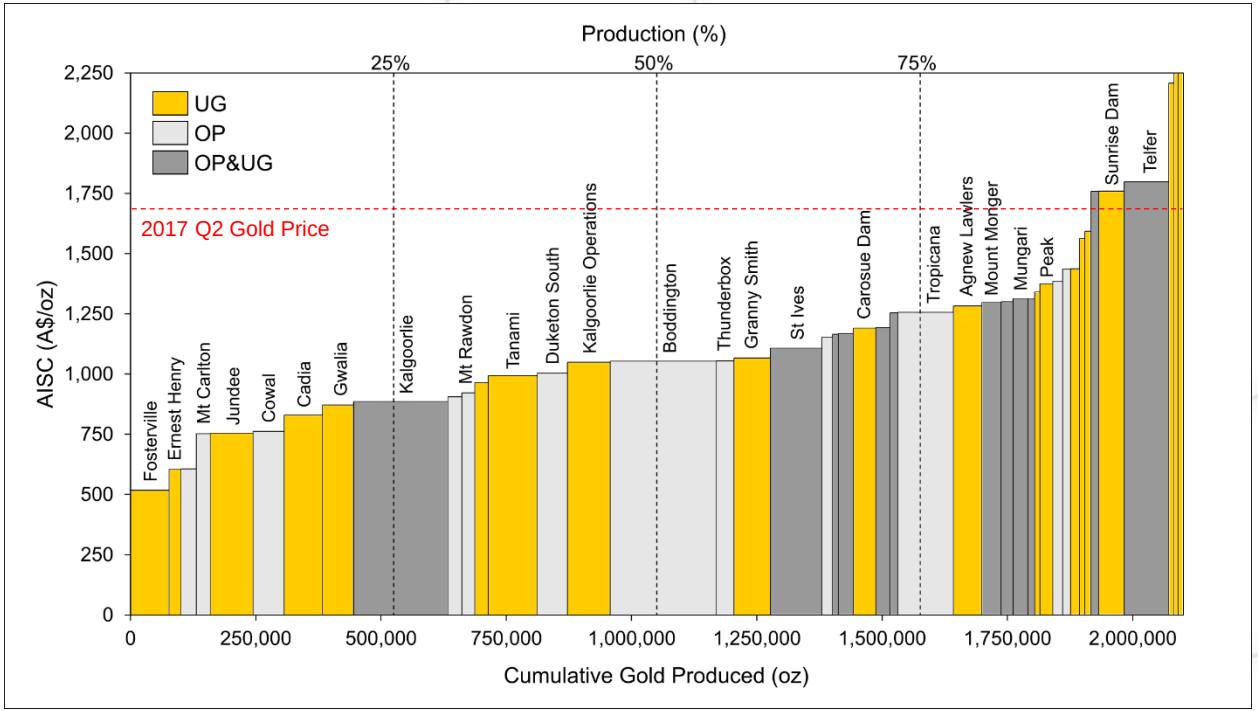


Cost Curve – Co-AISC (Adjusted)

2017 Q2
Adjusted Co-AISC

1st Fosterville A$517/oz

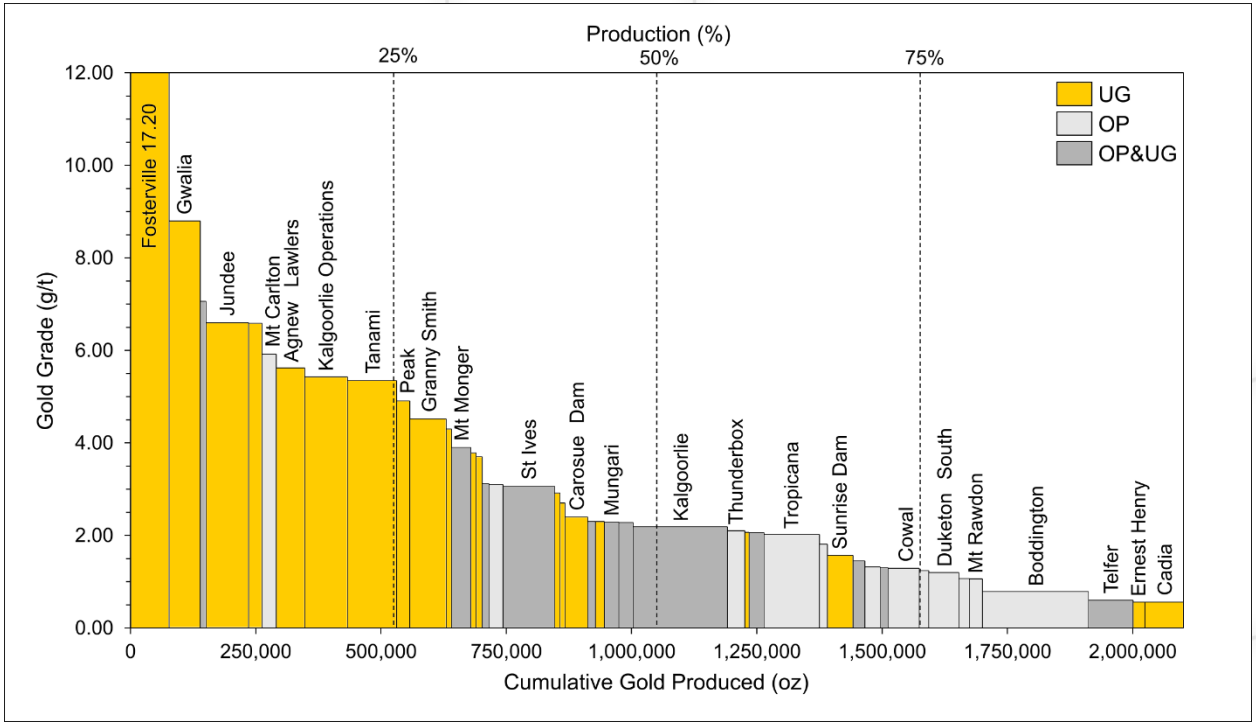
Gold-plus mines
- Ernest Henry
- Cadia
- Mt Carlton
- Boddington
- Hera
- Peak
- Beta Hunt



Grade Curve – Ave Feed/Head Grade

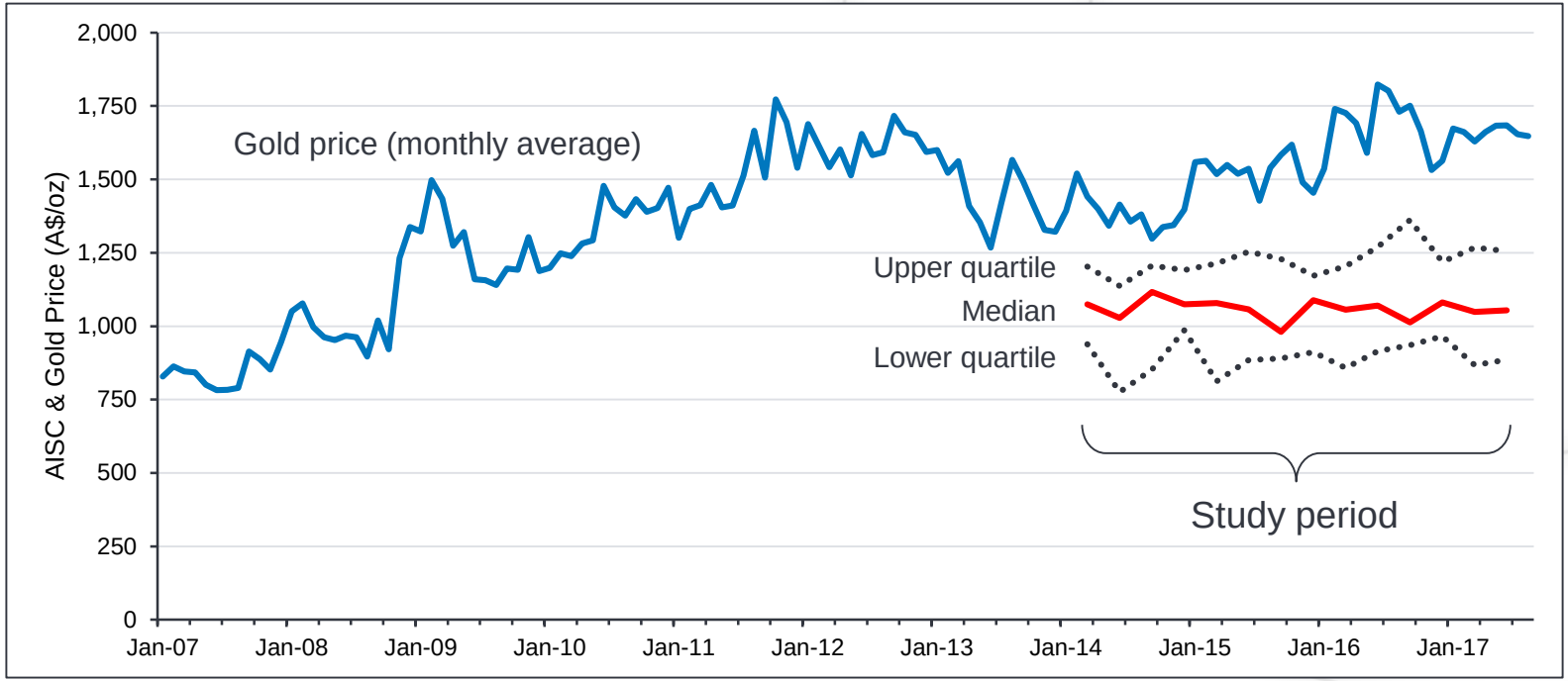
2017 Q2
Reported Ave
Feed Grade (g/t)

Highest – Fosterville
High quartile ≥ 5.35 g/t
Median = 2.19 g/t
Low quartile ≤ 1.24 g/t
Lowest – Ernest Henry
& Cadia



Time Series Analysis
Australian Gold Mining
1 January 2014 to 30 June 2017

Time Series Study Period

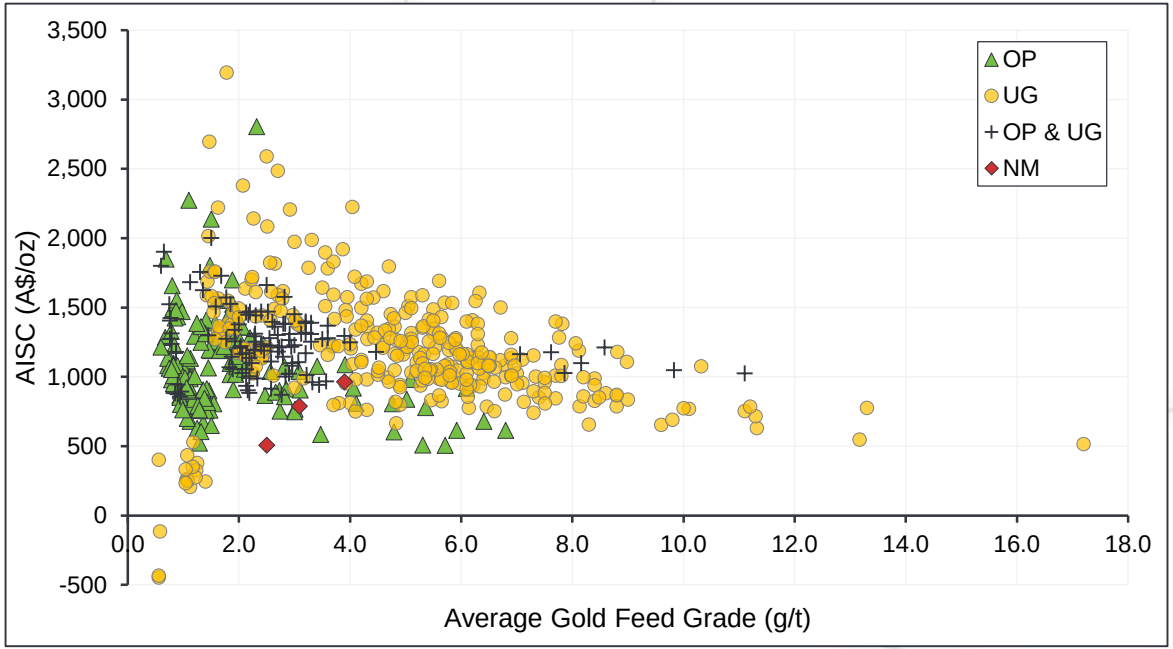


- Relatively stable study period – no evidence for cost escalation

All Mines – Reported Grade v AISC

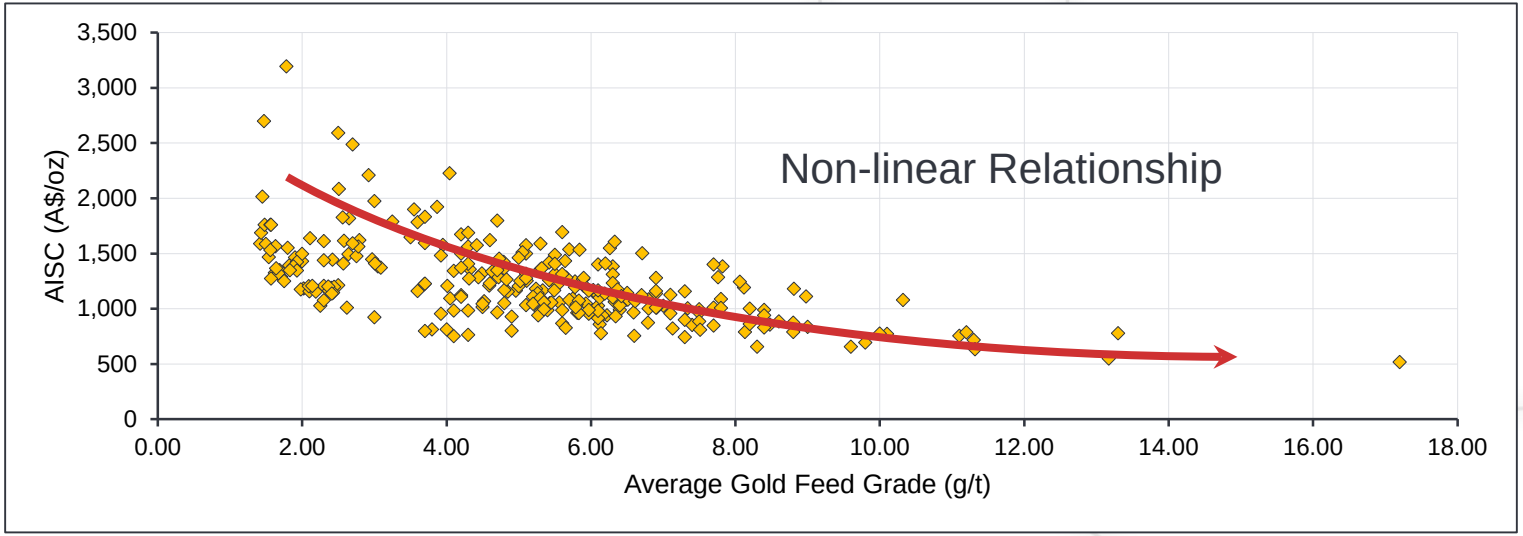
Reported Grade v AISC

- Still a scatter
- Industry trends emerging
- Gold-plus mines problematic



Grade v AISC

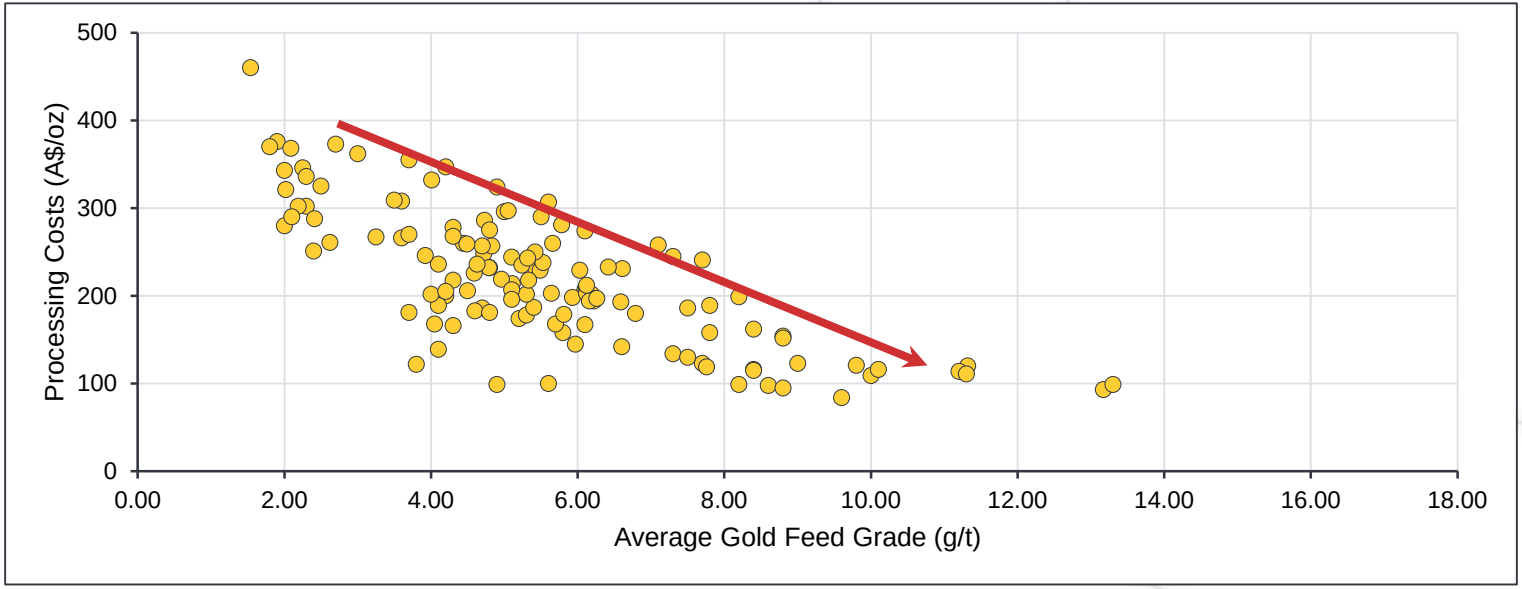
Underground gold mines – Overall grade cost relationships



Note: excludes underground gold-plus operations

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

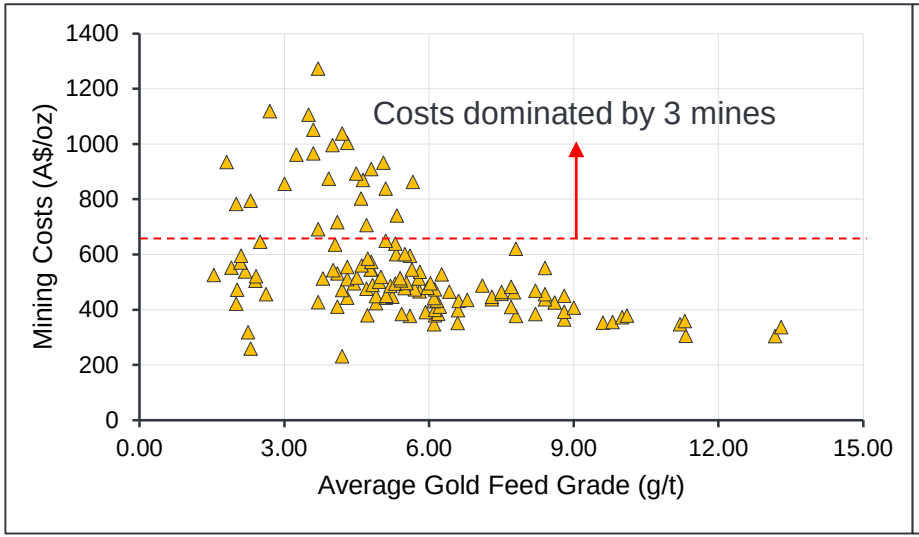
UG Mines - Grade v Processing Costs

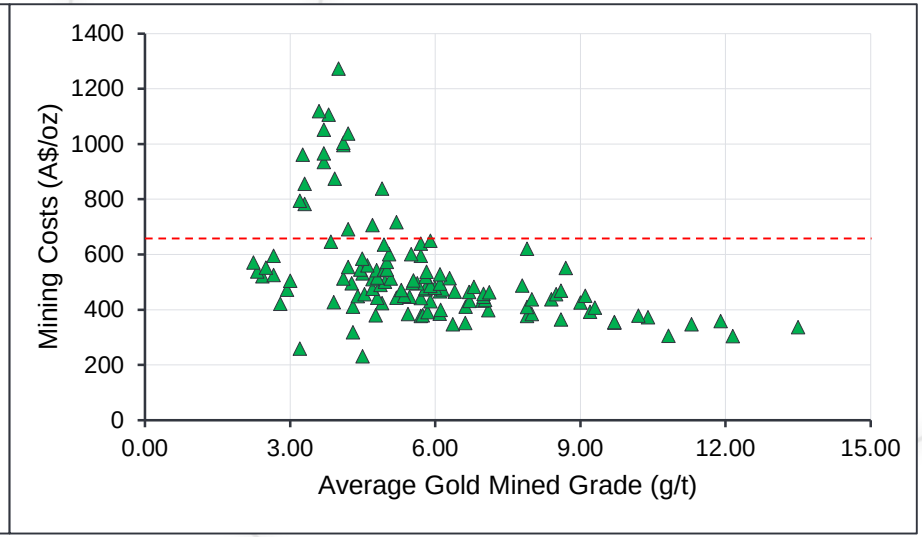


Note: excludes underground gold-plus operations

- Strong negative relationship between processing costs and grade

UG Mines - Grade v Mining Costs

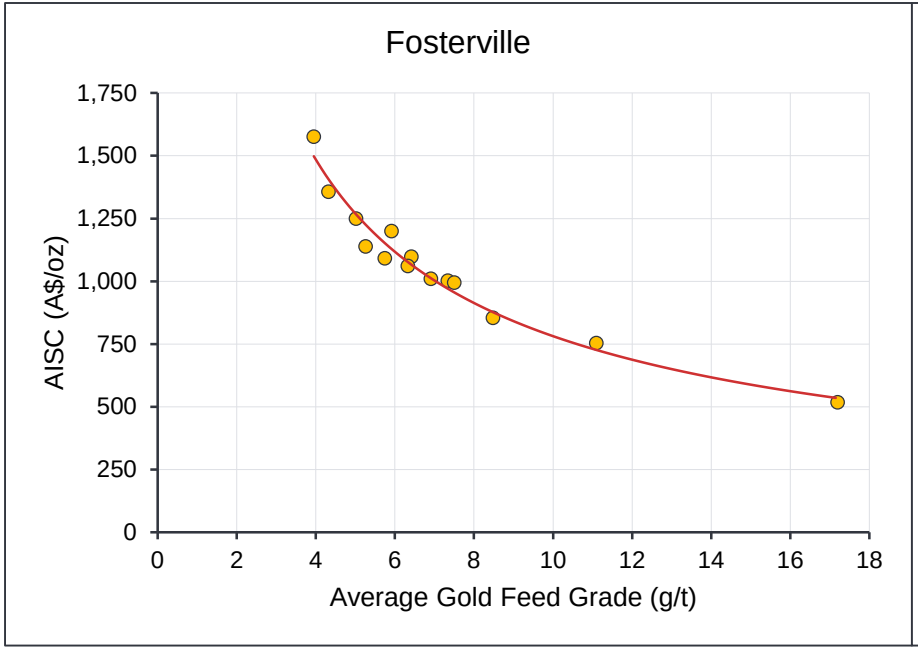


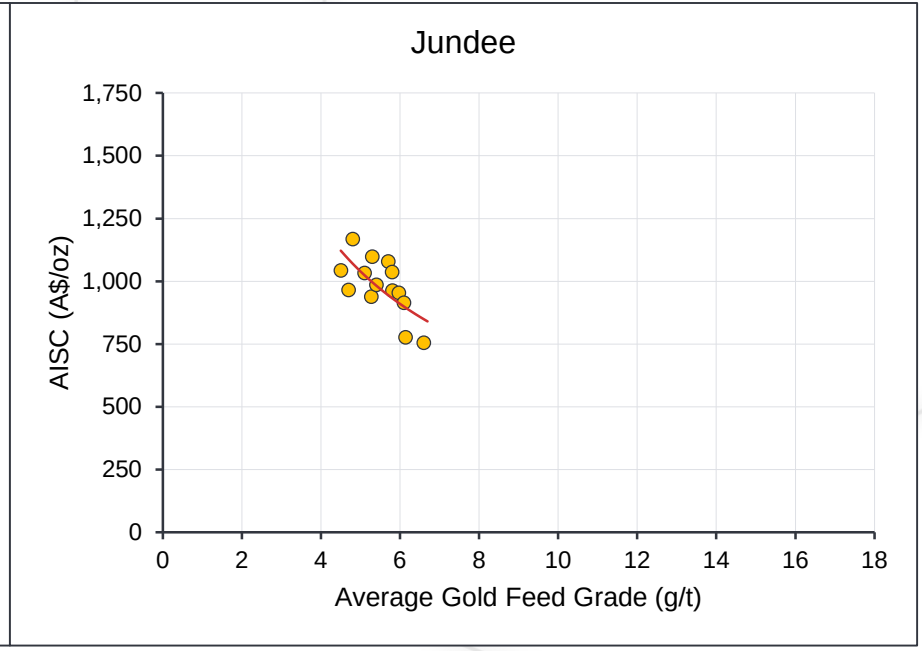


Note: excludes underground gold-plus operations

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

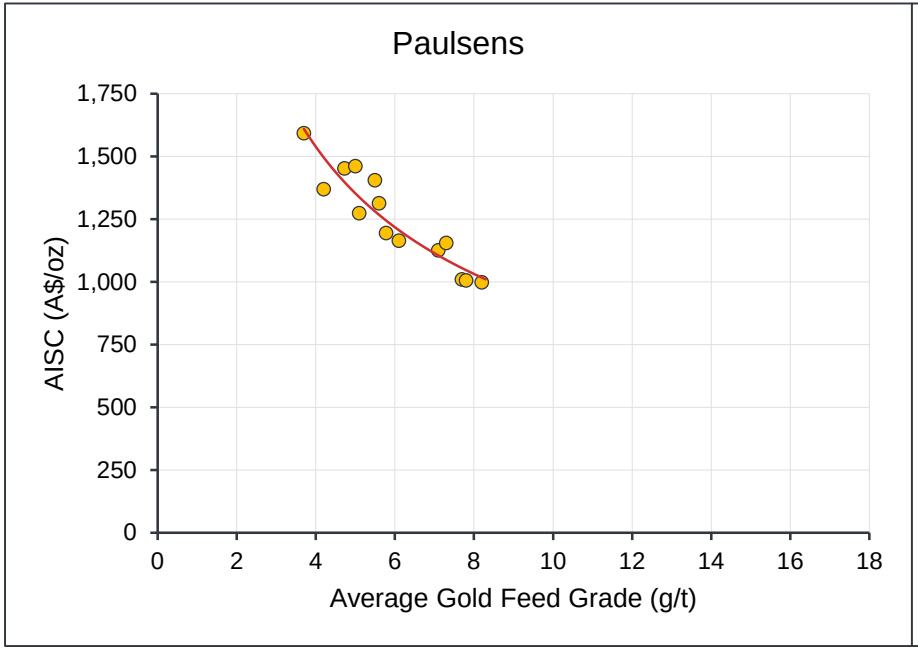
Individual Mines - Grace v AISC

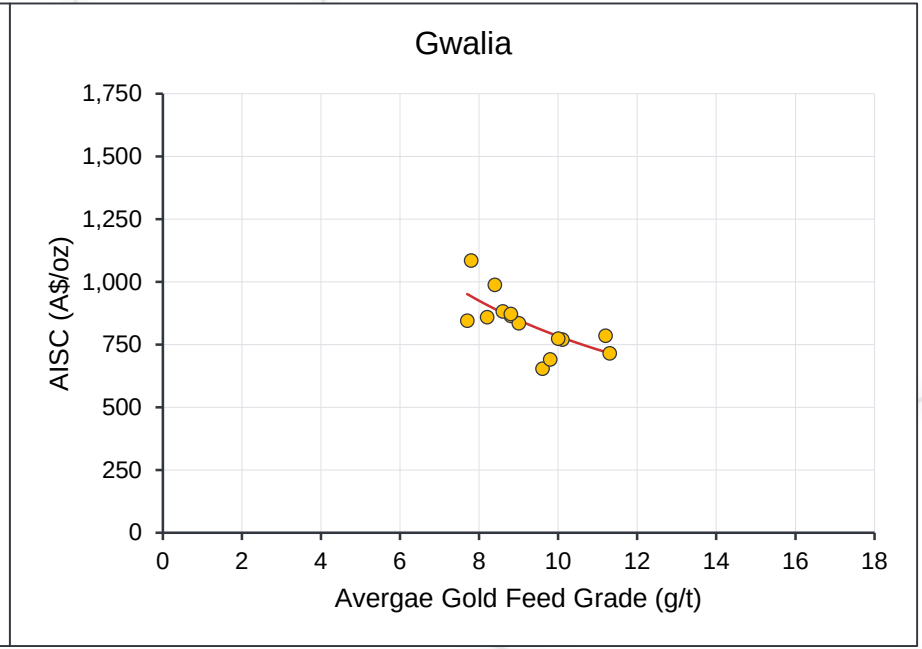




Non-linear relationship

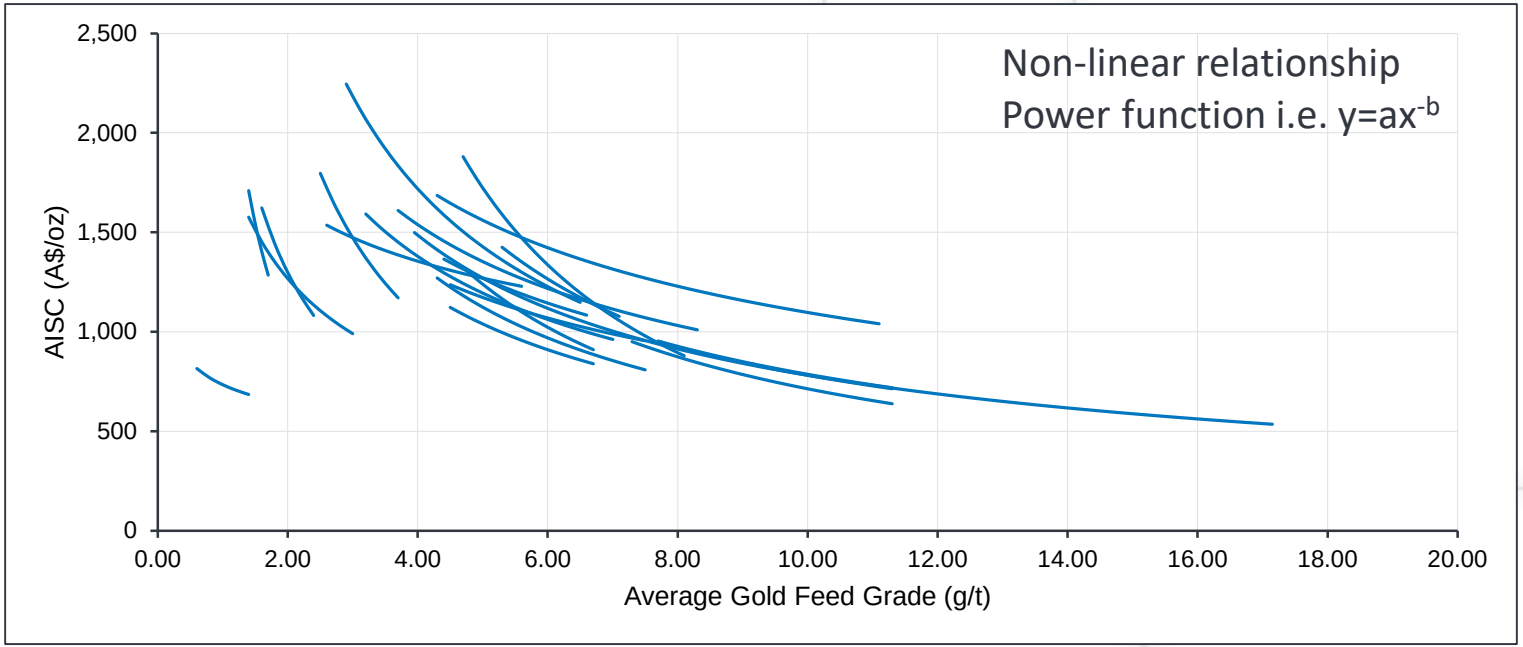
Individual Mines - Grace v AISC cont…





Non-linear relationship

Individual UG Mines Grade v AISC



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

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?

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Further Reading

- Ulrich, S., Trench, A & Hagemann, S. 2017. Towards an understanding of production costs at Australia's underground gold mines. 13th AusIMM Underground Operators' Conference. Gold Coast, Australia. 16-18 October.
- Ulrich, S., Kanakis, M.D., Groves, D., Hagemann, S., Sykes, J.P. & Trench, A. 2016. Is Grade King in Gold? A Preliminary Analysis of Gold Production Costs at Australian and New Zealand Mines. AusIMM New Zealand Branch Conference. Wellington, New Zealand. 4-6 September.
- 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.