Geological factors influencing the design of a narrow-reef autonomous gold miner

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Introduction

CMI focus areas

Real time risk management
monitor underground conditions

Human factors in mining
safety, health (dust, diesel fumes, heat, hearing loss, stress)

Novel mining methods
autonomous mining, non-explosive rock breaking, *in situ* leaching

CMI Carlow Road Campus
Why autonomous mining?

Costs

Safety

Resources to reserves
Costs

Deep underground mining expensive capex, labour, electricity

Comparison

current gold price ~ US$ 1 700/ounce (R380 000/kg)

surface mine – cut-off grades ~ 1g/t Au

typical deep South African gold mine cut-off grades ~ 7 g/t Au over a 1m stoping width

Mine headgear

Closed West Wits Consolidated open pit mine
Underground mining is a high risk activity

- high stress environment
- mining-induced seismicity
- rock falls
- rock bursts
- rock handling accidents – box-holes, tramming
- heat and humidity

Reduce number of miners exposed to high risk areas (working face)
South Africa has over 40% of the world’s gold resource base, according to the Department of Mineral Resources – 36 000 metric tons

Most are in the SAMREC resources category – deep

CMI research – convert much of the resources into mineable reserves in the future using novel, safe mining technologies
Conventional mining methods
1 m stope width
drill and blast
labour intensive

Longhole mining
drill and blast
<1 m stope width, ~70-80cm
can be partly mechanised

Narrow reef autonomous mining
designed to be <50cm high
autonomous – minimal human control
mines only ore – no waste
Narrow reef autonomous mining machine - concept

Functional attachments
- Underground navigator
- Sounding device
- Gold analyser
- 3D scanner – mapping
- rock breaker - miner

Platform
Max. height < 50cm

Courtesy – Dr. D. Vogt
Geological factors - critical

Dip of reef

- typical Wits at surface – 45 to 70
- Langlaagte outcrops of Main Reef – ideal dip – 0 to 30
- otherwise too steep

Standard Bank Museum
Main Reef Stope
Geological factors – critical

Strength of rock

Quartz-rich
Tough!

Rock Breaking
Drill and blast - cheapest

Non-explosive
impact ripper
drilling out the reef
controlled foam injection
diamond wire cutting
electrical methods

Main Reef Leader – City Deep Gold Mine
Geological factors - critical

Nature of the orebody

Composition/mineralogy

- gold
  - in situ detection
  - XRF
  - Laser
- uranium
  - radioactivity
- pyrite
  - XRF
- carbonaceous matter

Gold Analyser – COMRO 1990
Geological factors - critical

Structural disturbance

- Folding determines amount of dip
- Faulting results in abrupt disruptions

Ideally – map out area ahead of mining, but not always possible

Savuka Gold Mine

Joints
Free State Goldfield - folding

From: McCarthy, 2006
Free State Goldfield - faulting

Faulting of Basal Reef

Legend
- Karoo Sequence
- Ventersdorp Supergroup
- Basal Reef
- Eldorado - Aandenk
- Dagbreek - Virginia
- Witwatersrand Supergroup
- West Rand Group
Geological factors - other

Hanging-wall rocks

Determines roof support - costly

horizontal parting planes

bedding planes – cross beds
Geological factors - other

Footwall rocks

- quartzitic – stable
- shaley – heaving of footwall
Footwall heaving
Geological factors - other

Savuka Gold Mine
Core discing – high stress

Underground stress orientation

determination of mining direction

South Africa

principal stress $\sigma_1$ vertical (at depth)

general $\sigma_2$ NW-SE direction

local modification by faults, dykes/sills
Dykes and sills

Ages

- Ventersdorp (~2700 Ma)
- Pilanesberg (~1120 Ma)
- Karoo (~180 Ma)

In general not problematic unless associated with fault displacements
Geological factors - other

Depth

Autonomous miner will be designed for extreme depths
Type of conglomerate reef

- matrix- or clast-supported
- thick or thin
- carbon-seam
Geological factors - other

Gold distribution

- bottom loaded in carbon seam
- top loaded
- disseminated
Geological factors play an important role in the design of any autonomous narrow-reef miner in South Africa.

Thank you.

Questions?