Welcome
Investing in engineering, research and education in UMaT:
A roadmap for multiplying Ghana’s mineral wealth
• Mining industry trends and challenges (Deloitte report 2018)

• The importance of minerals to the economy

• Education, skills and mining expertise for mining in the 21st century and beyond

• Mining expertise, R&D and innovation, and exploration & investment attractiveness

• Questions Ghana needs to answer to leverage its mineral wealth
Mining industry trends and challenges
(Deloitte report 2018)
Deloitte report 2018
Mining industry trends and challenges

Electronic device monitors and technicians
Data system and software managers
Mechanics
Geographic Information System (GIS) specialists
Autonomous vehicle and drone operators

Deloitte report 2018
Mining industry trends and challenges (continued)

Incremental Commodity Demand in a 100% EV World

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Incremental Demand</th>
<th>Percentage of Today's Global Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium</td>
<td>2,898%</td>
<td>2,898%</td>
</tr>
<tr>
<td>Cobalt</td>
<td>1,928%</td>
<td>1,928%</td>
</tr>
<tr>
<td>Rare Earths</td>
<td>655%</td>
<td>655%</td>
</tr>
<tr>
<td>Graphite</td>
<td>524%</td>
<td>524%</td>
</tr>
<tr>
<td>Nickel</td>
<td>105%</td>
<td>105%</td>
</tr>
<tr>
<td>Copper</td>
<td>22%</td>
<td>22%</td>
</tr>
<tr>
<td>Manganese</td>
<td>14%</td>
<td>14%</td>
</tr>
<tr>
<td>Aluminum*</td>
<td>13%</td>
<td>13%</td>
</tr>
<tr>
<td>Silicon</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Steel</td>
<td>-1%</td>
<td>-1%</td>
</tr>
<tr>
<td>PGM</td>
<td>-53%</td>
<td>-53%</td>
</tr>
</tbody>
</table>

From stabilisation to growth, putting Ghana back to work and the importance of minerals to the economy
‘From stabilisation to growth, putting Ghana back to work’

• Special budgetary allocation of GH¢ 5m for UMaT campus infrastructure

• Tax Breaks to Position Ghana as a Higher-Education Hub

• Corporate income tax relief to private universities

• Training of small scale miners

• McKinsey & Co to help boost collections
Green shoots – Sprouts of progress towards a prosperous future

• Ghanaian government MOU with Volkswagen (VW) to establish a vehicle assembly facility and also assess the feasibility of a modern “Mobility Concept”

• Re-development of the Obuasi Gold Mine
Metallic mineral, metals and coal export contribution (as % of total). Simple Ave.

Source: Data UNCTAD; ICMM, http://data.icmm.com/
Australian contributions to exports
Growth in mining

Source: Australian Bureau of Agricultural and Resource Economics, Australian Commodities Statistics, and Department of Industry and Science
Ghana GDP versus gold price

Source: Gold Prices from World Gold Council and GDP from World Bank Data
Gold mining is a major driver of Ghana’s economy

Among the top corporate tax payers over the past 20 years are:

Source: Ghana Chamber of Mines (2017), World Bank
Enhancing indirect employment contributions through supplier development programmes

• Potentially one mining position in Ghana supports 28 other livelihoods, in Peru 19 jobs and in South Africa 1.4 million jobs, each supporting around nine dependents.

• Community development through preferential community employment and procurement, and water security.

Gold Fields operations
and projects worldwide

Source: Gold Fields
The potential and the time it takes are seen in Gold Fields’ 25-years in Ghana

Community spend

Employment

In country procurement

Government revenue

Infrastructure

Source: Gold Fields
Education, skills and mining expertise for mining in the 21st century and beyond
## QS World university rankings 2018
### Mineral & mining engineering

<table>
<thead>
<tr>
<th>2018 rank</th>
<th>University</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Colorado School of Mines</td>
<td>United States</td>
</tr>
<tr>
<td>2</td>
<td>Curtin University</td>
<td>Australia</td>
</tr>
<tr>
<td>3</td>
<td>McGill University</td>
<td>Canada</td>
</tr>
<tr>
<td>4</td>
<td>Technische Universität Bergakademie Freiberg</td>
<td>Germany</td>
</tr>
<tr>
<td>5</td>
<td>Pennsylvania State University</td>
<td>United States</td>
</tr>
<tr>
<td>6</td>
<td>Queen's University at Kingston</td>
<td>Canada</td>
</tr>
<tr>
<td>7</td>
<td>The University of Western Australia</td>
<td>Australia</td>
</tr>
<tr>
<td>8</td>
<td>Universidad de Chile</td>
<td>Chile</td>
</tr>
<tr>
<td>9</td>
<td>The University of New South Wales (UNSW Sydney)</td>
<td>Australia</td>
</tr>
<tr>
<td>10</td>
<td>The University of Queensland</td>
<td>Australia</td>
</tr>
</tbody>
</table>

Colorado School of Mines is planning to launch a first-of-its-kind interdisciplinary graduate program in space resources in 2018
Crisis in mining engineering education

• Stacey et al (2008) showed the World’s mining engineering education and research sphere was in crisis.

• Mines cannot operate without mining engineers, who are required for regulatory (as well as practical) purposes.

Australian mining engineering graduates in short supply

- In 2017, 171 people were expected to graduate from Australian mining engineering courses, falling to 98 this year (2018), to 69 in 2019 and 47 in 2020.

- It will be difficult to source mining engineers from overseas.

Source: Debra Stirling (Chair of the Monash Mining & Resources Advisory Board); Monash University Lens; https://lens.monash.edu/2018/04/16/1346398/mining-story
North American mining engineering graduate situation

• In 2014 40% of Canadian mining professionals and technicians were 50 years old or older.

• ‘Missing generation’ in the Canadian mining sector, with most employees over 50 or under 35.

• Specialised geoscience programmes at U.S. colleges and universities fell from a high of 25 in 1982 to 14 in 2014.

Current Canadian mining engineering situation

• Mining and minerals engineering programmes were the fastest growing engineering disciplines between 2009 and 2013 at +56%, though in 2016 it unfortunately also showed the greatest decline with enrolment down 11.8%.

• The mining sector must work hard in a joint effort with academic institutions to ensure graduates are placed, else it may lead to another “lost generation” in the industry.

Current Canadian mining engineering situation

Source: https://engineerscanada.ca/reports/canadian-engineers-for-tomorrow-2016#data-tabulations-engineering-enrolment-and-degrees-awarded
Mining expertise, R&D and innovation
The engineering circle or wheel of design and project value development with time

(Fig.1) Engineering Circle (Design Process)

(Fig.2) Project value development with time (Schematic project timeline)

Source: Stacey et al., 2007 & 2008
Mining – From hand, to mechanised to automated, to ...?

- R&D is moving at incredible speed.

- Canada and Australia have world class R&D mining centres. South Africa have opened their own version last month.

Source: Internet, accessed September 2018; various, including South Deep and mining global.com innovations pictures.
Mining research

• No investment in research = no long-term future for that industry.

• South Africa introduced tax incentives for R&D and opened the Mandela Mining Precinct (MMP).

• Australia reaping rewards of billions of dollars of exports from the millions it spent on R&D in the past decades.

• Canada’s new CLEER proposal: Powering Clean Growth through Mining Innovation.

Researchers per million inhabitants and R&D as % of GDP

Potential economic impact of current and future technologies – Mckinsey estimates

- Potential economic impact of technology of ~US$370 billion per year worldwide by 2025;
- 17% of projected cost base of the industry globally at that time.

### Table: Potential economic impact of sized² applications in 2025, $ billion, annually

<table>
<thead>
<tr>
<th>Applications</th>
<th>Description</th>
<th>Potential economic impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations management</td>
<td>• Deeper understanding of the resource base</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>• Optimization of material and equipment flow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Increase in mechanization through automation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Monitoring of real-time performance vs plan</td>
<td></td>
</tr>
<tr>
<td>Equipment maintenance</td>
<td>• Improved anticipation of failures</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>• Reduced unscheduled breakdowns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Longer equipment life</td>
<td></td>
</tr>
<tr>
<td>Health and safety</td>
<td>• Minimized exposure to dangerous conditions</td>
<td>10</td>
</tr>
<tr>
<td>Equipment supply</td>
<td>• Improved purchasing analytics</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>• Internet of Things–enabled R&amp;D into cost-efficient equipment design</td>
<td></td>
</tr>
<tr>
<td>Human productivity</td>
<td>• Augmented reality (built on better human-machine interaction)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>• Task-based activity monitoring</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>370</td>
</tr>
</tbody>
</table>

Rio Tinto control room in Perth for automated iron ore mine in the Pilbara

Autonomous (driverless) trucks at West Angelas mine (Rio Tinto, Australia)

Source: www.mining.com; (Image: Christian Sprogoe Photography | Rio Tinto)
Autonomous (self-directed) drill rigs
(Rio Tinto, Australia)

Autonomous locomotive (Rio Tinto, Australia)

Global miners are also in the race to embrace innovation

• Goldcorp, Barrick, Gold Fields, Vale and BHP are a few of the many majors embracing R&D, innovation and the implementation thereof, with initiatives across the spectrum of operations.

• Asset optimisation tools can deliver significant benefits, lowering maintenance costs, increasing asset utilisation, reducing capital expenses, plus improved environmental health and safety benefits.

Goldcorp, tele-remote operators, Red Lake Gold Mines, Ontario

Source: Facts and Figures of the Canadian Mining Industry 2017 (MAC)
Asteroid “Ryugu” (1km) exploration
Pictures from its surface

- Hayabusa-2 spacecraft (Mothership)
- Deployed 2 small robotic explorers (rovers 1a & 1b, left above)
- Capturing images (on right)

A miner from the future?
Exploration and investment attractiveness
Behre Dolbear: ‘Where to Invest in mining 2015’
Ranking of countries for mining investment

1. Canada
2. Australia
3. United States
4. Chile
5. Mexico
6. Peru
7. Namibia
8. Botswana
9. Colombia
10. Ghana
Gold is where you find it
(Beta Hunt mine near Kambalda)

Questions Ghana needs to answer to leverage its mineral wealth
The value multiplier
A 2011 example from the USA

Source: Prof. Frimpong, S.; Multiplying the Impact of Mineral Resources: The US Experience; Missouri University of Science and Technology; USA.
Questions to be answered to leverage Ghana’s mineral wealth

Thank you

QUESTIONS AND ANSWERS


Ghana loves everybody, and everybody loves Ghana