Mapping mineral systems in Australia from the roots to the deposits  Dr Richard Blewett, Geoscience Australia

Queensland: Resources and investment overview  Mr Tony Knight, Geological Survey of Queensland

New insights into the setting and style of base metal mineralisation in the Northern Territory  Dr Ian Scrimgeour, NT Geological Survey

Gap analysis: Uncovering Western Australia’s Mineral Resources  Dr Trevor Beardsmore, WA Department of Mines, industry Regulation and Safety

South Australia: new discoveries, new opportunities  Mr Rohan Cobcroft, Geological Survey of South Australia

Victoria: emerging world-class gold opportunities  Cameron Cairns, Geological Survey of Victoria

Tasmania: new data and under cover potential  Dr Andrew McNeill, Mineral Resources Tasmania
Mapping mineral systems in Australia from the roots to the deposits

Dr Richard Blewett, Mineral Systems Branch
Geoscience Australia
Deep roots of the giants: Olympic Dam

Olympic Dam

Brittle upper crust

Ductile lower crust

Upper mantle

Fluid / melt pathways?

Conductivity

Depth (km)

Distance (Km)

Graham.Heinson@adelaide.edu.au
Last decade - where and what quality?

Over the same time there were 12 Tier 2 discoveries and 60 Tier 3 discoveries.

Over the last decade no Tier 1 discoveries were made in Australia.
Bringing all together: national mineral potential

Dulfer et al., 2014
National pre-competitive databases: team effort
National pre-competitive databases: team effort

• Australia’s national geoscientific data is quality-assured and delivered FREE
• Historical exploration data is open file so subsequent exploration can build on prior work
Provide a 20 km spaced national framework for AEM surveys

Map:
- cover-thickness
- cover-character
- hydrogeology
- direct-detection

Reduce exploration risk & stimulate investment
AusAEM: mapping cover over LARGE areas

GALEISBSTDDEM conductivity (refcond=0.001 S/m log10)
AusAEM example: one of many new basement conductors

Ian Roach
Crustal architecture

Doublier & Korsch 2017
Deep seismic 2D fence around Mt Isa

cover thickness

province boundary

Century (next slide)

Ernest Henry

Moho

Malcolm Nicoll
Interim PreSTM 17GA-SN1 and 06GA-M2

Century Pb-Zn Mine

Basin control is lithospheric in scale

Tanya Fomin

AUSTRALIA MINERALS
Isotopic mapping

PDAC 2007 – Nd map of the Yilgarn

Champion & Cassidy 2004

600 km
Isotopic architecture: a new national atlas

[Image of isotopic architecture diagrams]

National geochronology coverage

Deeper

Shallower

[K-]Ar-Ar

↑

Pb-Pb

↑

U-Pb

↑

Lu-Hf

↑

Sm-Nd

Heat Fluids Metals
Isotopic architecture: a new national Pb isotope map
Mantle architecture and metal fertility
AusArray: passive seismic

AusLAMP: magnetotellurics
Integrating seismic reflection, MT and velocity

P Wave velocity model slice at ~150 km

MT slice at 70 km

2D reflection seismic ‘fence’ to 60 km

resistive

conductive

Fast velocity

Slow velocity

1000 km
Lithospheric gradients: control of basin-hosted deposits

Czarnota et al, 2018 (AGU)

Pb isotope - μ
Lithospheric gradients: control of basin-hosted deposits

Czarnota et al, 2018 (AGU)
90% sediment-hosted base metals
200 km from craton edge
Take home message

• Large deposits have deep roots that can be mapped through the lithosphere
• Australia is leading the world in mapping mineral systems at the scale needed to identify concealed ore bodies
• The free data, tools and decision-support systems are unprecedented
• Come visit the Australia Minerals booth to learn more
Thank you

For free national and regional geoscientific datasets visit: portal.geoscience.gov.au

Contact: mineralspromotion@ga.gov.au

Visit the Australia Minerals booth
Queensland: Resources and investment overview
Queensland
World-class resource opportunities

Industrial
- Base metals
- Metallurgical coal
- Bauxite

Energy
- Gas/LNG
- Thermal coal
- Oil

Technology
- Cobalt
- Vanadium
- Rare Earths
Queensland
National level initiatives

Coordinated programs for exploration and development of critical minerals

Establishment of new co-operative research centre project
Queensland
State level initiatives

Government program of support to drive new discovery
- New exploration
- Collaboration with industry & researchers
- New studies
  - Secondary minerals
  - Common user infrastructure
  - Research roadmap
- New geoscience data systems
- Collaborative grants to boost exploration
Queensland Research – recent outputs

- New datasets
  - AEM/radiometric
  - Gravity
  - Magnetotelluric

- New tool kits
  - Geochemistry
  - Deposit atlases

- New data compilations
  - Mt Isa region

Northwest Mineral Province Deposit Atlas Prototype
Mount Isa Cu-Pb-Zn-Ag and Ernest Henry Cu-Au
January 2018

SOLID GEOLOGY INTERPRETATION of the southern EASTERN FOLD BELT, Mt Isa, Northwest Queensland.

Mark HINMAN, Danny HUISMAN, Glen LITTLE & Matt PORTER
June, 2018

The Geochemistry Tool Kit
A geochemical exploration reference for northwest Queensland
Queensland Geophysics

- Magnetotelluric (MT)
  - Excellent results in exploring through deep cover
  - Successfully identifying major structures at depth
  - Modelling and analytical capability well developed
  - Rapid uptake by industry to explore frontier areas

Cloncurry MT survey 3D image
Queensland
Data-driven exploration – our approach

Effective and efficient use of knowledge to enable industry success
(discovery, cost, time, resources, waste)
Queensland

Strong support to innovation
## Queensland

### Industry sample snapshot 2019 – base & tech metals

<table>
<thead>
<tr>
<th>Company</th>
<th>Market cap ($M AUD)</th>
<th>Project</th>
<th>Minerals</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hammer Metals</td>
<td>$8</td>
<td>Perentie</td>
<td>Copper</td>
<td>Exploration</td>
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<tr>
<td>Minotaur</td>
<td>$12</td>
<td>Osborne</td>
<td>Copper</td>
<td>Exploration</td>
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<tr>
<td>Aeon Metals</td>
<td>$200</td>
<td>Walford Creek</td>
<td>Copper/cobalt</td>
<td>Exploration</td>
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<tr>
<td>Australian Mines</td>
<td>$111</td>
<td>Sconi</td>
<td>Nickel, scandium, cobalt</td>
<td>Offtake agreement with SK Innovation</td>
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<tr>
<td>Multicom</td>
<td>Unlisted</td>
<td>St Elmo</td>
<td>Vanadium</td>
<td>Production start 2021</td>
</tr>
<tr>
<td>Red Metals</td>
<td>$23</td>
<td>Maronan, Three Ways, Gulf</td>
<td>Copper, lead, zinc, gold, silver</td>
<td>Exploration</td>
</tr>
</tbody>
</table>
Queensland
Opportunities across the entire value chain
Queensland
Investor information pathways through government
Queensland
Key contacts & more information

Tony Knight
Chief Government Geologist
Geological Survey of Queensland
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Caoilin Chestnutt
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Javier Jativa
Trade and Investment Commissioner - North America
E: TIQNorthAmerica@tiq.qld.gov.au
New insights into the setting and style of base metal mineralisation in the Northern Territory

Ian Scrimgeour, NT Geological Survey
McArthur Basin
1.64 Ma SEDEX style
(carbonate associated)
Unmetamorphosed, hosted in pyritic black shales, associated with carbonates, adjacent to growth faults

Aileron Province (Arunta)
1.82-1.78 Ma
VMS and Broken Hill style
(mafic associated)
Metamorphosed, spatially associated with mafic rocks and chemical sediments
North-trending zone of multiply reactivated syn- and post-depositional faulting

Locally thick successions of 1640 Ma HYC Pyritic Shale Member of the Barney Creek Formation associated with growth faults

Barney Creek Formation contains dolomitic and pyritic siltstones and shales, dolomitic carbonate breccia

**McArthur River Zn-Pb-Ag** mine
227 Mt @ 9.2% Zn, 4.2% Pb, 41 g/t Ag

**Teena Zn-Pb**: 58 Mt @ 11.1% Zn and 1.6% Pb

**Myrtle Zn-Pb**: 43.6 Mt @ 4.09% Zn and 0.95% Pb

MMG and Teck are most active explorers
CSIRO-NTGS study on McArthur Basin

• Gravity acquisition by NTGS, reprocessing and stitching of multiple industry AEM surveys
• Solid geology and structural interpretation of geophysical data
• 2D forward modelling of high-resolution gravity profiles
• Carbon isotope and sequence stratigraphic assessment of McArthur Group
• Deformation-fluid-flow modelling
• Integration of results with geodynamic framework of northern Australian basin systems
Solid geological interpretations
Potential field modelling
Two styles of sub-basin

**Type 1**
Bound by NNW-trending faults along strike of the Emu Fault Zone, eg Glyde, Caranbirini

**Type 2**
Bound by EW-trending normal fault Myrtle, Teena
Triggers for fluid flow

- **Extension and sub-basin development during early deposition of the Barney Creek Formation**
  - Growth on inherited E-W faults in central BFZ
  - Against parts of the Emu Fault Zone in elongate sub-basins
  - Not conducive to upward fluid flow

- **Potential N-S oriented, ca. 1640 Ma deformation?**
  - Syn-sedimentary deformation recognised at HYC
  - EW folding recognised in parts of BFZ, timing is poorly constrained

- **Correlates with the Riversleigh event on the Lawn Hill Platform**
  - May be linked to accretion of Warumpi terrane onto the NAC
  - Trigger for driving mineralising fluids up faults from depth
Key findings in McArthur Basin study

- Multiple episodes of extension and crustal shortening
- Anomalously thick sequences of mafic volcanic units preserved within the Tawallah Group have spatial association to known mineralisation and are penetrated by syn-sedimentary faults
- Short-lived compressional event at end of deposition of the Barney Creek Formation may be tectonic driver for fluid flow and mineralisation
- C isotope stratigraphy is a powerful tool for regional correlation, combined with sequence stratigraphy
Fraynes Formation
1642 ± 4 Ma

Barney Creek Formation
1640 ± 3 Ma

‘greater McArthur Basin’
Continuous distribution of prospective stratigraphy established over vast area of northern Australia
NTGS studies of base metal deposits across the Aileron Province

Syngenetic deposits have ages 1825-1780 Ma – typically associated with mafic/bimodal magmatism in clastic sediments associated with exhalites (garnetites, tourmalinites, banded iron-rich rocks).

Sulfur isotopes consistently show magmatic S source for both syngenetic and epigenetic deposits

Todd River Resources - EM1 (Mt Hardy)
35.5m at 14.7% Zn, 2.92% Pb, 0.91% Cu and 59 g/t Ag, incl. 11.3m at 22.9% Zn, 3.35% Pb, 1.0% Cu and 58g/t Ag

Independence Group – Grapple
9 m @ 1.8g/t Au, 3.26% Cu, 49.1g/t Ag, 3.63% Zn, 1.09% Pb and 0.26% Co

KGL Resources – Jervois
25.8 Mt @ 1.49% Cu, 27.1 g/t Ag
Jervois Cu-Ag project
KGL Resources Ltd

Stratabound copper-silver-lead-zinc mineralisation

Mineralisation at 1.79 Ga with second phase at 1.76-1.75 Ga (NTGS, 2019)

25.8 Mt @ 1.49% Cu, 27.1 g/t Ag (including Pb-Zn resource)

Copper-rich resource:
21.9 Mt @ 1.63% Cu, 20.2 g/t Ag

- Environmental approvals well advanced
- FID expected during 2019

stratiform mineralisation

1787 ± 6 Ma
1786 ± 4 Ma
Broken Hill-style origin at Jervois? (McGloin et al 2019, NTGS Record and in prep)

- association with other metaexhalites (eg garnetites, magnetite-rich layers, apatite-rich layers)
- tourmaline has amongst the lowest $\delta^{11}B$ values known globally, similar to Broken Hill deposits
- interpreted as metamorphosed continentally-derived muds that underwent diagenesis and metamorphism early in basin evolution
- Jervois is interpreted to strong affinitites with Broken Hill-style deposits
- Overprinted by epigenetic magnetite hosted copper-silver
The Northern Territory has substantial base metals resources and potential in varying settings

- SEDEX in northern basins
- Broken Hill, VMS and epigenetic in the craton margins

Large amounts of geoscience data and research by NTGS and its collaborative partners are available (and ongoing) to assist exploration targeting
Mistaken Perceptions

All near-surface ore bodies are discovered and mined

Declining discovery rate

Australia is a mature exploration space

So, why invest?
Buried Potential!

Bedrock exposure is limited
Minerals are in exposed bedrock
Regolith covers ~80% of the land
Prospective rocks continue under cover

Australia is largely unexplored and has significant mineral potential
Challenge recognised

“... promote Australia to be the preferred destination for investment in exploration, and to advocate opportunities in covered greenfield areas.”

Industry Roadmap
1. Characterise Australia’s cover
2. Investigate Australia’s lithospheric architecture
3. Resolve the 4D geodynamic and metallogenic evolution of Australia
Exploration Geoscience supported

“... recommendations on how Australia’s resources sector can remain globally competitive and sustainable.”

Resources 2030 Taskforce

Australian resources—providing prosperity for future generations

“... future research to impact positively on Australian life: improving the safety, security and well-being of Australians while contributing positively to the nation’s prosperity and management of environmental challenges.”
The role of Government Geoscience

- Provide pre-competitive data & knowledge:
  - Crustal architecture
  - 4D geological history
  - Metallogeny
- Improve prospectivity perceptions and reduce exploration risk
- Encourage exploration:
  - in under-explored regions
  - to economic basement through cover (regolith and sedimentary basins)
The Gap

- Region between exposed cratons
- Prospective basement covered and poorly understood
- “Missing link” in understanding Australia’s geological evolution
- Requires fundamental geoscience work
- Some parts recently studied
- Other parts not so much (= FOCUS!)
  (Paterson/Rudall, west Arunta)
Program 1: Innovative Drilling ($5 million)

- Government-Industry co-funded exploration drilling
- Stratigraphic and mineral potential drilling using new technologies
- National Drilling Initiative (part of MinEx CRC)

Successful applications: R17 & R18

857 successful applications to date
Program 2: Geophysical Surveys

- Airborne gravity surveys
- Airborne electromagnetic surveys (AEM)
Program 2: Geophysical Surveys

- Airborne electromagnetic surveys (AEM)

GSWA, NTGS and GA to conduct AEM surveys in March-September 2019, as part of the Exploring for the Future geoscience program.
Program 2: Geophysical Surveys

- 2D deep crustal seismic data
- Passive seismic data
- Magnetotelluric (MT) data

Basement geology & evolution

Mapping structure at depth
Understanding crustal deformation processes
Exploration Incentive Scheme

Program 3: Encouraging exploration through cover

- Kidson Sub-basin deep crustal **Seismic Survey**, co-funded by GA as part of Exploring for the Future and DMIRS Exploration Incentive Scheme
  
  Acquisition of 872 km between 17 June & 7 August 2018. Release of data at APPEA 2019

- Drilling decision support and targeting
- Depth of cover and its interfaces
Exploration Incentive Scheme

Program 4: 3D prospectivity mapping

- WA Geology Online
- Mineral Systems Atlas
- Mineral systems analysis
- Onshore Petroleum Systems
- Lithosphere visualisation
- Mapping geodynamic settings
- Enhanced geochronology and isotopic fingerprinting
Exploration Incentive Scheme

Program 5: promoting strategic research with industry
Mineral Exploration Cooperative Research Centre


AIMS

Create new mineral deposit discovery opportunities in covered regions:
- develop more efficient exploration technologies (particularly around drilling)
- investigate selected regions of covered basement (National Drilling Initiative)

A$218 million over 10 years
- $50M cash - Commonwealth Government
- $41M cash - geological surveys and industry
- $49M non-staff in-kind
- $78M or 311 FTE staff in-kind
Mineral Exploration Cooperative Research Centre

Program 1
Drilling technologies
More productive, safer and environmentally friendly drilling methods

Project 1
Drilling Optimisation

Project 2
Coiled tubing drilling for definition of mineral deposits

Program 2
Data from drilling
New technologies for collecting data while drilling

Project 3
Real-time downhole assay

Project 4
Petrophysical logging while drilling

Project 5
Seismic in the drilling workflow

Project 6
Automated 3D modelling

Program 3
National Drilling Initiative
Exploration data on never before sampled rocks that are hidden but prospective for minerals

Project 7
Maximizing the value of data and drilling through cover

Project 8
Geological architecture and evolution

Project 9
Targeting mineral systems in covered terranes
The Gap and the NDI

- In The Gap:
  - relationships between basement tectonic units are poorly understood
  - drilling is sparse
  - mineral deposit prospectivity and footprints are unknown
- Need better understanding of
  - geology of cover and basement
  - links between tectonic entities
  - potential metallogeny
- Focus on areas within the pink polygons
The Gap and the NDI

- Studies over buried basement to:
  - map regolith and basement geology
  - depth to basement (and other interfaces)
  - mineral deposit footprints
- Will involve:
  - field mapping
  - analysis of legacy drilling
  - geophysical data interpretation
  - mineralization studies
  - National Drilling Initiative (with RoXplorer®?)
RoXplorer® coiled tubing (CT) rig (licenced to IMDEX)

Rohan Cobcroft
Acting Director Geological Survey of South Australia

Australian Minerals Seminar - March 4, 2019
Toronto, Canada
New discoveries, new opportunities

State overview
Mineral Exploration
  Copper
  Gold
Leading the way to discovery
new programs
easy data access
South Australia: Responsibly Sourced Minerals—transforming our future

community engagement  
safe work practices  
environmental responsibility

Minerals keep us connected  
Minerals take us where we want to go  
Minerals power our communities
Resource rich

South Australia: many opportunities across key commodities
South Australia – Mining

South Australia has a proven track record as a mining State:

• Australia’s major copper producer, a third of Australia’s copper ~300,000 tonnes
• Australia’s major producer of Uranium ~5000 tonnes
• Olympic Dam world rankings
  – fourth largest copper deposit
  – second largest gold deposit
  – largest uranium deposit
• Jacinth-Ambrosia - world’s largest zircon mine
• Siviour - Australia’s largest undeveloped graphite deposit
South Australia produces a broad range of mineral and petroleum commodities. Sales values are on the rise with steadier commodity prices.
South Australia’s Mineral Production and Exports

2017 - 2018 MINERAL AND PETROLEUM INDICATORS

- **$158m** spent on exploration for new deposits
- **$1,596m** capital expenditure investment in new mines and petroleum
- **$5,643m** production value driving economic development
- **$237m** dollars worth of royalties for future state growth
- **$3,993m** worth of commodities exported to global trading partners
- **12,500 people** employed locally and in regional South Australia

**Sources:** AUS Cet 8412.8, company reports, 4291 & DFM

--

Mineral Exploration in South Australia

Mineral & Petroleum Indicators data package.csv

--

Australia MINERALS
South Australian Mineral Exploration
South Australia has exploration opportunities across a broad range of commodities and mineralization styles.
Exploration – momentum building

- Exploration approvals ↑ 37%
- Approved drill metres ↑ 31%
- Cu represents >50% of activity
  - IOCG’s, magmatic Cu-Ni, Sed-Cu, Iode Cu-Co
- Fe-ore, Gold >25%
- also U, HMS, Zn, Co, C, Ag, diamonds, kaolin
Copper – heat is on

**IOCG’s**
- Olympic domain - BHP, Oz/Red Metal,
- FMG, Aeris/Argonaut, SIMEC

**Magmatic Cu-Ni-Co**
- Fowler Domain - Western Areas
- Musgrave Province
- Coompana Province

**Sediment-hosted Cu ± Co**

**Lode-style Cu ± Co & other**
- Havilah, Ausmex, Hillgrove
Bornite, known as peacock ore, is an ore mineral of copper.

Copper was central to the early economic development of South Australia and continues to be a major contributor to the economy.

This rare specimen of bornite, from the Olympic Dam mine, is on display at the South Australian Museum.
South Australian Copper to the World

- Accelerate exploration, **discovery** and information
- Develop **innovative** infrastructure, services and research
- **Engage** to build industry and community capacity
COPPER to the WORLD
2019 CONFERENCE

17-18 June 2019 • ADELAIDE • • • #C2TW

• A Global Forum for Copper connections: leading innovation for complex copper resources development in Australia and internationally

• A forum to share insights into the copper industry including new technologies, sustainable environmental practices and innovation in exploration.

• Showcase Australia to international and national companies as the place to invest for opportunities in the copper resources sector

• Early bird registrations opening soon - Adelaide Convention Centre

Gold – resources building

Christie Domain
- Aurora Tank (Goshawk)
- Jumbuck

Central Gawler Gold Province
- Tarcoola – exploration upside
- Barns-Baggy Green

Cleve Domain
- Weednanna

Jumbuck resource incr: 294k oz (↑ 34%)

Goshawk
- Multiple high grade Au-intersections
- Pending resource estimate

Weednanna
Maiden resource 181k oz @ 5.1 g/t
DISCOVER GOLD in SOUTH AUSTRALIA

SOUTH AUSTRALIA
Solid gold opportunities for discovery

- Exploration tools to open up new search spaces and reduce discovery risks.
- Diverse opportunities in mines and projects for investors and business.
- Responsibly sourced gold for our modern lives and future.

DiscoverGold@sa.gov.au
Discover Gold is South Australia’s program to deliver renewed incentive to improve exploration discovery rates, with a view to; Increasing resource exports and Growing future industries and jobs.

What we will deliver is based on 3 stakeholder impact themes:

**GEOSCIENCE**
Geoscience and exploration tools to build and create new gold search space and reduce risks - workshops with gold experts, predictive analysis, T-S diagrams, map data and spatial tools, data acquisition and packages

Engaging exploration companies, research partners, universities, industry experts

**INVESTMENT ATTRACTION**
Conversations and analysis to frame the golden opportunities

Engaging investors, brokers, exploration and mining companies

**MINERALS IN OUR COMMUNITIES**
Engage with people in our cities and regions around gold sources and use in everyday life

Engaging our communities
Long term investment – leads to discovery

• Completion of key collaboration projects
  – Gawler Craton Airborne Survey, Olympic Domain MT, Fowler Domain AEM

• Rollout of new Geological Survey projects
  – Commodity studies
  – Fowler to Flinders - ‘mining the core library’
  – Linking geology to ground water
  – MinEx CRC – National Drilling Initiative
  – IOCG project
SARIG is a secure digital map based portal that delivers state wide geological and geospatial data.

Information delivered by SARIG is Open file and FREE.
South Australia Drill Core Reference Library

• New benchmark in geoscience workflow
• Real time non destructive analysis
• Starting point for new generative activities
• Key component of ‘virtual subsurface exploration’ experience
Closing remarks

1. More to discover….
   - *Exploration / discovery on the increase*

2. Support to industry through geoscience data
   - *Delivery of key programs and new data*

3. New commodity strategies
   - *Focus on discovery – Copper and Gold*

4. Open access data
   - *SARIG and Tonsley Drill Core Library*
Further information

If you wish to discuss developments and opportunities in South Australia please visit us the Australia Minerals Pavilion.

Rohan Cobcroft – Director Geological Survey
Michael Smith – Senior Case Manager
VICTORIA – World-class gold opportunities

Cameron.Cairns@ecodev.vic.gov.au
Manager Minerals Geoscience
Geological Survey of Victoria

earthresources.vic.gov.au/
Elephants and Headframes – Why explore for gold in Victoria?

- Total all-time gold mined globally: ~165,000 tonnes*
- Victoria’s recorded gold production (since 1851): ≥2,500 tonnes
- >1.5% of world gold production, from only 0.15% of global land area
- Victoria’s goldfields occupy just 0.03% of global land area

Victoria’s goldfield geology: 2 Orders of Magnitude (100x) richer in gold than the global average

*numbersleuth.org
The prize – Fosterville: 8.7Moz and growing

Production 2018
356,230oz @ 24.9g/t Au
Recovery: 97.3%
Operating: $200/oz
AISC: $442/oz

Current reserves (February 2019)
2.7Moz @ 31.0g/t Au
+60% on 2018
Swan Zone: 2.34Moz @ 49.6g/t Au

Guidance
2019: 550,000-610,000k ($170-$190/oz)
2020: 550,000-610,000k
2021: 570,000-610,000k

Fosterville: Lower Phoenix Fault - Eagle ore body, drill hole UDH1501: 12.5m @ 500.7 g/t Au (4.5m ETW)
Fosterville Mineral Reserves

Thousands of Ounces

Grams per tonne

Dec. 31/13  Dec. 31/14  Dec. 31/15  Dec. 31/16  Jun. 30/17  Dec. 31/17  Dec. 31/18

5.2  5.6  7.0  9.8  17.9  23.1  31.0

Kirkland Lake Gold 21/02/19
Victoria – Seamless geology
Victoria - gold occurrences
Victorian gold occurrences
Victorian gold occurrences

Nearly 50% of the surface area of known goldfield geology extends under (shallow) cover – geophysics demonstrates the connectivity.

~1500+ tonnes Au yet-to-find – but predictive capacity has to grow

Recent success at Fosterville, Costerfield, Morning Star and Ararat demonstrate that brownfields can deliver.
The opportunity – Lockington

- North Bendigo Zone (1,128 km²)
- Ordovician (turbidite) host-rocks
- Demonstrated vein-hosted orogenic gold (py-asp) under cover (40-100m)
  - 10km x 5km footprint
  - Surface geochemistry, gravity, drilling
- Fosterville to immediate west
  - Multiple coincident regional structural features
- Low population density, regional/rural setting
- Very active exploration environment

**Ground release planned for 2019**
Lockington – Regional (ground) gravity

Successful regional aircore drilling program to investigate Au and As in soil profile (of overlying basin)

04LOKC001: 15m @ 0.53g/t Au, 203ppm As from 75m (first hole)

04LOKC010: 15m @ 1.27g/t Au, 290ppm As from 96m
Lockington – Regional (ground) gravity

05LODH001
7.7m @ 4.24g/t Au from 166m

05LODH004
1.8m @ 12.40g/t Au from 154.6m
1.6m @ 19.49g/t Au from 224.5m
12m @ 2.47g/t Au from 270m

05LODH005
4.1m @ 6.28g/t Au from 230.8m

06LODH012
0.6m @ 10.40g/t Au from 289.6m

Select diamond drill hole results, downhole interval, no cut off supplied.
Gold Undercover

- Multi-disciplinary modern applied geoscience
- **24 reports**, new (free) data, two seminal papers
- Potentially 70Moz yet to find

**Pre-competitive data and knowledge**
- free maps, reports, data - stats?

(Seamless) Geology
- 1:250k and 1:50k
- 3D 1:250k full-crust model

**Modern state-wide geophysics**
- Magnetics: 200-400m line spacing
- Ground gravity: 1.5 km nominal spacing
- Deep seismic reflection

**Extensive Drill Core Library**
- 1.5 million metres drill core/cuttings (~A$2.3B)
Great drilling results 2018

<table>
<thead>
<tr>
<th>Company</th>
<th>Intersection</th>
<th>Production / Prospect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MELBOURNE ZONE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mandalay Resources</td>
<td>0.58m @ 272.1 g/t Au &amp; 13.3% Sb (ETW)</td>
<td>Costerfield (Youle)</td>
</tr>
<tr>
<td></td>
<td>0.16m @ 551 g/t Au &amp; 29.6% Sb (ETW)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.4m @ 352 g/t Au &amp; 18.1% Sb (ETW)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.66m @ 338.8 g/t Au &amp; 14.4% Sb (ETW)</td>
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</tr>
<tr>
<td>Carrawine Resources</td>
<td>92.7m @ 3.22 g/t Au</td>
<td>Hill 800</td>
</tr>
<tr>
<td></td>
<td>90.1m @ 3.1 g/t Au</td>
<td></td>
</tr>
<tr>
<td></td>
<td>37m @ 4.91 g/t Au &amp; 0.4% Cu</td>
<td></td>
</tr>
<tr>
<td>Centennial Mining</td>
<td>24.8m @ 11.44 g/t Au</td>
<td>A1 (3960 Area)</td>
</tr>
<tr>
<td></td>
<td>33.8m @ 7.74 g/t Au</td>
<td></td>
</tr>
<tr>
<td>AuStar Gold Limited</td>
<td>1.3m @ 45.4g/t Au</td>
<td>Rose of Denmark</td>
</tr>
<tr>
<td></td>
<td>0.5m @ 162.2 g/t Au</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.3m @ 28.2 g/t Au</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.78m @ 150.6 g/t Au</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.55m @ 734.3 g/t Au</td>
<td>Morning Star (McCally’s)</td>
</tr>
<tr>
<td></td>
<td>9.75m @ 66.62 g/t Au, incl 0.2m @ 876.12 g/t Au</td>
<td>Morning Star (Maxwells)</td>
</tr>
<tr>
<td></td>
<td>1.8m @ 46 g/t Au</td>
<td></td>
</tr>
<tr>
<td><strong>BENDIGO ZONE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kirkland Lake Gold</td>
<td>11.9m @ 134 g/t Au, including 0.3m @ 3.441 g/t Au (ETW)</td>
<td>Fosterville (Swan)</td>
</tr>
<tr>
<td></td>
<td>3.6m @ 167 g/t Au, incl 0.3m @ 1.776 g/t Au (ETW)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.45m @ 289 g/t Au (6m ETW), incl 0.75m @ 2.857 g/t Au (0.6m ETW)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4m @ 353 g/t Au (3.4m ETW), incl 0.35m @ 3.740 g/t Au (0.3m ETW)</td>
<td></td>
</tr>
<tr>
<td>Catalyst Metals</td>
<td>16m @ 63 g/t Au</td>
<td>Four Eagles (Boyd’s Dam)</td>
</tr>
<tr>
<td></td>
<td>14m @ 101 g/t Au</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5m @ 36.2 g/t Au</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16m @ 8.2 g/t Au</td>
<td></td>
</tr>
<tr>
<td><strong>STAWELL ZONE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Navarre Minerals</td>
<td>10.6m @ 6.2 g/t Au</td>
<td>Irvine (Resolution)</td>
</tr>
<tr>
<td></td>
<td>10.8m @ 3.8 g/t Au</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4m @ 6.6 g/t Au</td>
<td>St Arnaud</td>
</tr>
<tr>
<td></td>
<td>4m @ 5.5 g/t Ag</td>
<td></td>
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<tr>
<td><strong>STAVELY ZONE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stavely Minerals</td>
<td>92m @ 0.34% Cu &amp; 0.12 g/t Au, 4.4 g/t Ag</td>
<td>Thursday’s Gossan</td>
</tr>
<tr>
<td></td>
<td>283m @ 0.16% Cu</td>
<td></td>
</tr>
<tr>
<td></td>
<td>194m @ 0.16% Cu</td>
<td>Thursday’s Gossan</td>
</tr>
<tr>
<td></td>
<td>73m @ 0.32% Cu &amp; 0.13 g/t Au</td>
<td></td>
</tr>
<tr>
<td></td>
<td>63m @ 0.84% Cu &amp; 0.11 g/t Au</td>
<td></td>
</tr>
<tr>
<td></td>
<td>incl 6m @ 6.73% Cu &amp; 0.84 g/t Au, 15 g/t Ag</td>
<td></td>
</tr>
<tr>
<td>Navarre Minerals</td>
<td>46m @ 8.1 g/t Ag</td>
<td>Glenly</td>
</tr>
<tr>
<td></td>
<td>33m @ 2.1 g/t Ag</td>
<td></td>
</tr>
</tbody>
</table>

Selected publicly reported mineralised intersections 2018, as of late January 2019. All intersections are downhole, unless Estimated True Width (ETW) is stated.
Thank you

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earthresources.vic.gov.au/
Introduction

• One of MRT’s roles is to reduce investment risk by developing a robust geological framework of the State

• “Removing” the vegetation – LiDAR and new DEMs

• Establishing the geological framework – mapping and geophysics

• Looking deeper into the crust – passive seismic and MT (on-booth presentation)

• The third dimension – Geophysically corroborated 3D modelling

• Data delivery

• New frontiers - The Tasmania Basin
Removing the vegetation

- 54% of state covered by LiDAR (of varying quality); coverage of north and east to be completed in 2019

- 25m state-wide DEM >20 years old – not being revised by State mapping

- Have produced statewide 10m and 10+2m DEMs
Establishing the geological framework

- Digital seamless 1:250K geology complete and being maintained
- Digital seamless 1:25K geology >54% complete (>88% in highly mineralised areas)

Program:
- Complete 1st generation 1:25k coverage in NW Tasmania
- Developing improved data model
- Updating existing mapping as opportunities arise
Establishing the geological framework

• Geochronology:

• Joint projects with GA, UTas, Boise State U, UBC, U Sth Florida

• Supports regional mapping and addresses specific problems:
  • Direct dating of mineralisation (Re-Os on molybdenite and U-Pb in cassiterite)
  • How robust are our geochemically- and petrographically-based correlations? (CA-TIMS U-Pb on volcanics; detrital zircon U-Pb on Neoproterozoic- Cambrian sediments).

Detrital zircon reference database
Establishing the geological framework

• **Gravity:**
  - 84,000 gravity data stations (<1 to 7 km spacing)
  - Improving data coverage to 1 km or better spacing (outside WHA)
  - Improved terrain corrections & updating mantle model

• **Magnetics / radiometrics:**
  - Airborne magnetic and radiometric data at ≤ 200m line spacing
  - Proposed Eastern Tiers Survey (Tasmania Basin)

• **Physical Properties data:**
  - Acquiring new data opportunistically to reduce bias toward mineralised areas
  - Company datasets – used in modelling but data not made public
The Third dimension

- Tasmania first to complete jurisdiction-wide 3D geoscientific model in 2003.
- New generation of 3D models with increased geological detail in targeted regions.

Input data:
- Mapped geology
- Interpreted x sections
- Drilling
- Magnetic and gravity data
- Physical properties data
Data Delivery

- TIGER system - linked databases
- TheLIST- viewers for spatial data
- AuSGIN portal

- Continuous Improvement of quality and completeness of data
- Re-modelling data structures to map to GeoSciML and EarthSciML
- Improved linkages between individual modules of TIGER
- Increased availability of LIST layers (now >180)
New Frontiers

- The Tasmania basin:
  - Carboniferous and younger cover
  - Only 9 drill holes penetrate to basement
  - Obscures boundary between west and east Tasmania Terranes
  - Oroclinal model suggests that prospective stratigraphy underlies basin

- Reducing risk:
  - Co-sponsoring of Lachlan Orogen ARC-Linkage project
  - Data acquisition to start with airborne geophysics, regional mapping, from 2021, possibly leading to MinEx CRC project in mid-2020s
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From Cayley (2014)
Thank you
For more information go to: www.mrt.tas.gov.au