Lessons From The Explorer Challenge
The Power of the Crowd and Open Data

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All figures are expressed in Australian dollars unless stated otherwise.

Exploration Results as referred to on Page 15

1 Information extracted from OZ Minerals Quarterly Report for the three months ended 30 September 2014, dated 14 October 2014 and is available at https://www.ozminerals.com/uploads/media/ASX-2014-Sep-Quarterly-Report-b7eed6fb-ed79-4514-9aec-13dc2c3af87b-0.pdf

2 Information extracted from OZ Minerals ASX Release entitled ‘Significant copper mineralisation returned from Khamsin prospect’ dated 6 May 2013 and is available at https://www.ozminerals.com/uploads/media/ASX-20130506-Khamsin-Results-505cf178-fc34-44ad-91e9-ed98004518af-0.pdf

3 Information extracted from OZ Minerals ASX Release entitled ‘First production from Prominent Hill copper-gold operation’ dated 26 February 2009 and is available at https://www.ozminerals.com/uploads/media/ASX_20090226a_PH_first_production-5dc67ae1-acf1-46cd-9c5a-07f97ba1ea5a-0.pdf

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A modern mining company
Explorer Challenge

Mineral exploration in 2019

/ The exploration process is iterative and takes time. More money doesn’t necessarily help.

/ We generate vast amounts of data that does not always result in discovery.

/ The low hanging fruit in the best jurisdictions appears to have been picked.

  – Trade sovereign/social/security risk for exploration risk? Make discoveries but maybe not mines.

  – Go deeper? Increase exploration spend and capital intensity.

  – Study Harder? Ascend from explorer, to specialist, to oracle.
We learned a lot about Prominent Hill

Breccia Characterisation
Tom Blenkinsop, James Cook University

How extensive is hydrothermal brecciation?
What are the host rock controls on breccia formation?

Sedimentary facies mapping and Petrography
Stuart Bull and Sebastien Meffre, CODES
We learned a lot about Prominent Hill

What is the prospect-scale structural architecture?

Detailed structural mapping and modelling

Rod Holcombe, HCO
Gawler IOCG Research

We learned a lot about Prominent Hill

What is the regional crustal-scale architecture?

a) ca. 1600 - 1592 Ma

b) ca. 1592 - 1582 Ma

c) ca. 1582 - 1560 Ma

d) ca. 1560 - 1540 Ma

Tectonothermal evolution of the Inlier

Mitchell Neumann, OZ Minerals
We learned a lot about Prominent Hill

What is the regional crustal-scale architecture?
We learned a lot about Prominent Hill

What is the regional crustal-scale architecture?

2D Seismic Reflection Survey
Thomas Harris, Finbarr Murphy, Charles Funk, Peter Betts
We learned a lot about Prominent Hill

Outcrop deformation mapping

*John Steward, PGN Geoscience*

What is the regional crustal-scale architecture?
We learned a lot about Prominent Hill

How, when and where is additional porosity formed?

Secondary Porosity Creation and Destruction

Pat Williams, Clump Mountain Geoscience
We learned a lot about Prominent Hill

What is the paragenesis?

- Albite
- White mica
- Calcite
- Smectite/Illite
- Biotite
- K-feldspar
- Leucosome
- Tourmaline
- Chlorite
- Tremolite/Acbsolite
- Magnetite
- Quartz
- Albite
- Chlorite
- Calcite
- Hematite after mafics
- Pyrite
- Hematite Staining (Red rock)
- Smectite/Illite
- Sericite
- Calcite
- Leucosome

Silicification
- Gold I
- Sericite/Muscovite
- Chlorite (V)
- Hematite (after mafics/Mt)
- Silica (Colloform)
- Biotite
- Fe hydroxides
- Pyrite
- Bornite
- Fluorite/Barite Stage I
- Earthy hematite
- Steely Hematite
- Pyrite
- Specular Hematite
- Pyrite
- Fluorite/Barite (veins)
- Chalcopyrite
- Bornite
- Chalcocite
- Covellite (supergene)
- REE-bearing phases
- U-bearing minerals
- Gold II
- Carbonates/Quartz

Deposition of lower GRV and red beds
- Emplacement of rhyolitic dykes
- Hilbata-related magnetism
- Magnetite skarn formation
- PHZ
- Faulting-folding; overturning of sequence
- Belt system: dykes-white micas-illite
- Silicified dolomite

STAGES I and II

STAGE III

STAGE IV

STAGES V and VII

STAGES V and VII

Detailed Paragenesis
Jorge Benavides, OZ Minerals
We learned a lot about Prominent Hill

Reconstructing Ore Fluid History
Tobias Schlegel, ETH Zurich

Geochemical zonation in alteration halo at PH
Putra Sadikin, Masters Thesis
Gawler IOCG Research

We learned a lot about Prominent Hill

We drew lots of cross sections!

2000 square kilometres of cross sections at 200m spacing
Ian Anderson, Paul Hehuwat, OZ Minerals
We know a lot about Gawler IOCGs
... and that’s a fantastic competitive advantage!

/ Fremantle Doctor¹
  – 44.5m @ 2.0% Cu, 1.3g/t Au,
    51.0m @ 1.8% Cu, 1.2g/t Au

/ Khamsin²
  – 334.0m @ 0.8% Cu, 0.2g/t Au
    (including 108.0m @ 0.9% Cu, 0.4g/t Au)

/ Ankata³
  – 129.3m @ 2.6% Cu, 0.6g/t Au
    (including 59.0m @ 3.9% Cu, 0.3g/t Au)
Gawler IOCG Research

We know a lot about Gawler IOCG’s ... but maybe we are a little too smart!

/ Increasingly model-driven exploration in-house.

/ Increasingly difficult to identify and rationalise targets which don’t fit the OZ Minerals IOCG model.

/ Subconscious bias pulls our attention to well-known prospects – we avoid new frontiers.

/ By searching for the exact features of our detailed exploration model, are we making a new discovery more difficult?

/ It’s not just us – the industry does it too!
Thinking Differently – were all low hanging fruit *actually* picked?

- Terabytes of collected data isn’t valuable if it isn’t being put to work.
- Tapping into a global ideas market ensures diversity of thought.
- Insight and ideas from outside the mining industry empowers a shared, sustainable future.
- Human-centred approach creates opportunities for unusual partnerships and genuinely unique exploration methodology.
Unearthed provided the bridge to the non-geologic community.

Data was made easy to understand and painless to access through a custom-built online portal.

Records were cleaned and accompanied by metadata, and comprehensive explanations.

Kickoff presentations at PDAC in Toronto and a webinar with OZ Minerals domain experts.

“Geoscience 101”
Explorer Challenge

Getting new people involved

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1st Prize Team: Couched in Uncertainty
Hugh Sanderson and Derek Carter
Location: Australia

Background: Hugh Sanderson is freelance programmer, with an interest in Artificial intelligence (AI)/Machine Learning (ML), and Derek Carter has a background in surveying, GIS and mining.

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2nd Prize Team: Hong and Low
Cher Keng Heng and David Low
Location: Singapore

Background: Formally trained in electronic engineering, David Low made a career switch to data science eight years ago. He is now co-founder and Chief Data Scientist of chessbox startup Pandas and guest lecturer at the National University of Singapore. Cher Keng Heng began his first job as a computer vision engineer in 2001. Recently, he left his company and started a freelance business in providing deep learning algorithms.

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3rd Prize Team: Avant Data Solutions
Andrew Vinciguerra and Zhen Wang
Location: Australia

Background: Andrew is a full-time chemical engineer, and a part time developer. Zhen Wang is a Data Scientist at Avant Data Solutions, a bespoke machine learning consultancy.

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/ Separate Data Science competition specifically tailored to encourage experts in machine learning, programming, mathematics, etc. to get involved.

/ Competition tailored to provide real time feedback to entrants on how well their models were predicting mineralisation across different geologic terranes.

/ Data scientists were able to adapt their trade to the geologic problem surprisingly quickly.

/ A large number of teams with no geologic background achieved high accuracy predictions well above random chance – It works!
Explorer Challenge
Making it attractive

/ 1,000,000 good reasons to get involved.
/ Learning opportunities for participants.
/ Business opportunities for successful teams.
/ Bringing data scientists and geoscientists together.
/ Promoting opportunities and understanding of the resource sector.
/ Promoting Australia’s fantastic pre-competitive mineral exploration data.
Explorer Challenge

Main challenge

/ 3 months produced 37 models, 400+ targets.
/
/ A faster, lower risk, more certain exploration strategy.
/
/ Exciting new ideas, perspectives, models and methodologies – not just impacting exploration but raising questions throughout the business.
/
/ Consensus targets are independent, multidisciplinary, diverse and valid.
/
/ Biggest challenge now is keeping an open mind and not letting our detailed domain knowledge bias our thinking!
Explorer Challenge

Learnings

/ What we think is impossible probably isn’t.
/ Data-driven predictions of geology, mineralisation, alteration, etc. are achievable.
/ Other industries have tools, techniques and methodologies that can be applied to mineral exploration - we just don’t know each other’s challenges well enough yet.
/ Opening your data is less scary than you think.
/ Multidisciplinary teams see things differently.
/ With a combination of many models, we can build confidence through consensus.
Explorer Challenge

Going forward

/ More open data will yield better models in a much shorter time frame

/ Sharing our hard problems will produce better solutions.

/ Growing a distributed and diverse expert community in exploration will build better relationships between industry, communities and government.

/ We will gain more confidence in our targets before we drill them.

/ We will strive to increase the speed and success rates of economic discoveries.
The future of mineral exploration