IMPROVING PRODUCTIVITY IN PROCESSING OPERATIONS

NOVEMBER 2015

INTERNATIONAL REGION

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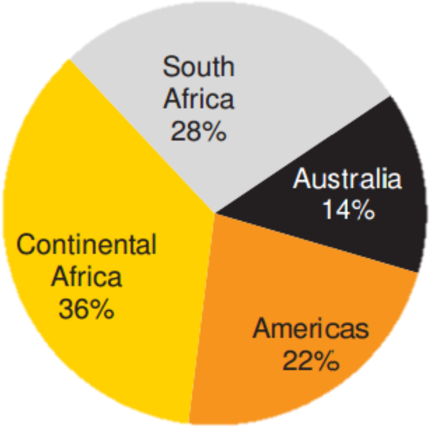
OUTLINE

1. The strategies AGA has used to increase productivity
2. Project case studies
3. Lessons Learnt – Tips from the trenches!

AGA - WHAT WE ARE

Diversified Gold Mining Company Operating 19 Mines in:

Gold Production
~4 Moz (*2015)



- South Africa
- DRC
- Ghana
- Guinea
- Mali
- Tanzania
- Australia
- Argentina
- Brazil
- Colombia (projects)

What We Were

- Long-life, generally mature, gold mines
- Good cash flow but relatively high costs
- Average AISC gold production cost in 2013 was US$1227/oz

Where We Are

- Costs reduced and margins improved
- International operations now in lowest quartile AISC
- Working to create further value
- Maintain options to grow

IMPROVEMENTS ON INDUSTRY ALL-IN SUSTAINING COSTS

We are making systemic changes to our cost structure…

*Average AISC for companies excludes AngloGold Ashanti International Operations
**Polymetal and Polyus; AGA International AISC excludes central corporate overhead, which when allocated would amount to c.$24/oz in Q2'2015

Source: Company reports, JPM

…working our way down the industry cost curve.

PRODUCTIVITY STRATEGIES AND COST REDUCTION METHODS

Existing Mines

- Project 500
- Example Sunrise Dam

New Mines

- Tropicana – Focus on Energy
- Gramalote – Innovative design

Technology Enabler

- Sorter evolution

1. INNOVATIONS FOR EXISTING MINES

Business Drivers for Change

Priorities changed after 2013 Gold price slump

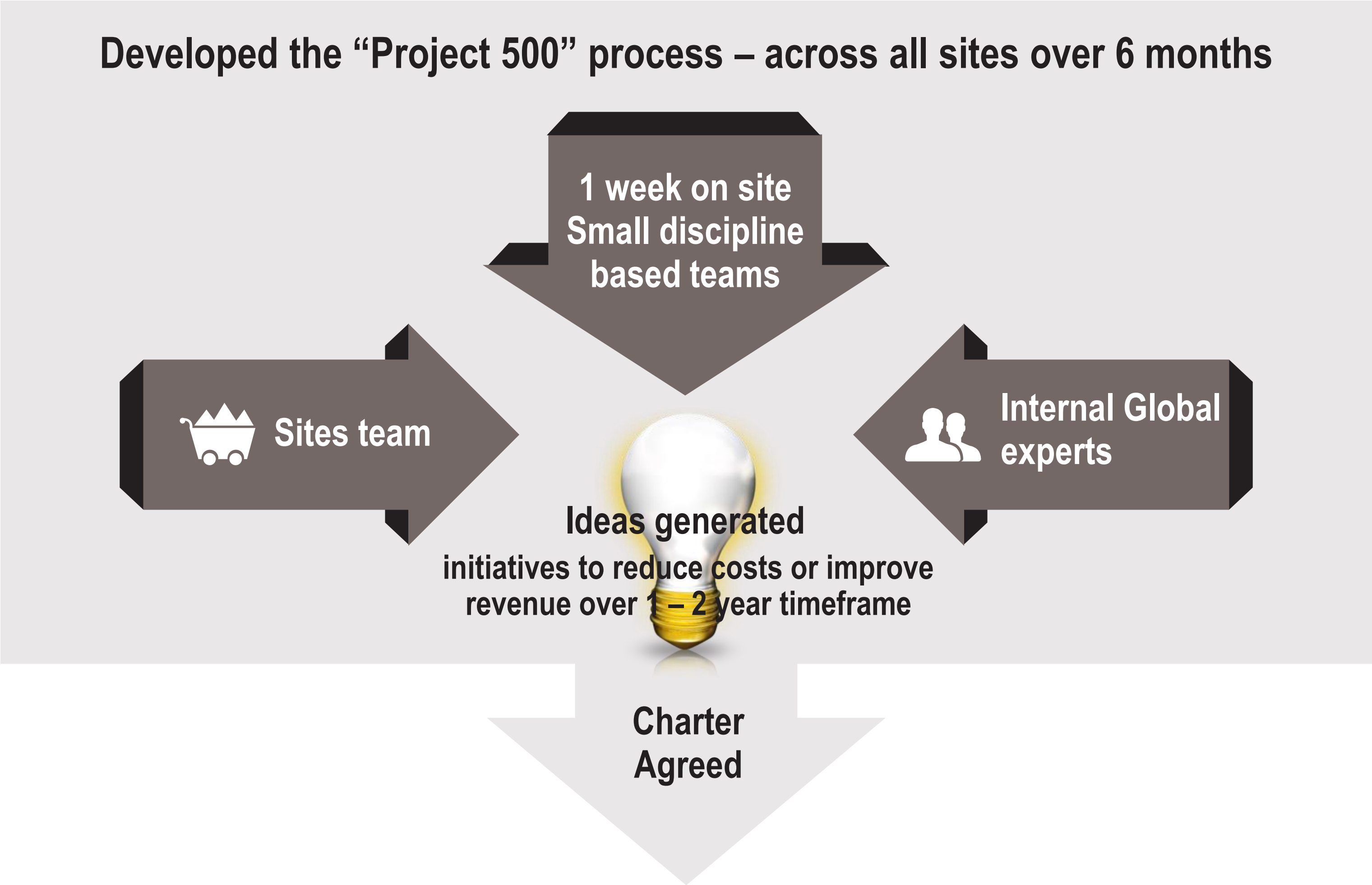
High Cost of existing mines

Global Business Imperative

- Sustainably reduce costs at existing mines
- Cut $500m out of the business

1. INNOVATIONS FOR EXISTING MINES

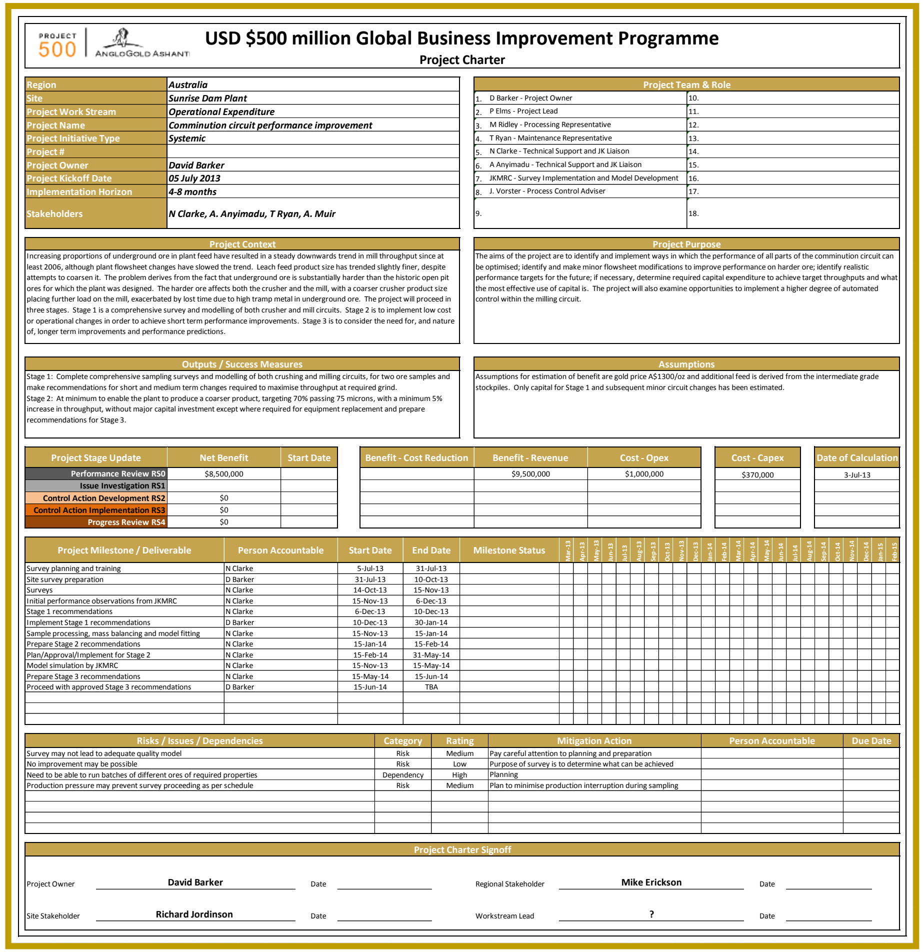
How productivity and cost reductions were achieved:



1. INNOVATIONS FOR EXISTING MINES

One Page Charter per Initiative

- Describe
- Quantify benefit
- Determine schedule
- Signed by GM & Regional SVP



PROJECT 500 | AngloGold Ashanti

USD $500 million Global Business Improvement Programme

Project Charter

Region	*Australia*
Site	*Sunrise Dam Plant*
Project Work Stream	*Operational Expenditure*
Project Name	*Comminution circuit performance improvement*
Project Initiative Type	*Systemic*
Project #	
Project Owner	*David Barker*
Project Kickoff Date	*05 July 2013*
Implementation Horizon	*4-8 months*
Stakeholders	*N Clarke, A. Anyimadu, T Ryan, A. Muir*

Project Team & Role	
1. D Barker - Project Owner	10.
2. P Elms - Project Lead	11.
3. M Ridley - Processing Representative	12.
4. T Ryan - Maintenance Representative	13.
5. N Clarke - Technical Support and JK Liaison	14.
6. A Anyimadu - Technical Support and JK Liaison	15.
7. JKMRC - Survey Implementation and Model Development	16.
8. J. Vorster - Process Control Adviser	17.
9.	18.

Project Context

Increasing proportions of underground ore in plant feed have resulted in a steady downwards trend in mill throughput since at least 2006, although plant flowsheet changes have slowed the trend. Leach feed product size has trended slightly finer, despite attempts to coarsen it. The problem derives from the fact that underground ore is substantially harder than the historic open pit ores for which the plant was designed. The harder ore affects both the crusher and the mill, with a coarser crusher product size placing further load on the mill, exacerbated by lost time due to high tramp metal in underground ore. The project will proceed in three stages. Stage 1 is a comprehensive survey and modelling of both crusher and mill circuits. Stage 2 is to implement low cost or operational changes in order to achieve short term performance improvements. Stage 3 is to consider the need for, and nature of, longer term improvements and performance predictions.

Project Purpose

The aims of the project are to identify and implement ways in which the performance of all parts of the comminution circuit can be optimised; identify and make minor flowsheet modifications to improve performance on harder ore; identify realistic performance targets for the future; if necessary, determine required capital expenditure to achieve target throughputs and what the most effective use of capital is. The project will also examine opportunities to implement a higher degree of automated control within the milling circuit.

Outputs / Success Measures

Stage 1: Complete comprehensive sampling surveys and modelling of both crushing and milling circuits, for two ore samples and make recommendations for short and medium term changes required to maximise throughput at required grind.
Stage 2: At minimum to enable the plant to produce a coarser product, targeting 70% passing 75 microns, with a minimum 5% increase in throughput, without major capital investment except where required for equipment replacement and prepare recommendations for Stage 3.

Assumptions

Assumptions for estimation of benefit are gold price A$1300/oz and additional feed is derived from the intermediate grade stockpiles. Only capital for Stage 1 and subsequent minor circuit changes has been estimated.

Project Stage Update	Net Benefit	Start Date
Performance Review RS0	$8,500,000	
Issue Investigation RS1		
Control Action Development RS2	$0	
Control Action Implementation RS3	$0	
Progress Review RS4	$0	

Benefit - Cost Reduction	Benefit - Revenue	Cost - Opex
	$9,500,000	$1,000,000

Cost - Capex
$370,000

Date of Calculation
3-Jul-13

Project Milestone / Deliverable	Person Accountable	Start Date	End Date	Milestone Status	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15
Survey planning and training	N Clarke	5-Jul-13	31-Jul-13																									
Site survey preparation	D Barker	31-Jul-13	10-Oct-13																									
Surveys	N Clarke	14-Oct-13	15-Nov-13																									
Initial performance observations from JKMRC	N Clarke	15-Nov-13	6-Dec-13																									
Stage 1 recommendations	N Clarke	6-Dec-13	10-Dec-13																									
Implement Stage 1 recommendations	D Barker	10-Dec-13	30-Jan-14																									
Sample processing, mass balancing and model fitting	N Clarke	15-Nov-13	15-Jan-14																									
Prepare Stage 2 recommendations	N Clarke	15-Jan-14	15-Feb-14																									
Plan/Approval/Implement for Stage 2	N Clarke	15-Feb-14	31-May-14																									
Model simulation by JKMRC	N Clarke	15-Nov-13	15-May-14																									
Prepare Stage 3 recommendations	N Clarke	15-May-14	15-Jun-14																									
Proceed with approved Stage 3 recommendations	D Barker	15-Jun-14	TBA																									

Risks / Issues / Dependencies	Category	Rating	Mitigation Action	Person Accountable	Due Date
Survey may not lead to adequate quality model	Risk	Medium	Pay careful attention to planning and preparation		
No improvement may be possible	Risk	Low	Purpose of survey is to determine what can be achieved		
Need to be able to run batches of different ores of required properties	Dependency	High	Planning		
Production pressure may prevent survey proceeding as per schedule	Risk	Medium	Plan to minimise production interruption during sampling		

Project Charter Signoff

Project Owner	David Barker	Date		Regional Stakeholder	Mike Erickson	Date	
Site Stakeholder	Richard Jordinson	Date		Workstream Lead	?	Date	

- Authorise resources
- Track progress centrally
- Identify risks

But accountability stays with the Site

PROJECT 500 – EXAMPLE

Reducing Reagent Consumption Costs at Sunrise Dam

Opportunity Identification

- Sunrise Dam is a mature operation under good control - limits opportunities
- But, process water is hypersaline
- Identified potential to reduce lime and cyanide consumption by maximising use of a new borefield supplying better quality water
- Savings possibly A$1 – 2 M/year

PROJECT 500 – EXAMPLE

Updated plant data working.xlsx

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
1	ReportDate	Shift	ActualDate	MillMoisture	GrindSize	PotableWaterCL_AM	PotableWaterCL_PM	PotableWaterPH_AM	PotableWaterPH_PM	upsize_ts	PmpPotWaterCL_AM	PmpPotWaterCL_PM	ProcessWaterSG	ProcessWaterSG2	ProcessWaterSG3	ProcessWaterSG4	ProcessWaterNaCN	ProcessWaterpH	Tails
2	1-Jul-13	D	1-Jul-13	0.780617	71.76938	0.7	0.8	5.36	5.97		0.7	0.8	1.116				11	8.16	
3	1-Jul-13	N	2-Jul-13	1.108902	69.26829	0	0	0	0					1.115	1.111	1.11			
4	2-Jul-13	D	2-Jul-13	0.927188	82.90258	0.7	0.6	5.35	6.37		0.7	0.6	1.105				9	7.97	
5	2-Jul-13	N	3-Jul-13	0.75431	68.10176	0	0	0	0					1.1	1.098	1.1			
6	3-Jul-13	D	3-Jul-13	0.413747	70.98704	0.8	1	5.32	6.33		0.8	1	1.099				11	8.31	
7	3-Jul-13	N	4-Jul-13	0.871898	68.79362	0	0	0	0					1.095	1.096	1.09			
8	4-Jul-13	D	4-Jul-13	0.788042	69.44444	0.4	0.8	5.53	5.41		0.4	0.8	1.098				16	8.23	
9	4-Jul-13	N	5-Jul-13	0.789982	68.98608	0	0	0	0					1.095	1.079	1.098			
10	5-Jul-13	D	5-Jul-13	0.705405	65.33865	0.6	0.5	5.08	5.46		0.6	0.5	1.107				15	7.9	
11	5-Jul-13	N	6-Jul-13	0.707399	67.92453	0	0	0	0					1.098	1.095	1.098			
12	6-Jul-13	D	6-Jul-13	1.050551	64.3	0.6	0.6	5.13	5.51		0.6	0.6	1.113				8.5	8.26	
13	6-Jul-13	N	7-Jul-13	1.146985	62.5498	0	0	0	0					1.113	1.109	1.112			
14	7-Jul-13	D	7-Jul-13	1.187387	68.85572	0.8	0.7	5.2	5.49		0.8	0.7	1.106				9	8.36	
15	7-Jul-13	N	8-Jul-13	0.951954	71.41434	0	0	0	0					1.106	1.099	1.081			
16	8-Jul-13	D	8-Jul-13	0.756231	67.63237	1	0.8	5.3	5.38		1	0.8	1.105				12	8.36	
17	8-Jul-13	N	9-Jul-13	0.77287	66.23506	0	0	0	0					1.105	1.089	1.105			
18	9-Jul-13	D	9-Jul-13	0.567295	68.29026	0.8	1	4.99	5.31		0.8	1	1.101				15	5	
19	9-Jul-13	N	10-Jul-13	1.148437	68.78728	0	0	0	0					1.101	1.101	1.102			
20	10-Jul-13	D	10-Jul-13	1.2493	68.6	1	1	5.38	5.25		1	1	1.127				30	8.04	
21	10-Jul-13	N	11-Jul-13	1.211923	71.57058	0	0	0	0					1.127	1.096	1.125			
22	11-Jul-13	D	11-Jul-13	0.692898	73.77866	1	1	5.16	5.65		1	1	1.12				28	8.18	
23	11-Jul-13	N	12-Jul-13	0.522611	75.89641	0	0	0	0					1.12	1.103	1.12			
24	12-Jul-13	D	12-Jul-13	0.688603	73.18769	0.7	1	4.81	4.81		0.7	1	1.128				11	8.03	
25	12-Jul-13	N	13-Jul-13	0.399893	78.82118	0	0	0	0					1.128	1.098	1.128			
26	13-Jul-13	D	13-Jul-13	0.624059	74.28571	1	1	5.52	5.74		1	1	1.11				14	8.6	
27	13-Jul-13	N	14-Jul-13	0.586301	83.10277	0	0	0	0					1.11	1.101	1.11			
28	14-Jul-13	D	14-Jul-13	1.001252	73.24778	1	1	5.09	5.8		1	1	1.106				6	7.88	
29	14-Jul-13	N	15-Jul-13	0.704148	71.556	0	0	0	0					1.106	1.095	1.106			
30	15-Jul-13	D	15-Jul-13	0.41234	71.54229	1	1	5.1	5.51		1	1	1.106				17	8.5	
31	15-Jul-13	N	16-Jul-13	0.485774	74.13623	0	0	0	0					1.106	1.09	1.106			
32	16-Jul-13	D	16-Jul-13	0.623004	72.7	1	1	5.27	5.54		1	1	1.112				9	8.54	
33	16-Jul-13	N	17-Jul-13	0.568797	69.69093	0	0	0	0					1.112	1.088	1.112			
34	17-Jul-13	D	17-Jul-13	0.831458	64.1635	1	1	5.12	5.46		1	1	1.112				9	8.42	
35	17-Jul-13	N	18-Jul-13	1.079754	67.52221	0	0	0	0					1.112	1.095	1.112			
36	18-Jul-13	D	18-Jul-13	0.495418	66.79803	0.7	0.7	5.77	5.61		0.7	0.7	1.111				10	8.25	

Reducing Reagent Consumption Costs at Sunrise Dam

Investigation

- Statistical analysis of comprehensive plant production records
- Laboratory test work on site
- Inspect the water supply system and review permits

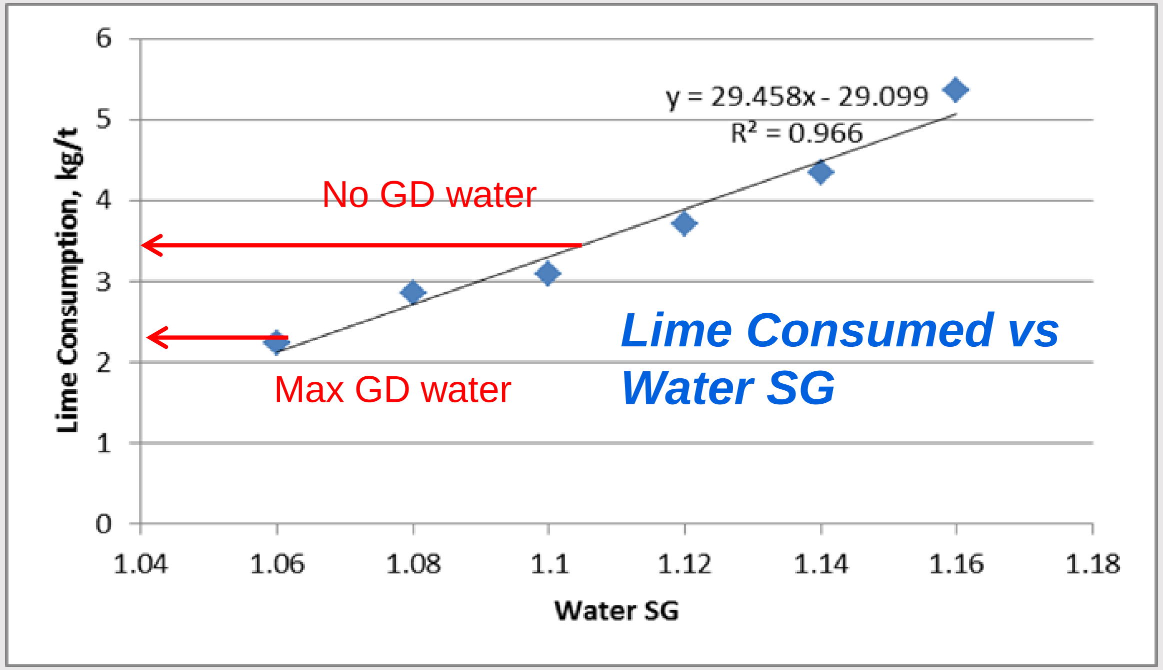
PROJECT 500 – EXAMPLE

Reducing Reagent Consumption Costs at Sunrise Dam

Findings – The Borefield

- Designed to dewater a new pit so “excess” water was discharged
- Pump records showed capable of >1 GL/y
- Permitted and sustainable to 1 GL/y
- Dissolved solids in process water reduced 15% by maximising rate

PROJECT 500 – EXAMPLE

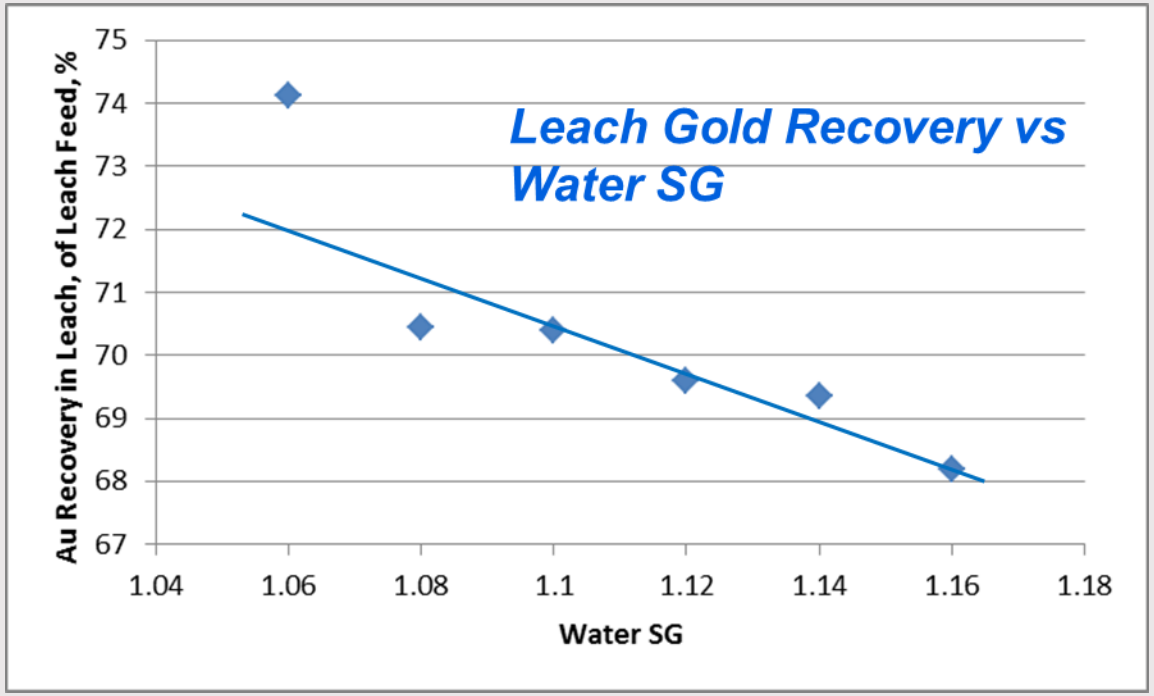


Reducing Reagent Consumption Costs at Sunrise Dam

Findings – Process EXPECTED

- Maximising GD water reduced lime by 1.3 kg/t
- Value attributable to Project 500 is $0.5 M/y
- Cyanide consumption also reduced

PROJECT 500 – EXAMPLE

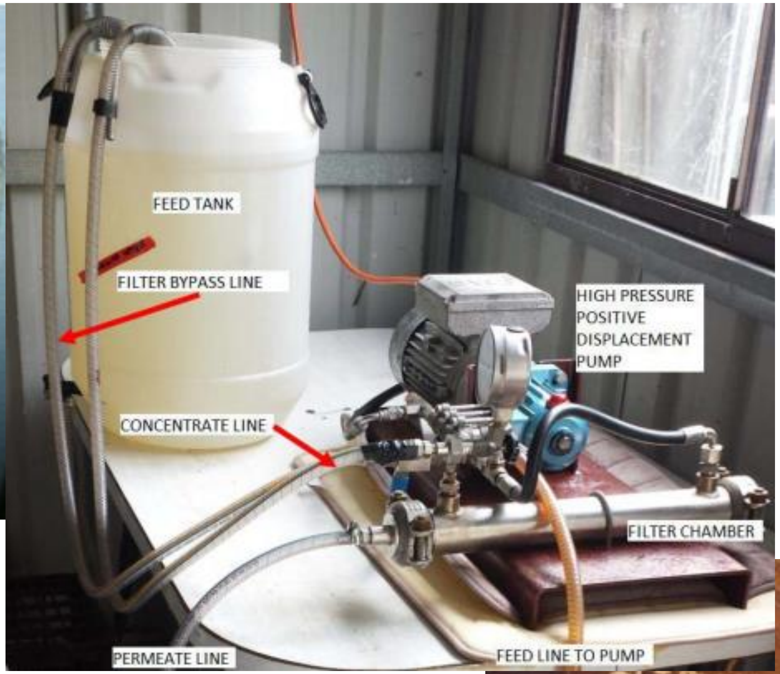


Reducing Reagent Consumption Costs at Sunrise Dam

Findings – Process UNEXPECTED

- Plant data shows increasing salinity reduces gold recovery
- Lab testing confirmed:
  - *65% recovery (of gravity tail) in potable water or sodium chloride solution*
  - *59% in process or pit water*
- Suggests it is the calcium and magnesium which reduce recovery

PROJECT 500 – EXAMPLE



900m³/hr NF Plant- Mexico

Images from Ecotechnol presentation Metplant 2015

Reducing Reagent Consumption Costs at Sunrise Dam

Future

- Nanofiltration can remove calcium and magnesium
- Potential 2 – 4% recovery improvement, or ~A$10 M/y
- Maximising GD water already achieved some improvement

PRODUCTIVITY STRATEGIES AND COST REDUCTION METHODS

Existing Mines

- Project 500
- Example Sunrise Dam

New Mines

- ***Tropicana – Focus on Energy***
- Gramolote – Innovative design

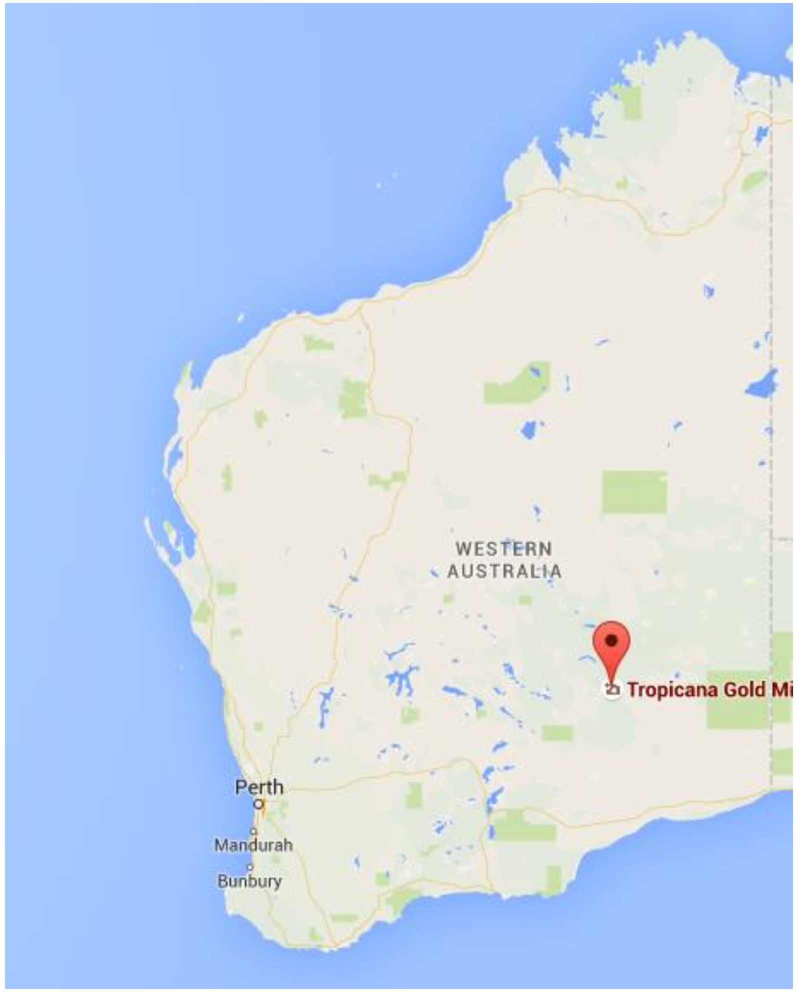
Technology Enabler

- Sorter evolution

2. INNOVATIONS FOR NEW MINES – TROPICANA WESTERN AUSTRALIA

Business Drivers for Change

- Hard ore and high energy costs
- Design focus on reducing energy consumption *(but power is still 50% of processing costs)*



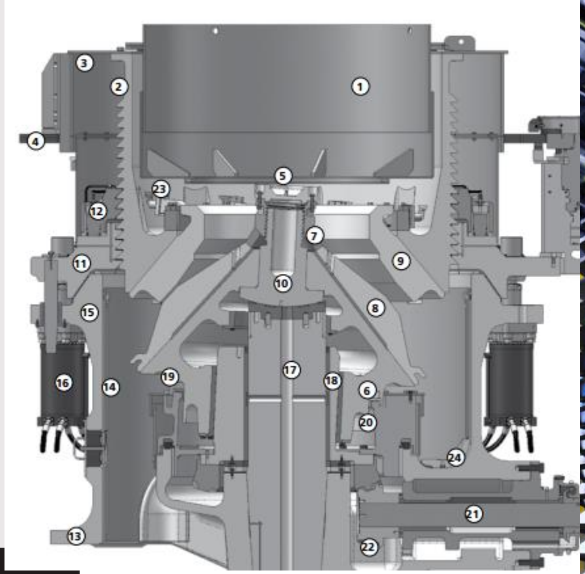
2. INNOVATIONS FOR NEW MINES – TROPICANA WESTERN AUSTRALIA

How productivity and cost reductions were achieved:

Comminution Circuit Evaluation

- Identify all technically feasible comminution options
- Develop conceptual designs from bench scale testing
- Estimate conceptual operating and capital costs

Comparative costs are quite precise although absolute imprecise



2. INNOVATIONS FOR NEW MINES – TROPICANA WESTERN AUSTRALIA

How productivity and cost reductions were achieved:

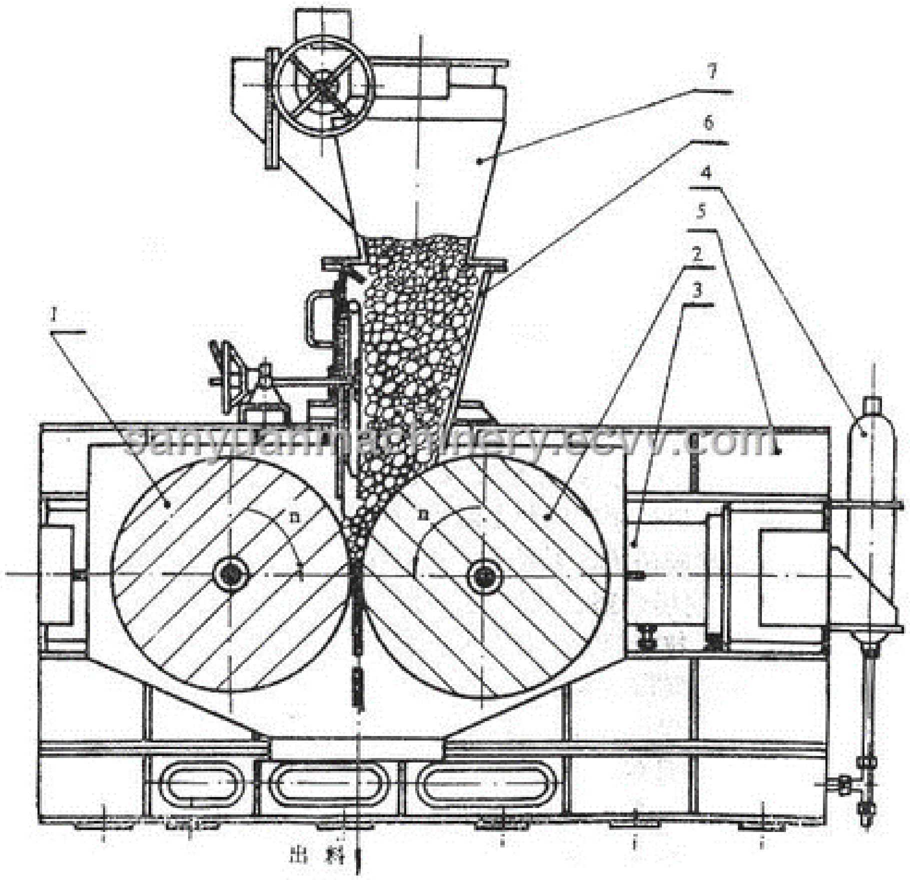
Optimum Comminution Circuit

- All options higher NPV than "standard" SABC (SAG + Ball + Pebble Crusher)
- Highest NPV High Pressure Grinding Rolls (HPGR) + Pebble Mill
- Next best HPGR + Ball

HPGR-Ball selected – ore variability risk with pebble mill

Option (150 µm grind)	Comparative NPV
Single stage SAG	1
HPGR-Ball	40
HPGR-Pebble	49
AG-Pebble	NA
Tertiary Crush-Ball	22

2. INNOVATIONS FOR NEW MINES – TROPICANA WESTERN AUSTRALIA



How productivity and cost reductions were achieved:

HPGR CIRCUIT CHALLENGES OVERCOME

- **Pilot** HPGR testwork showed fines production less than expected
- To maintain HPGR cost benefit…had to do a bigger share of the work
- Required relatively fine wet screening

With wet screening – no break in the chain from crusher to tails

2. INNOVATIONS FOR NEW MINES
– TROPICANA WESTERN AUSTRALIA

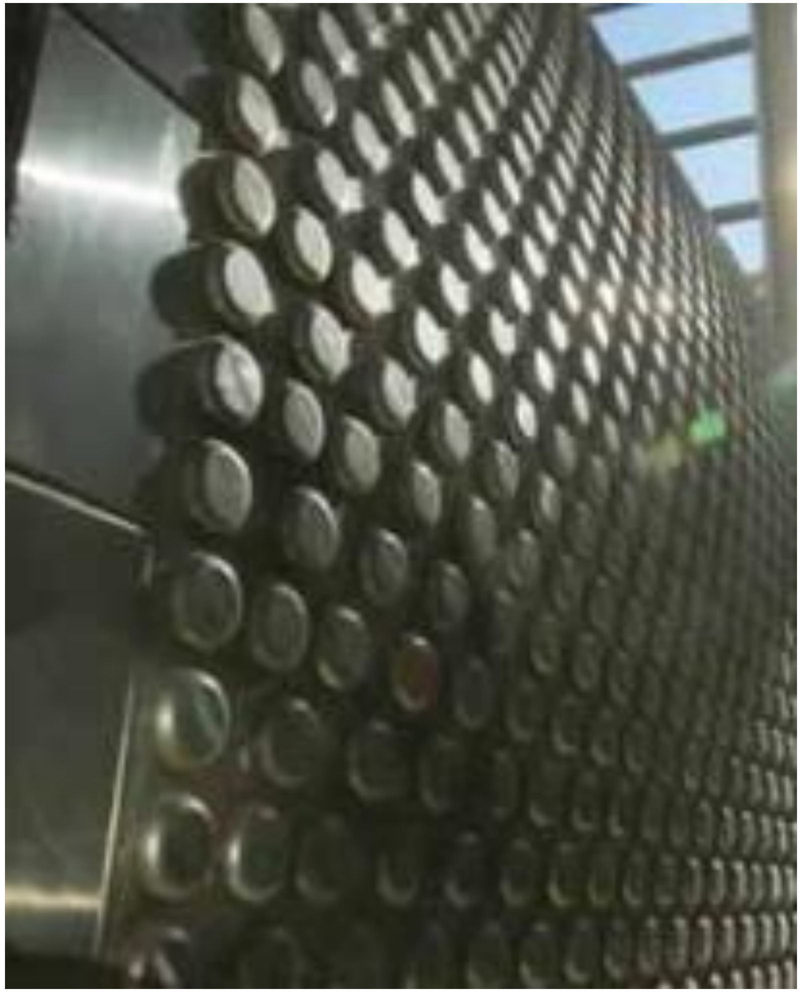
How productivity and cost reductions were achieved:

HPGR CIRCUIT CHALLENGES OVERCOME

- Wet screening also preferred to aid dispersion of the compressed HPGR product
- But wet screening prevents in-line storage of mill feed

Sequential dry drops on a pressed oxide ore

2. INNOVATIONS FOR NEW MINES – TROPICANA WESTERN AUSTRALIA

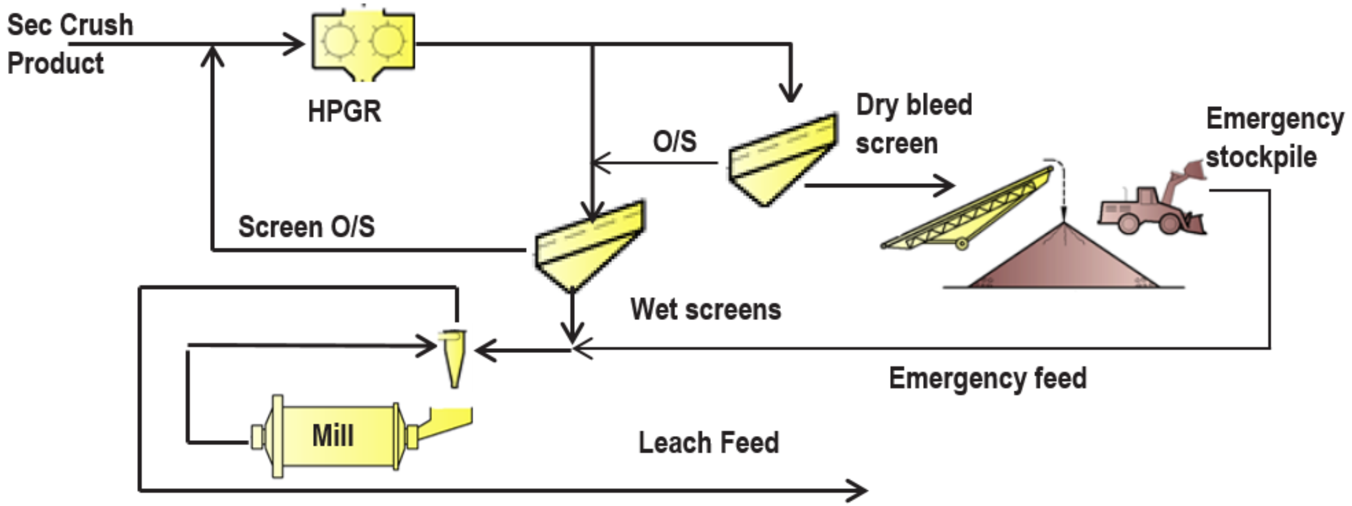


How productivity and cost reductions were achieved:

HPGR CIRCUIT CHALLENGES OVERCOME

- Result has been that previous Australian HPGR operations have had slow ramp up or not achieved design throughput

2. INNOVATIONS FOR NEW MINES – TROPICANA WESTERN AUSTRALIA



Outcomes achieved:

HPGR CIRCUIT INNOVATION

- Key innovation – dry screen a bleed stream & stockpile
- Low screen efficiency due to flake and fine dry screening is tolerable
- Target of 90% circuit utilisation reached in six months
- To reach target 95% utilisation dry screen circuit to be upgraded

2. INNOVATIONS FOR NEW MINES – TROPICANA WESTERN AUSTRALIA

Other Considerations

INNOVATE WITH CAUTION - Other Risks:

- Undersizing of wet screen
- Underestimating mill power required *(limited industry experience in estimating mill power required after HPGR)*
- Conflicting advice – 13 MW vs 15 MW
- Decision to install 14 MW mill with ability to draw >15 MW by VS drive
- Extra power has been needed:
  - *Mill efficiency has been lower than estimated*
  - *Extra power has compensated for 90% vs 95% utilisation*

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2. INNOVATIONS FOR NEW MINES – GRAMALOTE COLOMBIA

Jointly owned by AGA and B2Gold in Colombia

Business Drivers for Change

- Challenge is low grade – current published reserves 190 Mt at 0.51 g/t
- At PFS in 2013 project was economic but did not meet investment hurdles
- Understanding and exploiting favourable ore characteristics is key to economic development

HOW PRODUCTIVITY AND COST REDUCTIONS WERE ACHIEVED:

- Comprehensive team review in 2014 over 1 week (internal and external people)
- Generated ideas, evaluated economics, preliminary selection of options
- Over 12 months of testing has refined selection, still conceptual

GRAMALOTE – RECOGNISING POTENTIAL

Ore Characteristics:

- Gold is associated with pyrite
- Pyrite is very coarse – mostly >400 µm
- Very high float recoveries maintained to >300 µm
- Leach recovery 97% from 4% concentrate mass
- Values occur predominantly in veins and fractures with preferential breakage
- Flotation recovery from shallow oxide ore >80%

Size	Au Rec %	
µm	GER	GIR
300	99	94
212	99	96
150	99	99
106	97	99
75	99	97
53	92	98
38	97	94
-38	96	96

GRAMALOTE – MAKING CHANGES

Upgrading by Screening:

- Screening low grade ROM ore reduces mining cut off grade to 0.1 g/t
- Average 65% of gold reports to 40% of mass
- Treat ore between 0.1 and 0.35 g/t

Overall, resource recovery is improved and plant head grade increases

Coarser Flotation of Fresh Ore:

- Float fresh ore at 300 µm grind for 95% overall recovery

GRAMALOTE – MAKING CHANGES

Oxide Ore Processing:

- 40 Mt of oxide ore at 0.4 g/t
- Has to be mined
- Direct leaching gives ~100% recovery – but uneconomic
- Geology & mineralogy predicts gold in oxidised pyrite and quartz
- Wet scrubbing rejects slimes for low gold loss
- Floating deslimed ore gives >80% recovery at low cost

Overall, process changes estimated to more than double NPV

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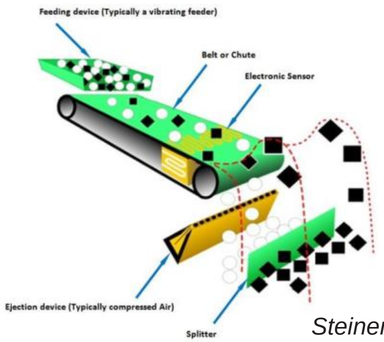
NEW TECHNOLOGY DEVELOPMENT – ORE SORTING

- Ore sorting can reject waste early and improve productivity
- “Proof of Concept” testing on ore at Sunrise Dam in 2011 demonstrated the necessary preconditions



Steinert

TOMRA

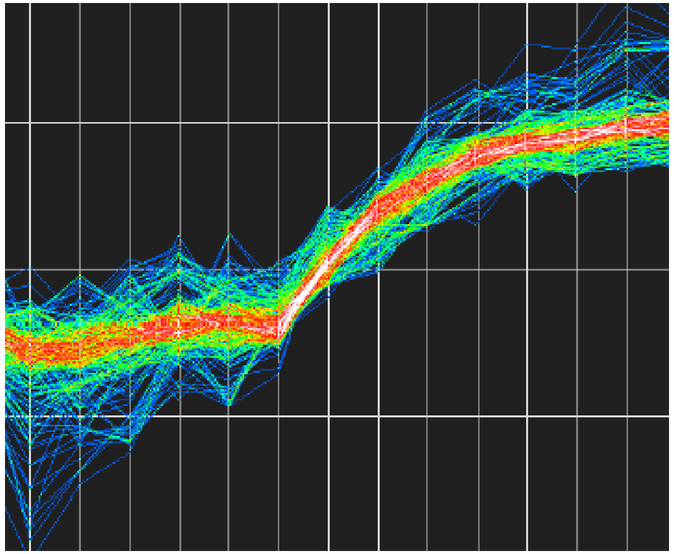
- Grade heterogeneity (high and low grade particles)
- Waste could be visually recognised

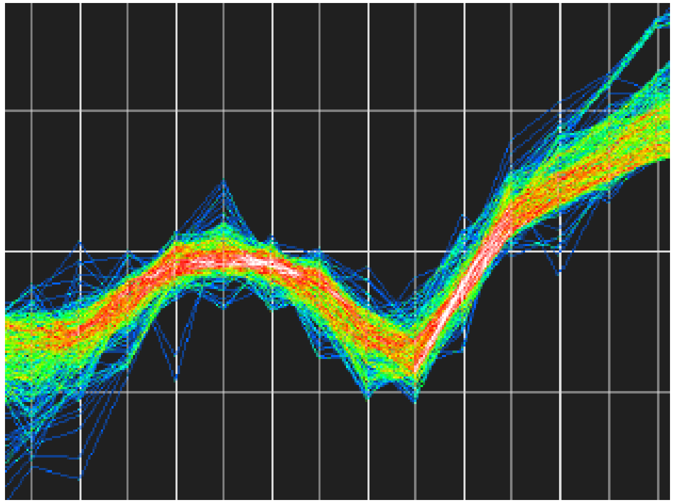
- But sorting technologies available then could not duplicate ability of human eye

NEW TECHNOLOGY DEVELOPMENT – ORE SORTING

A Technological Solution:

- Good relationship demonstrated at Tropicana between hyperspectral data and gold grade
- Idea tested on Sunrise Dam ore
- One particle in a set graded 900 g/t and carried 75% of the gold
- Sort based on hyperspectral data (NIR range) would theoretically achieve 97% of gold in 14% mass





Working with Vendors – A WIP

- Sorting technology has advanced due to plastics recycling
- Wavelength range for Sunrise Dam breaking new ground for use in mining
- Bulk testwork on specially fitted machine will commence December in Germany

ORE SORTING - APPLICATIONS

Sunrise Dam:

- Open Pit operations ceased in 2014
- Underground ramping up from 1 Mtpa to 3.7 Mtpa
- Stockpiled low grade open pit ore needed in medium term to fill mill
- Sorting can increase grade to mill for higher gold output

Brazil:

- Investigating sorting to increase ounce production without capital plant expansions
- Multiple sources
- On-site piloting commencing November

Geita – Tanzania:

- Investigating sorting of low grade stockpiles

LESSONS LEARNT FROM THE TRENCHES

They are ancient, but often ignored

Know what you are dealing with:

- Learn from the ore. Process mineralogy rules, OK? *(if you can find a process mineralogist)*
- Believe the experimental evidence, not accepted wisdom *(but double check)*
- An hour or two of simple hands-on testing is worth a week of debate
- Comparative trade-off studies should be based as much as possible on economics and not prior beliefs *(assuming all alternatives are fit for purpose)*

Genuinely work as a team:

- Collaborate openly with others, consultants, suppliers, and share ideas *(we all think we do, but how often do we see good ideas or criticisms being overruled and nobody is able to challenge it…)*
- The whole mine is a team *(amazingly geologists, miners, metallurgists and engineers can work together and achieve much more)*

QUESTIONS?