South Australian Chamber Of Mines & Energy

The Gambler's Game
Breakfast

03 July 2019

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Greg Hall
President

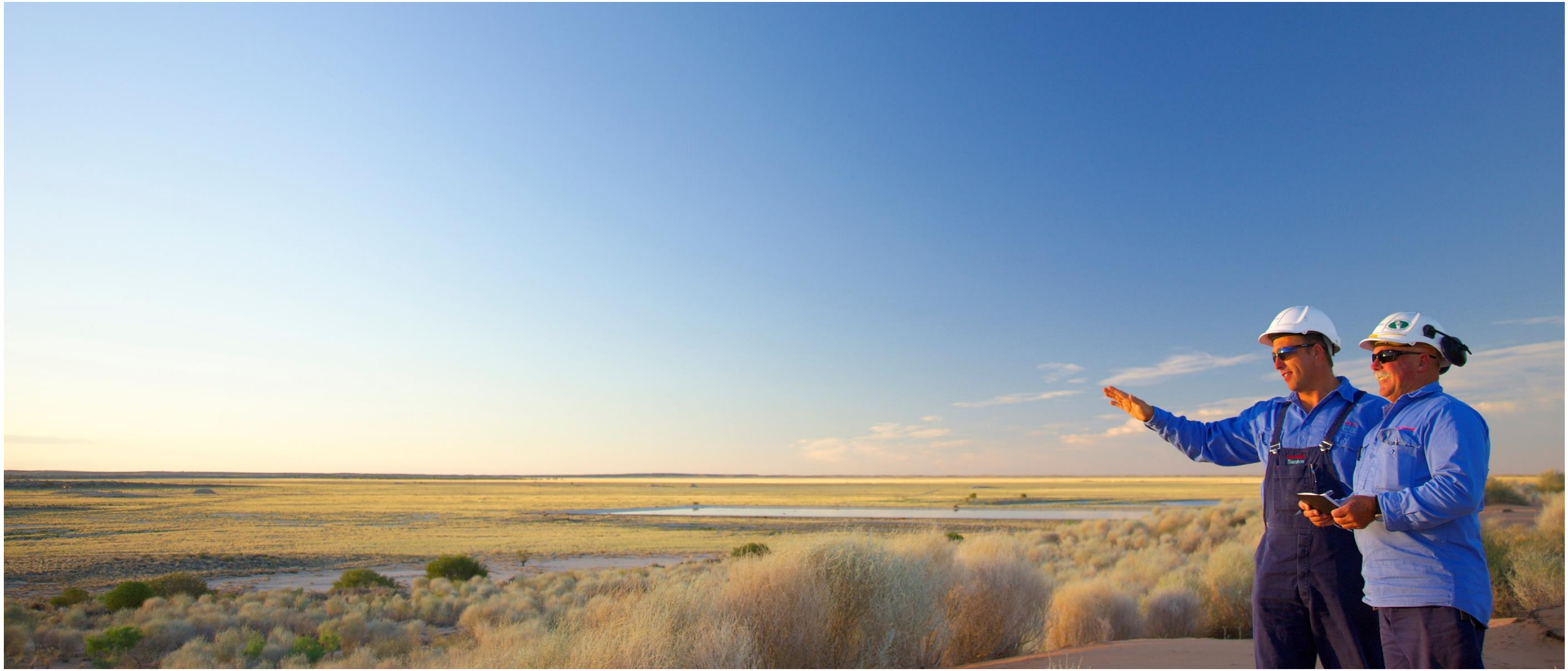
The Gambler's Game Breakfast

03 July 2019

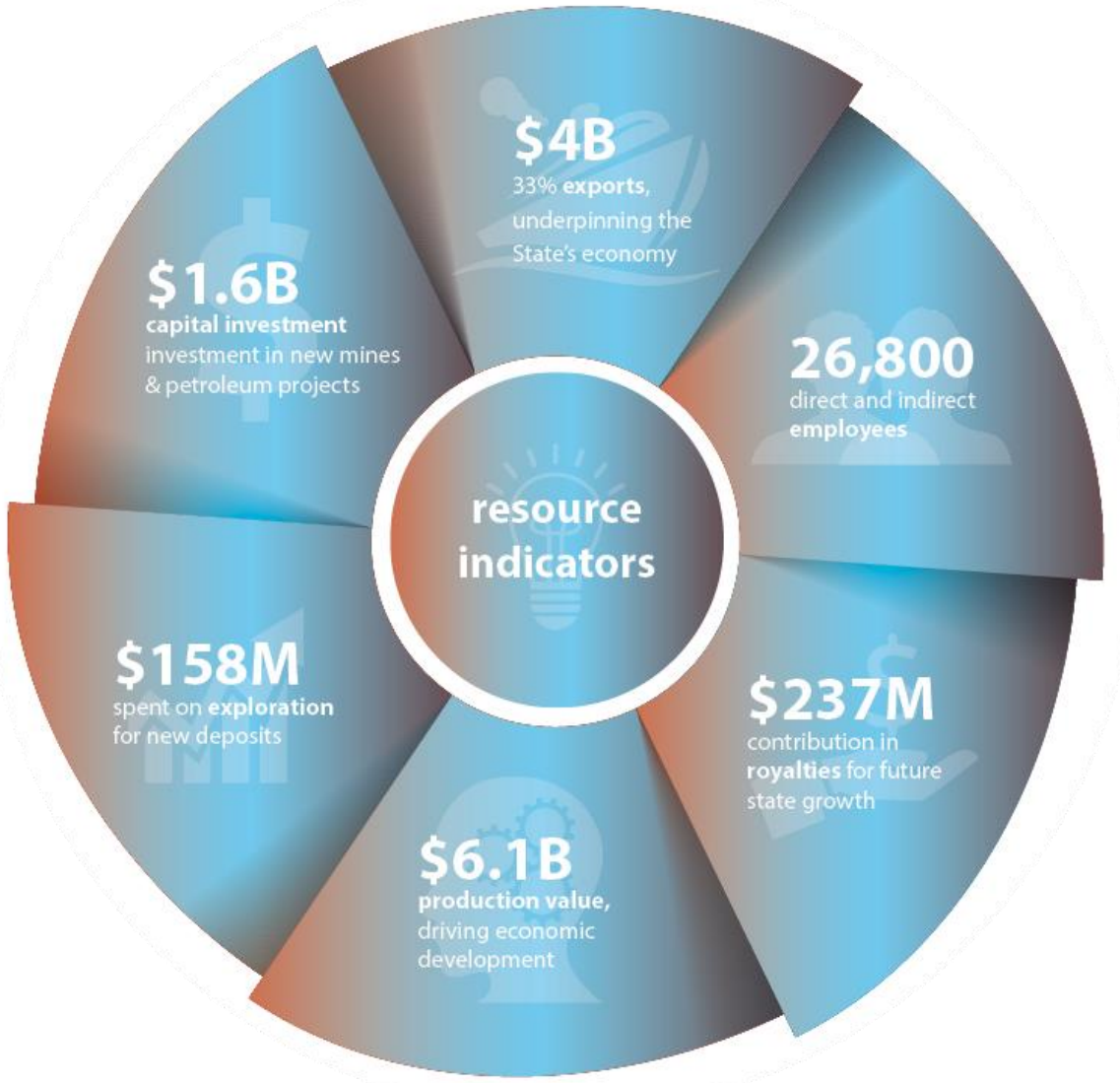
Carrapateena discovery

Deep cover

Land access



Contribution to the economy



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MINEX CONSULTING

Richard Schodde

Managing Director, MinEx Consulting

The Gambler's Game Breakfast

03 July 2019

Exploration Success
The Gambler's Game

Richard Schodde
Managing Director, MinEx Consulting
Adjunct Professor, Centre of Exploration Targeting, UWA

Introduction / Background

Richard Schodde

- B Eng (Hons) in Materials Engineering, MBA

- Minerals Economist, with 35 years experience in R&D, project evaluation, business strategy and exploration for WMC Resources and BHP Billiton
- Set up MinEx Consulting in 2008. Have over 100 clients – Mining Companies, Government Agencies and Investment Funds.
- Recognised as a World expert in the economics of mineral exploration – nominated by the Mining Journal as one of the top 20 power people in mining in 2015, 2016 & 2017

Focus is on what's the "business case" for exploration and how can we make money out of it

Overview

1. Mining Industry Facts
2. Exploration Industry Facts
3. Lead-Time to make a discovery
4. Likelihood and time required to convert a discovery into a mine
5. Factors driving the decline in discovery performance
6. Benefits to South Australia in “getting it right”
7. Current health of the Australian Junior Sector
8. Summary / Conclusions

The World's mining industry is huge, but South Australia accounts for only 0.3% of the total

1. MINING INDUSTRY FACTS

Mining Industry Facts

In the World there are currently:

SA = 0.3% of the total

SA = 0.7% of the Earth's land area

- Over 6800 major mines operating (with 18 in South Australia)
- ~810 mining companies with sales revenues > US$1m pa.
  In 2018 their combined revenue was US$1600 billion.
- ~475 of these mining companies are publicly listed.
  - Their combined market cap is currently US$1062 billion.
  - Total assets are $1259 billion and combined net profit in 2018 was $22.3 billion (giving a Return on Asset of only 1.8%)

Microsoft's Market Cap is $1030 B

- 96 mining companies are Australian-based (83 public and 13 private)
  - Only 4 have headquarters in South Australia

SA = 0.5% of the total

- The Australian mining industry employs ~160,000 people

There are currently ~10,000 active exploration projects in the World, delivering ~73 discoveries per year (i.e. 1-in-137 chance of success).

South Australia currently accounts for 0.5% of global exploration spend.

2. EXPLORATION INDUSTRY FACTS

Exploration Industry Facts

In the World there are currently:

- In addition to the 810 mining companies, there are 3500-4000 “junior explorers”

SA = 0.5% of the total

- Collectively they spent US$12,430 million on mineral exploration in 2018
- >30,000 exploration projects, of which ~10,000 are currently active.
- Over the last decade, 730 significant[#] new mineral deposits were found – an average of 73 discoveries per year … i.e. one-chance-in-137-of-success for a typical exploration project in a given year

But if you are looking for Tier 1 (World-Class) deposit the odds are 40x harder

This is equivalent to betting on “Red” coming up 7 times in a row on the Roulette Wheel

- On average, an exploration tenement is held for 5-10 years before being relinquished. In many cases the tenement gets picked-up / “recycled” again

However the odds get progressively worse over time

Note: Significant is defined as deposits that are >=“Moderate” in-size. i.e. >100koz Au, >10kt Ni, >100Kt Cu, 300kt Zn+Pb, >5kt U_3O_8 >5 Mt Heavy Minerals, >20 Mt Fe, >20 Mt Thermal Coal >10 Mt Met Coal, >3 Mt P_2O_5 and >3 Mt K_2O

On average it takes 2-3 companies 12 years to make a discovery.

3. LEAD-TIME TO MAKE A DISCOVERY

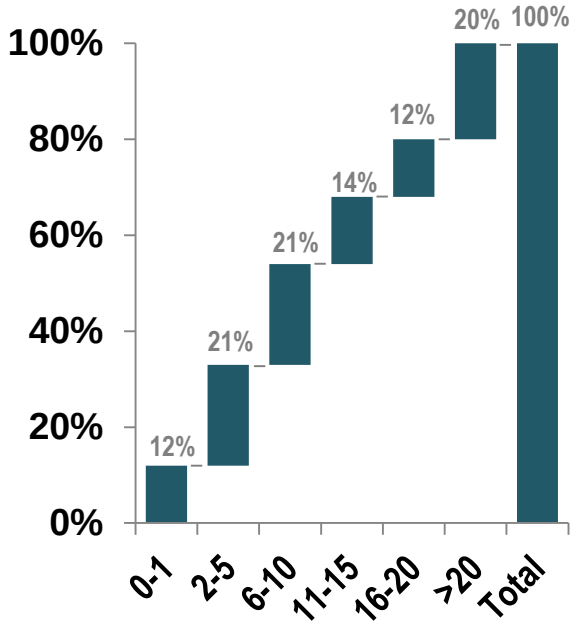
It takes persistence and patience to make a discovery

Time delay and number of companies involved prior to the actual discovery of a significant copper or gold deposit

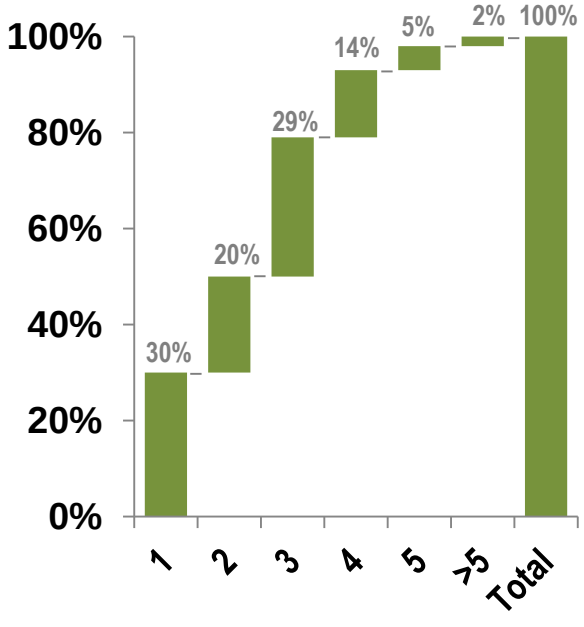
The average exploration time for a significant discovery was 12 years. One third were found within 5 years

On average, 2.5 companies explored the property prior to discovery

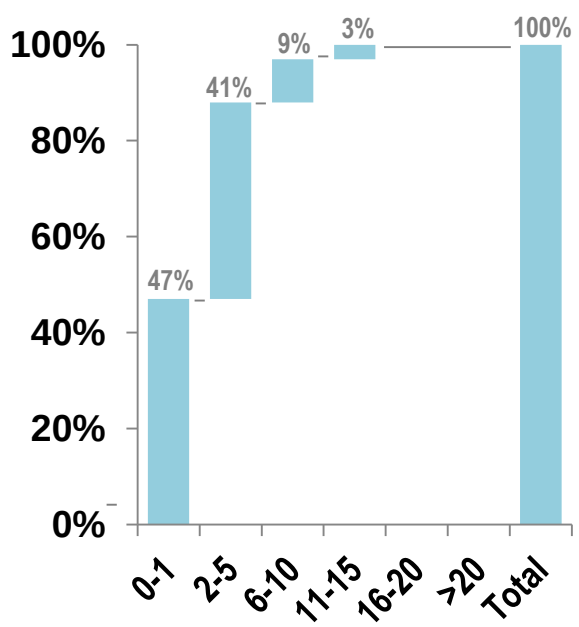
The successful company took on average 2.5 years to find the deposit



Time spent (in years) exploring the property before the discovery was made



Number of Companies who explored the property before the discovery was made



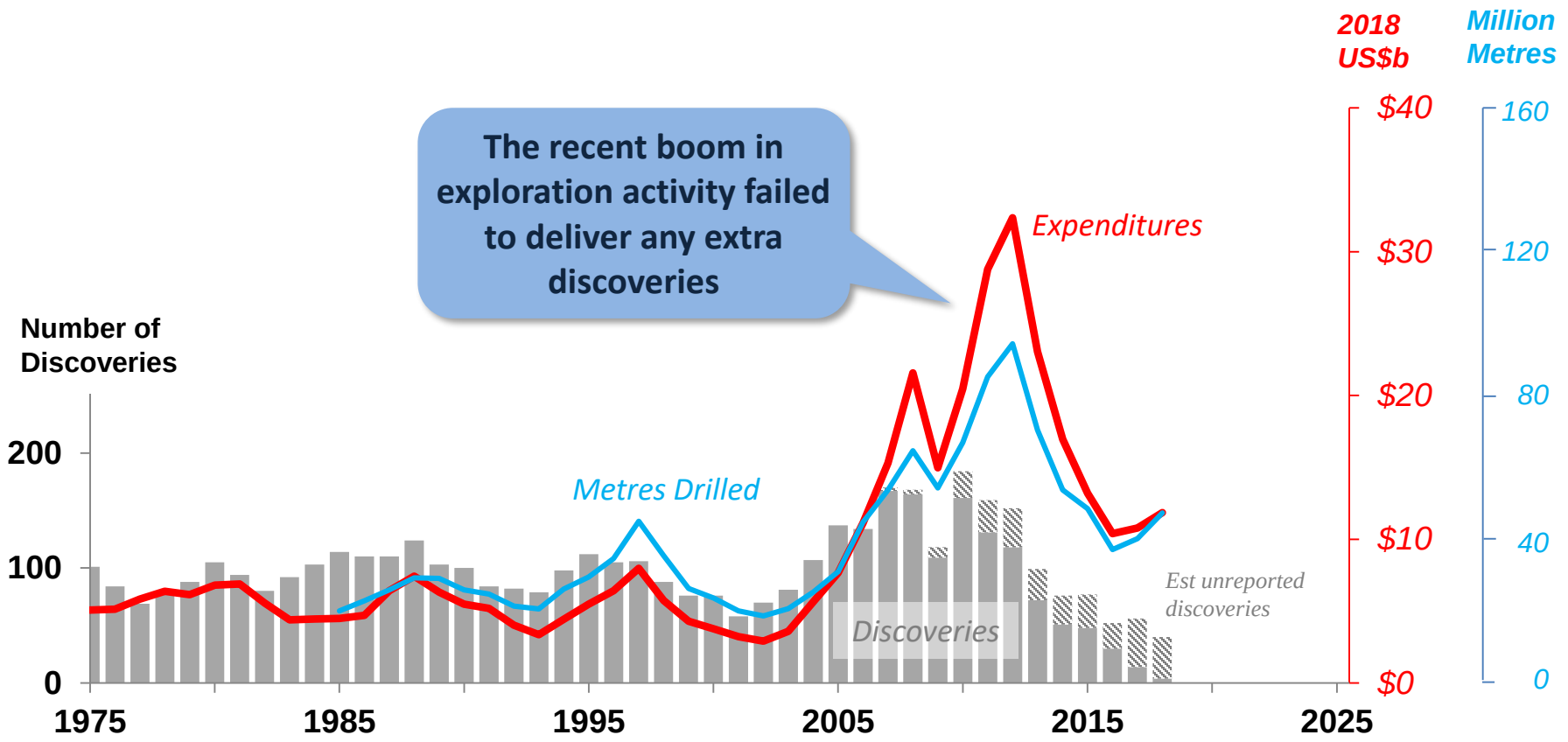
Time spent (in years) by the successful company exploring the property before the discovery was made

Note: Analysis is based on 100 significant (>100koz, >100 kt Cu) gold and copper discoveries in the Western World between 1960-2018. The analysis excludes any historical small-scale operations on the project lease.

Source: Minex Consulting © April 2019

Discovery Rate versus Exploration Drilling & Expenditures

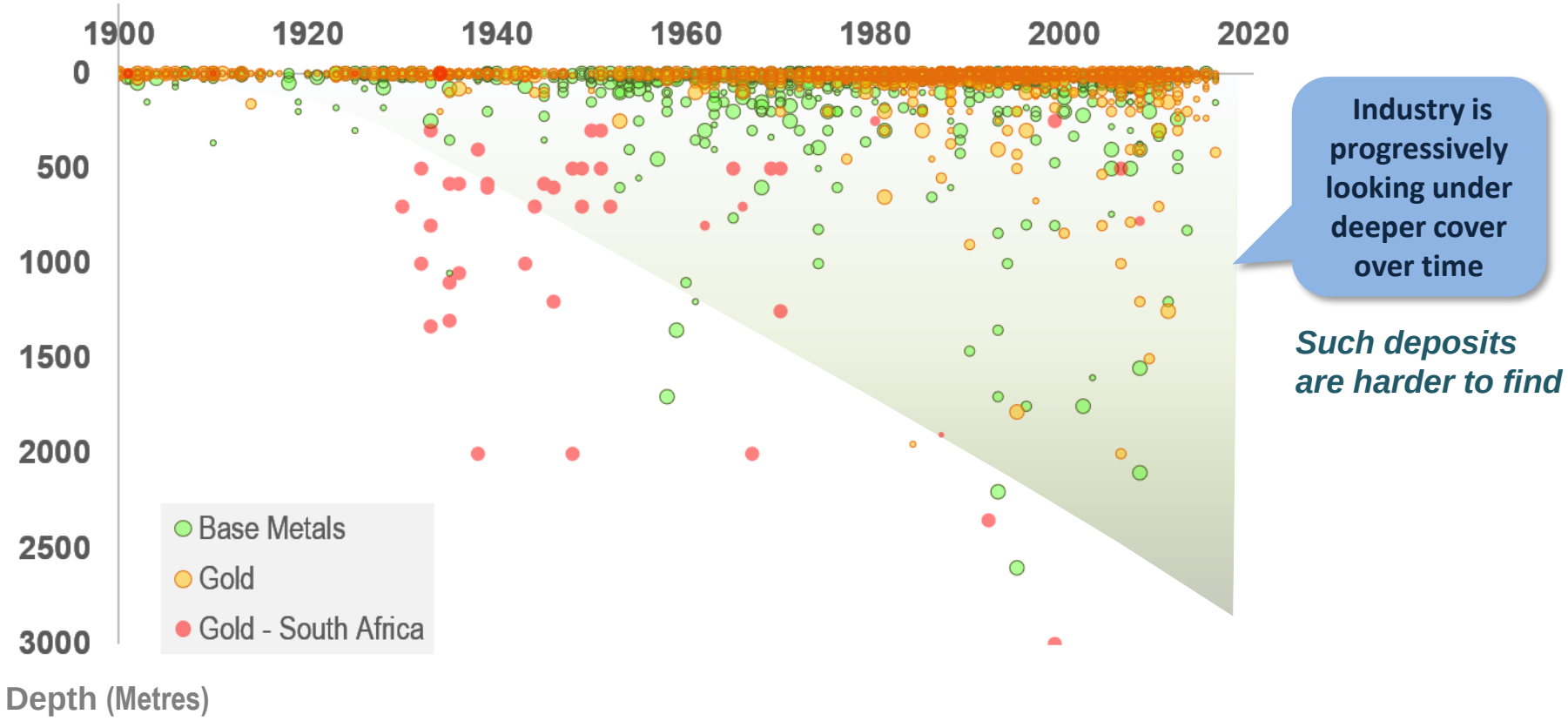
All Commodities World: 1975-2018



Source: MinEx Consulting © March 2019

Depth of cover versus discovery year:

Gold and Base Metal discoveries in the World : 1900-2016



Note: Size of the bubble refers to Moderate, Major and Giant discoveries
Analysis excludes Nickel laterites and under-sea deposits

Source: MinEx Consulting © March 2017

The story doesn't end here …

You now have to turn the discovery into a mine !

On average less than half of all discoveries turn into mines. Of those that do, the average lead time is 12 years (and getting longer)

4. LIKELIHOOD AND TIME REQUIRED TO CONVERT A DISCOVERY INTO A MINE

Less than half of all discoveries made in the World since 1950 have been put into production

And for those deposits that did get developed, the average delay was 12 years

	Number of Deposits			Average Delay (Years)
	Discovered	Developed	Conversion Rate	
Total	**4676**	**2120**	**45%**	**12.4**

Note: Based on deposits >100 koz Au, >100kt Cu, >300kt Zn+Pb, >10kt Ni, > 5kt U_3O_8 or other minerals of equivalent size
Excludes Bulk Mineral discoveries and satellite deposits within existing camps

Source: MinEx Consulting © September 2017

The conversion rate and delay period varies by commodity

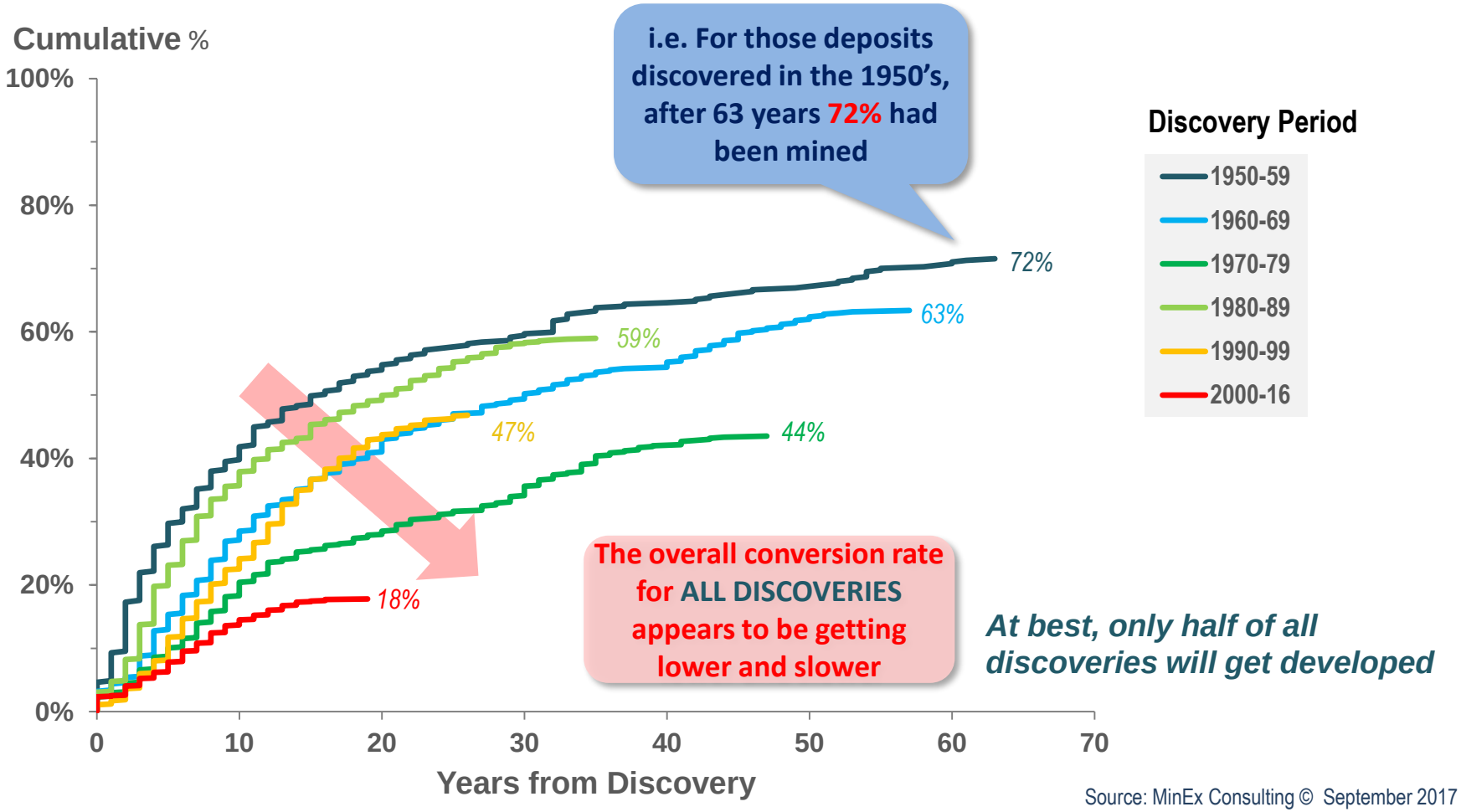
	Number of Deposits			*Contained Metal (Pre-Mined Resource basis)*				Average Delay (Years)
	Discovered	Developed	Conversion Rate	*Discovered*	*Developed*		*Conversion Rate*	
Gold	**1992**	**1018**	**51%**	*5751*	*3793*	*Moz Au*	*66%*	**10.2**
Copper	**950**	**353**	**37%**	*2541*	*1363*	*Mt Cu*	*54%*	**16.8**
Zinc+Lead	**313**	**169**	**54%**	*754*	*447*	*Mt Zn+Pb*	*59%*	**14.1**
Nickel (sulphide)	**208**	**82**	**39%**	*106*	*60*	*Mt Ni*	*57%*	**12.8**
Nickel (laterite)	**150**	**48**	**32%**	*149*	*64*	*Mt Ni*	*43%*	**19.5**
Uranium	**347**	**156**	**45%**	*8.5*	*4.8*	*Mt U*	*57%*	**13.4**
Other	**716**	**294**	**41%**	*na*	*na*		*na*	**11.9**
	---	---	---					---
Total / Average	**4676**	**2120**	**45%**				*~57%*	**12.4**

In terms of the amount of metal found, the conversion rates were higher … i.e. bigger deposits are more likely to be developed

Source: MinEx Consulting © September 2017

Cumulative Number of Discoveries that become mines: ALL

All Discoveries in the World >=Moderate in size



At best, only half of all discoveries will get developed

Source: MinEx Consulting © September 2017

Industry performance is affected by geological, economic, social and political factors

5. FACTORS DRIVING THE DECLINE IN DISCOVERY PERFORMANCE

Factors behind the decline in Discovery & Development Performance

- Average quality of projects is declining (the biggest/best deposits get found first; later waves of discoveries are often not as good)
- Having to explore under progressively deeper cover (which is technically riskier and more expensive to explore and develop)
- Having to explore in new countries / more-remote areas (which adds to the cost, and may involve taking on extra business risk)
- Land access and permitting issues are getting more complex – which takes extra time to resolve
- Regulatory obligations on exploration and mining companies are getting more onerous over-time

Possible solutions

Need to "re-set the clock" by coming up with new ideas for targeting

Pre-competitive data can help identify targets, at a lower cost

Put in better infrastructure to lower mining costs

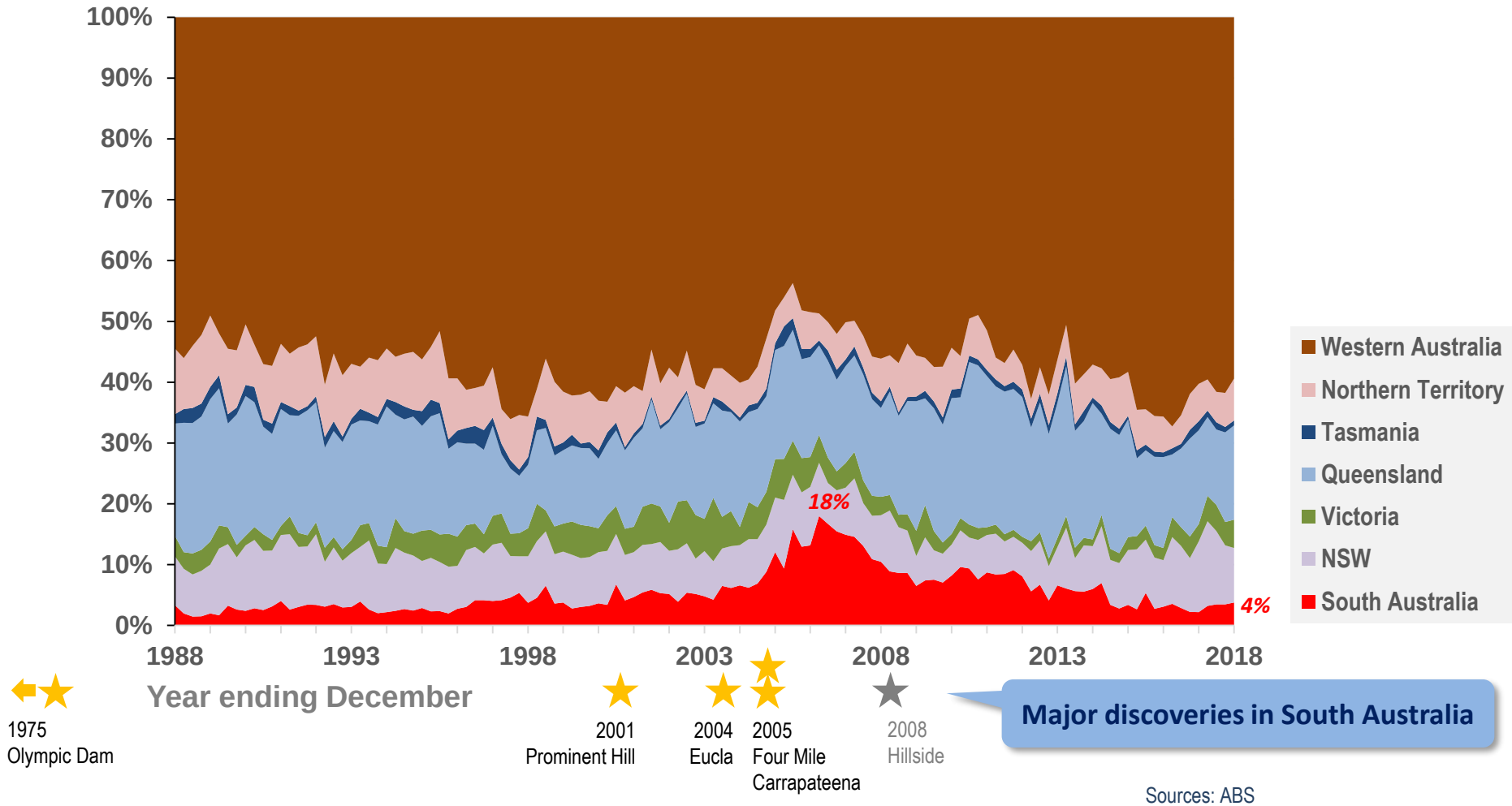
Streamline regulations

2200 new jobs at four new mines in South Australia

6. BENEFITS TO SOUTH AUSTRALIA FROM GETTING IT “RIGHT”

Expenditures are driven by exploration success

Relative share of exploration expenditures by Australian State: Dec 1988 to Dec 2018



Sources: ABS

Four new mines

US$1700m pa in revenues and 2200 jobs

Prominent Hill

Discovered in 2001

Started prodn in 2009

110 kt pa copper +
130 koz pa gold

Revenue = US$800m pa

900 workers

Four Mile

Discovered in 2005

Started prodn in 2014

1000-1200 tpa U3O8

Revenue = USD$60-80m

~144 workers

Eucla (Jacinth-Ambrosia)

Discovered in 2004

Started prodn in 2009
(currently on C&M)
300 ktpa zircon

Revenue ~US$300m pa

193 workers

Carrapateena

Discovered in 2005

Startup in Q4 2019

66 kt pa copper +
80 koz pa gold

Revenue ~$500m pa

~1000 workers

Capex = A$917m

The returns are highly asymmetrical – only 1 in 10 explorers deliver value to their shareholders

The industry is currently finding it hard to raise money

7. CURRENT HEALTH OF THE AUSTRALIAN JUNIOR EXPLORATION SECTOR

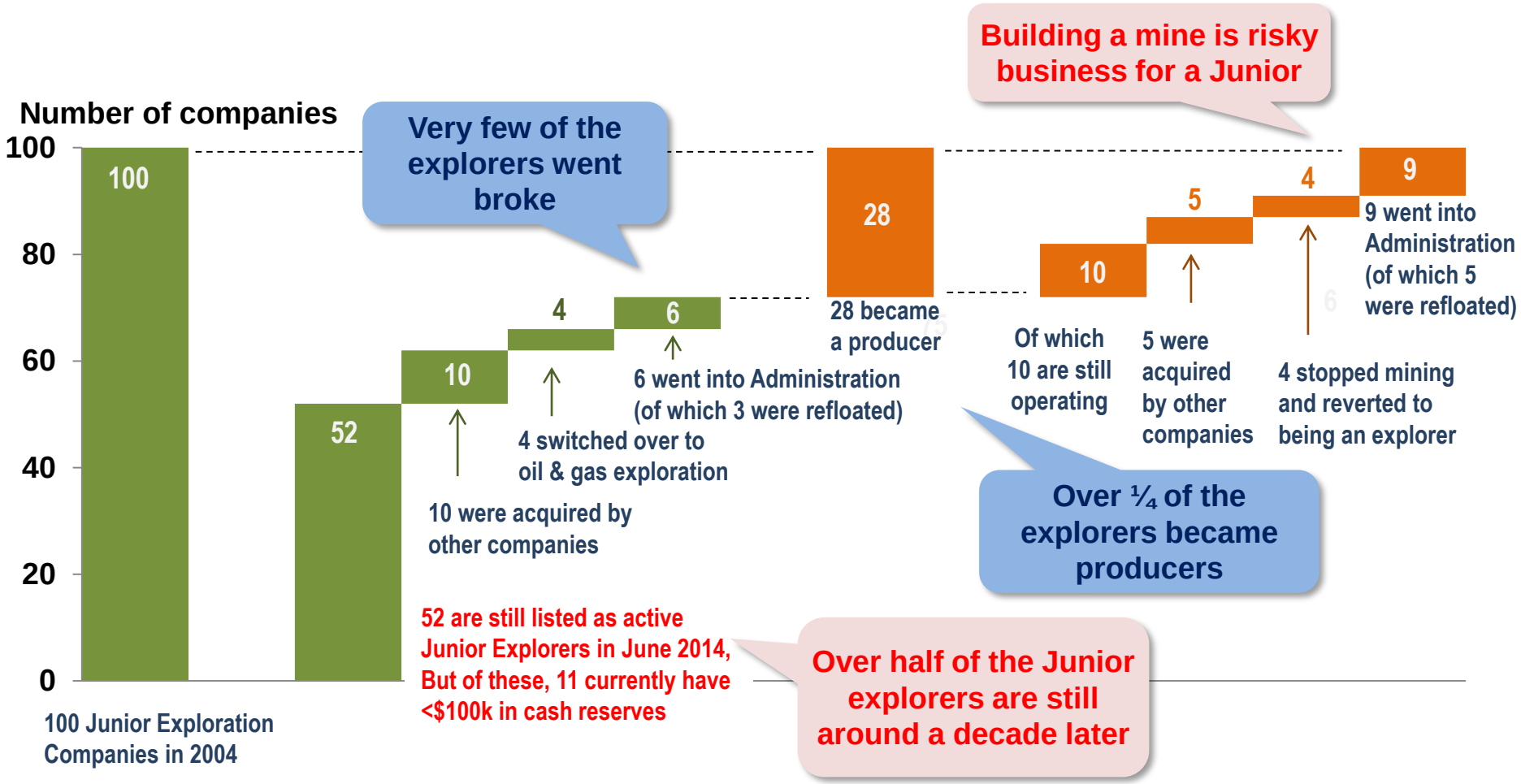
Junior explorers are incredibly resilient and long lived…

"Junior companies are like cockroaches … they can both survive a nuclear winter !"

Source: Canadian Mining Industry spokesperson (who wishes to remain anonymous) March 2014

History of Junior exploration companies over the last decade

(100 ASX-listed Junior Explorers in June 2004 versus June 2014)

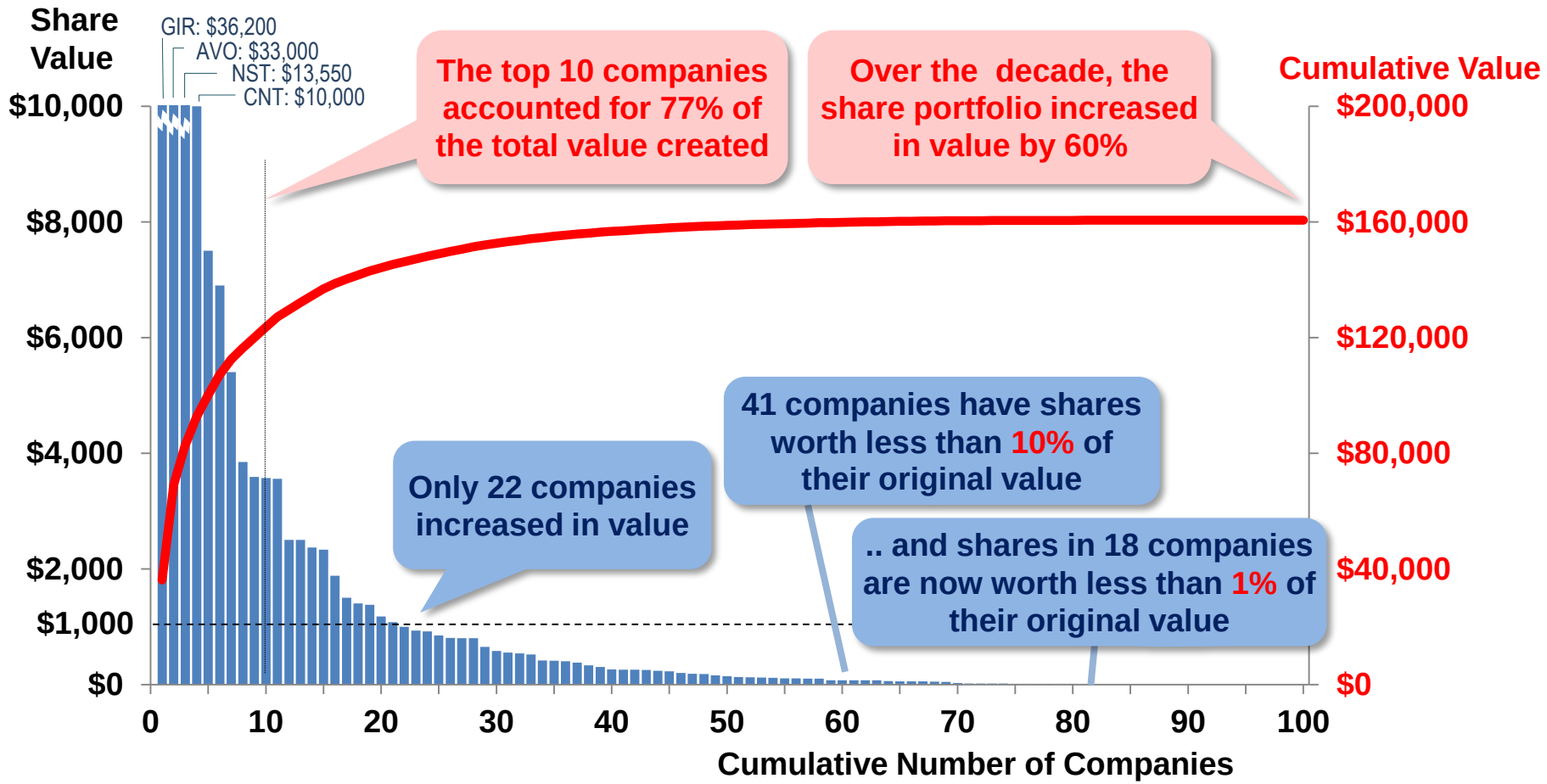


Note: The analysis is based on a random sample of 100 junior mineral exploration companies (out of ~300) listed on the ASX on 30th June 2004.

Source: MinEx Consulting © July 2014

Value of a portfolio of 100 ASX junior exploration companies

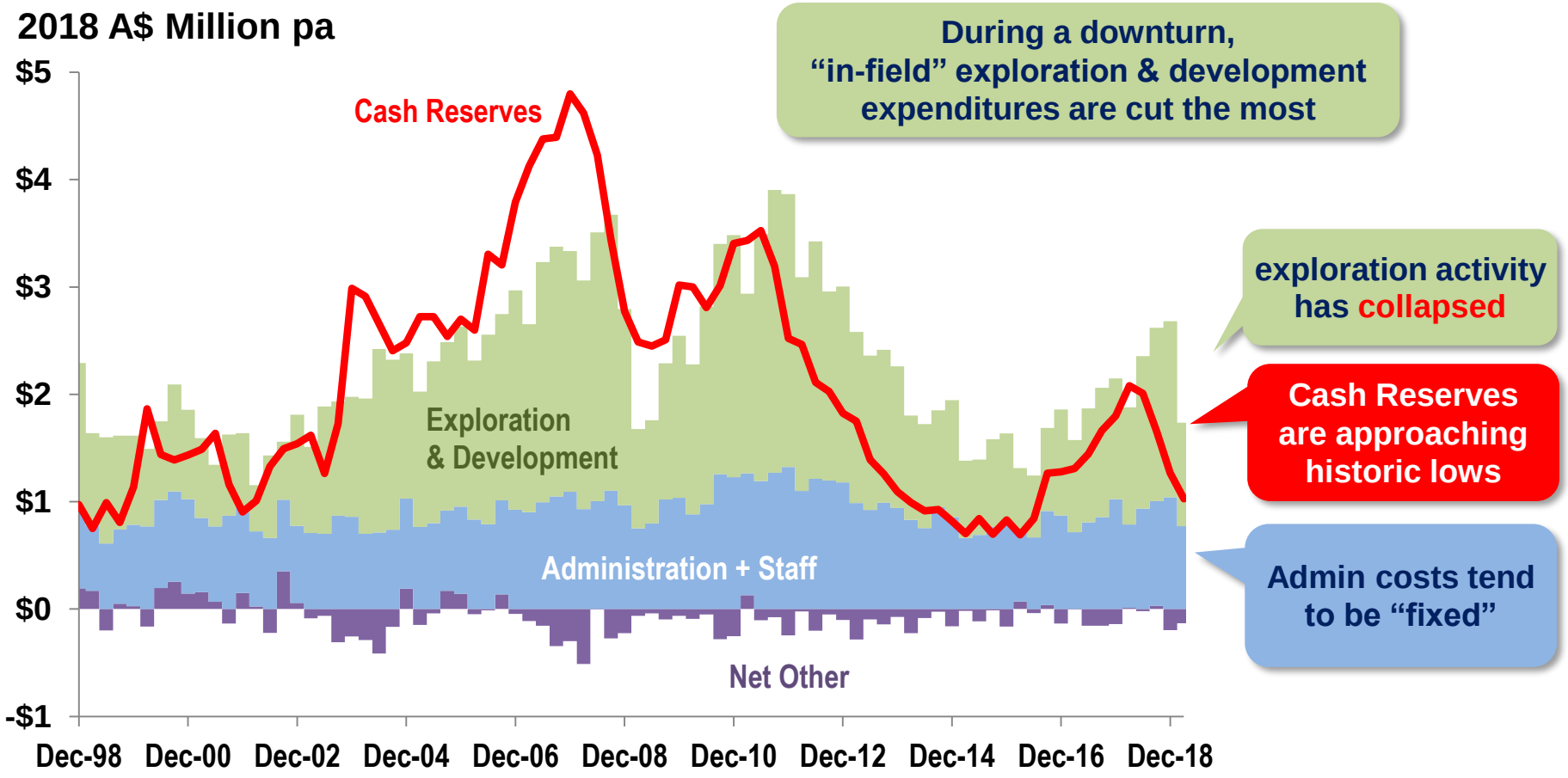
Each company purchased for $1000 on 4th July 2004 versus its value on 4th July 2014



Note: The analysis is based on a random sample of 100 junior mineral exploration companies (out of ~300) listed on the ASX on 30th June 2004.
Final value is based on share price prevailing on 4th July 2014, or on the date it was delisted from the ASX (through takeover or liquidation)

Source: MinEx Consulting © July 2014

Cash Reserves and Expenditures for the MEDIAN Australian Junior Exploration Company : Dec 1998-March 2019



Note: Survey based on a sample of 360 junior exploration companies listed on the ASX between 1998-2018.
"Net Other" includes production and other costs less interest income, mine revenue, asset sales Government Assistance and R&D tax credits.
Quarterly spend data has been multiplied by 4x to produce an annualised spend rate.

Source: MinEx Consulting © June 2019
based on Quarterly Reports to the ASX

8. SUMMARY / CONCLUSIONS

Summary / Conclusions

1. There are over 6800 mines in the World. 18 (0.3%) are in South Australia
2. There are 30,000 exploration projects in the World. 1/3rd of these are active, and of those the chance of finding a deposit in a given year is (on average) 1-chance-in-137. The odds of finding a World-Class deposits are 40x worse.
3. On average, it is the second or third company that finds the ore body. The lead-time to discovery is 12 years (and getting longer)
4. On average less than half of all discoveries get developed. Of these the average delay is 12 years (and getting longer)
5. The decline in discovery performance is due to the progressive move to explore under deeper cover in more remote areas. Government regulations and land access issues also add to the delays
6. South Australia currently accounts for 4% of Australia's exploration spend (and only 0.5% of global spend). Significant addition revenues and jobs can be created if we get it right
7. The Australian junior sector is currently doing it "tough" – it hard to raise cash

Contact details

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Copies of this and other similar presentations can be downloaded from my website

South Australian Chamber Of Mines & Energy

HILLGROVE RESOURCES

Peter Rolley

Chief Geologist, Hillgrove Resources

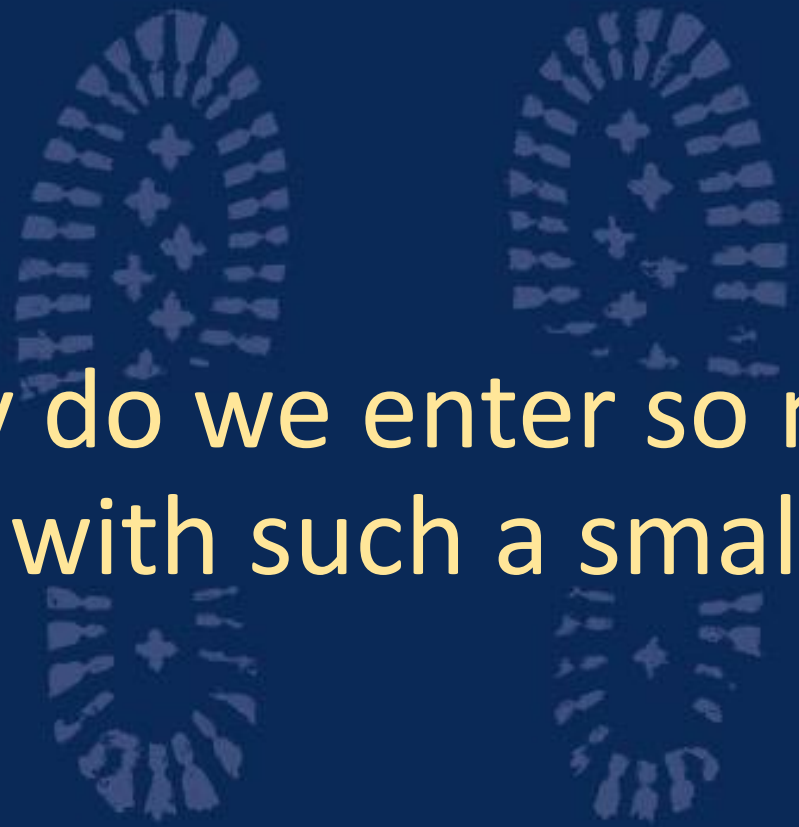
The Gambler's Game Breakfast

03 July 2019

SACOME BREAKFAST

What is ‘**mineral exploration**’…

SACOME BREAKFAST



…and why do we enter so much land yet end up with such a small footprint?

Presentation by Peter Rolley: 03 July 2019

"**Every** Rock has a story about it's life!"

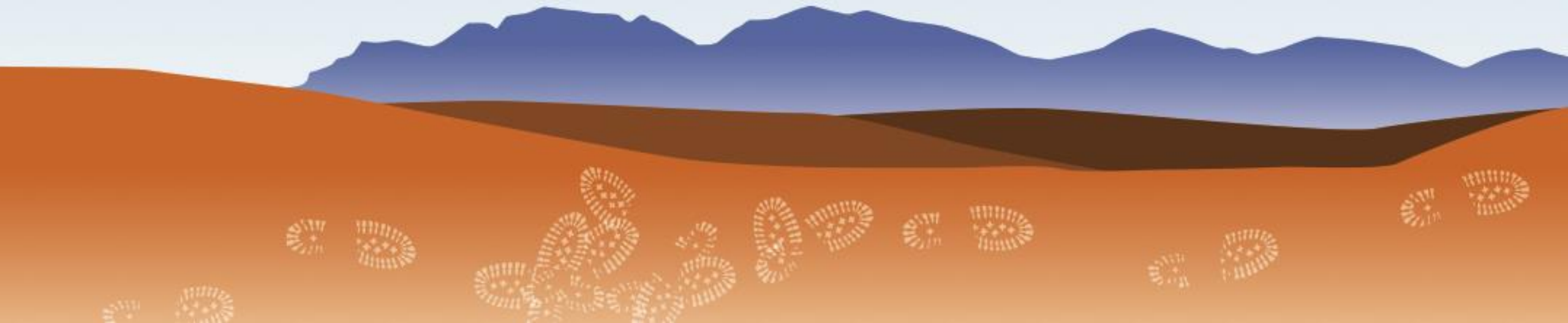
And rocks far away from a mineral deposit are connected to each other,

And point to where the mineral deposit may be hidden.

Mineral exploration is not mining.

Mineral Explorers follow the trail of clues across the land…

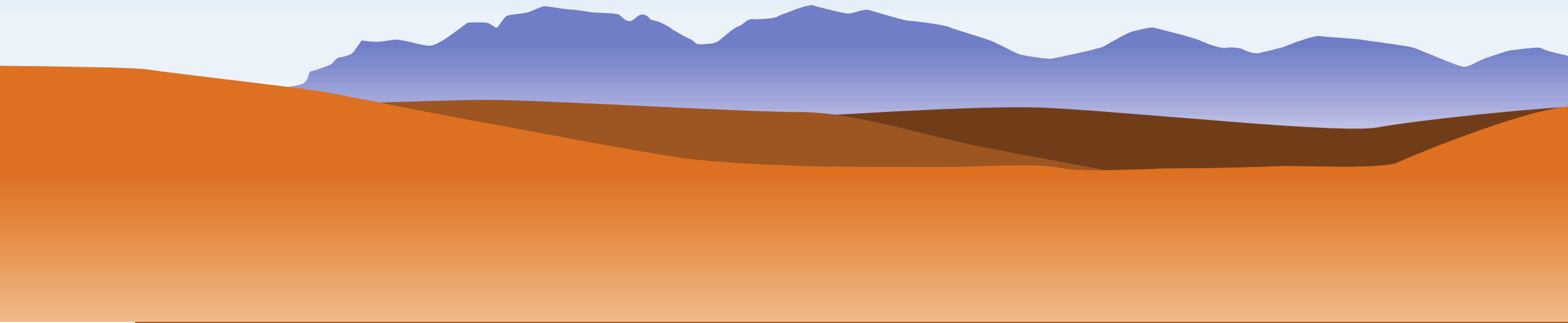
And hence need to visit a wide landscape.

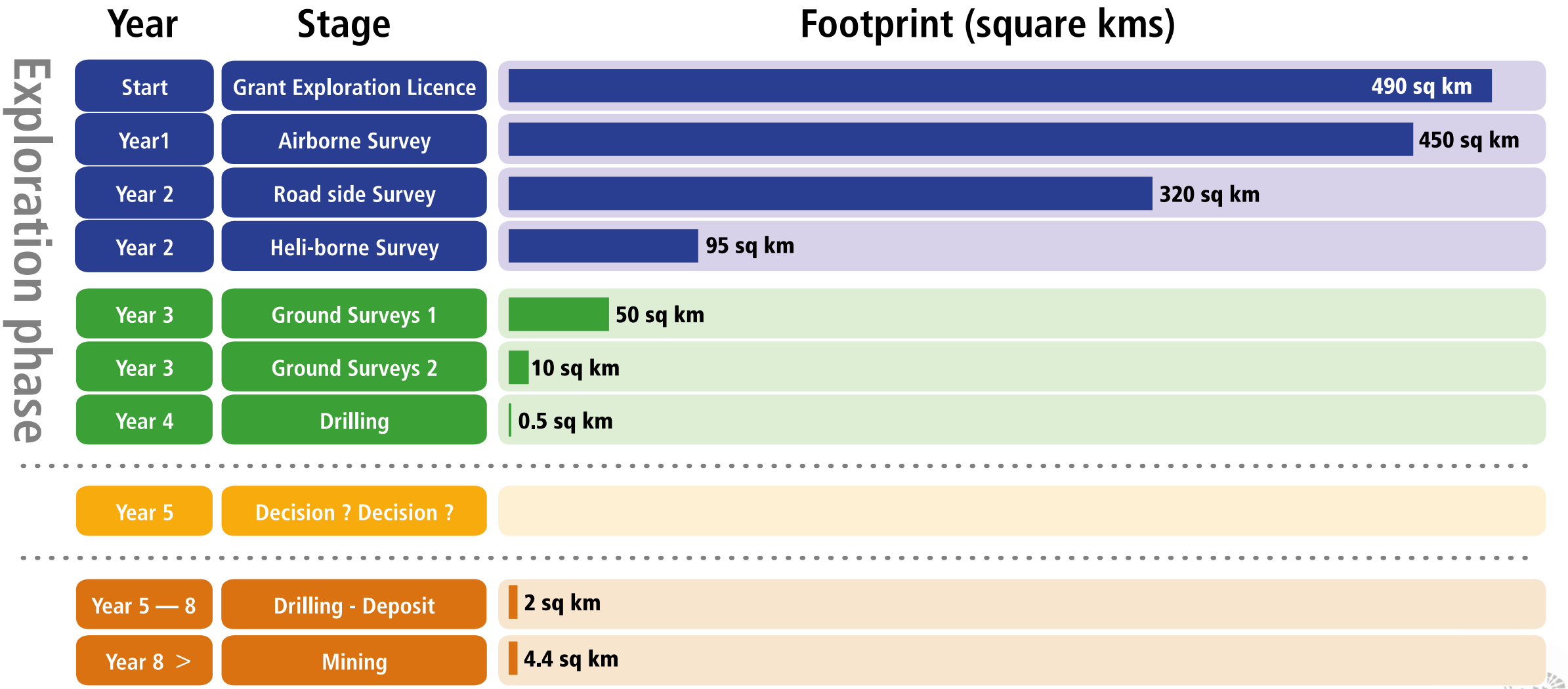


SACOME BREAKFAST

The following presentation summarises Hillgrove's story as a Mineral Explorer in the Adelaide Hills.

HILLGROVE
RESOURCES



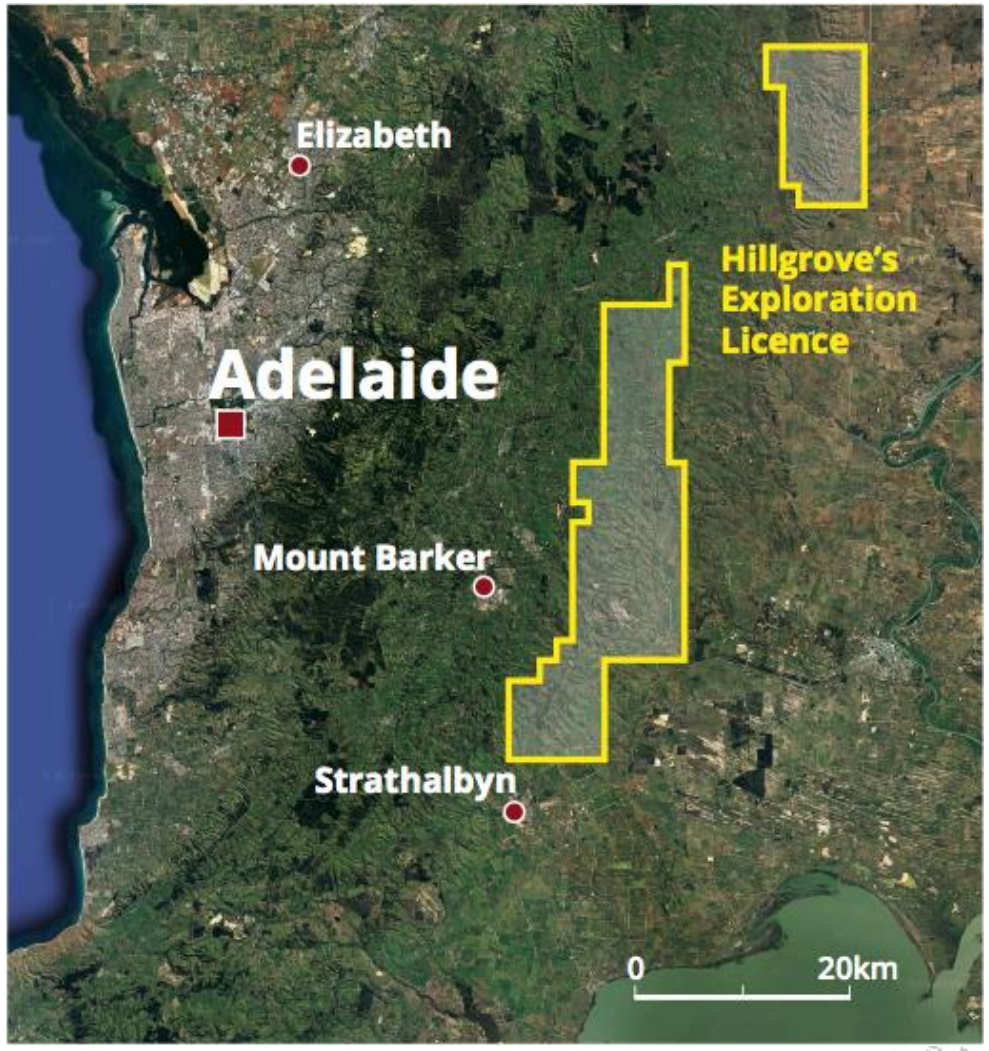


Please note, while Hillgrove has undertaken all these steps, they have not always followed this sequence.

Hillgrove hold an Exploration Licence in the Adelaide Hills.

It covers 490 sq kms (49,000 hectares).

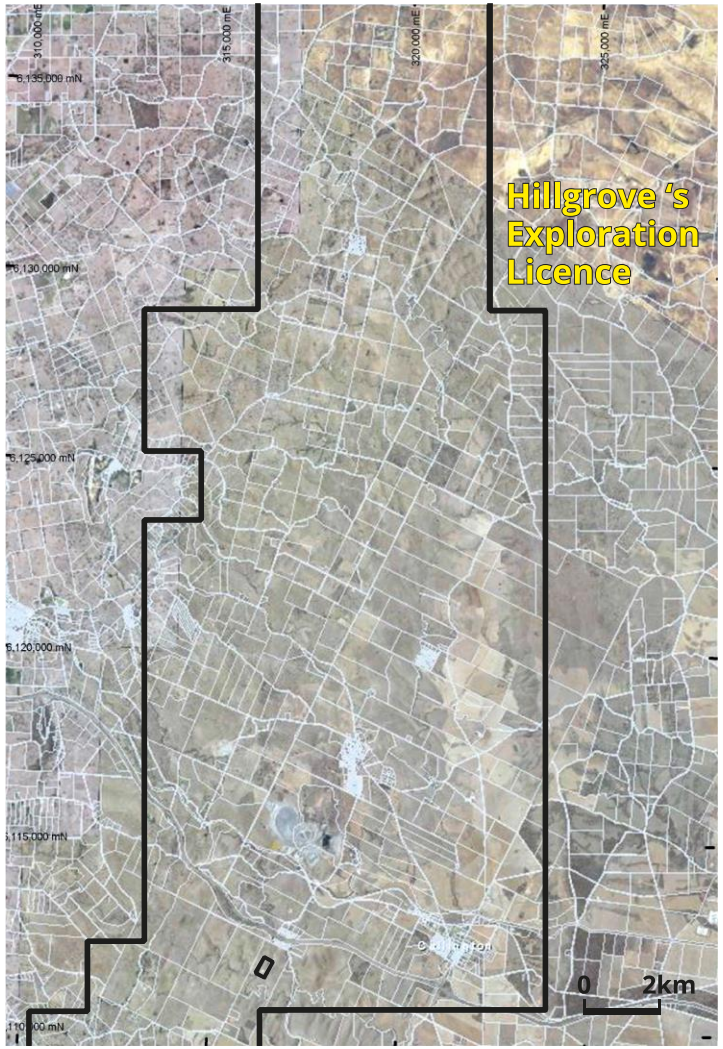
And includes a wide variety of land uses including cropping, grazing, vineyards, town sites, freeway, heritage vegetation, river valleys, …



Over the Exploration Licence there are approx 2,900 land allotments.

At the date of granting of the Exploration Licence, the landowners are not contacted.

However, the location of the licence is freely available to everyone as public images through the Government website – SARIG.

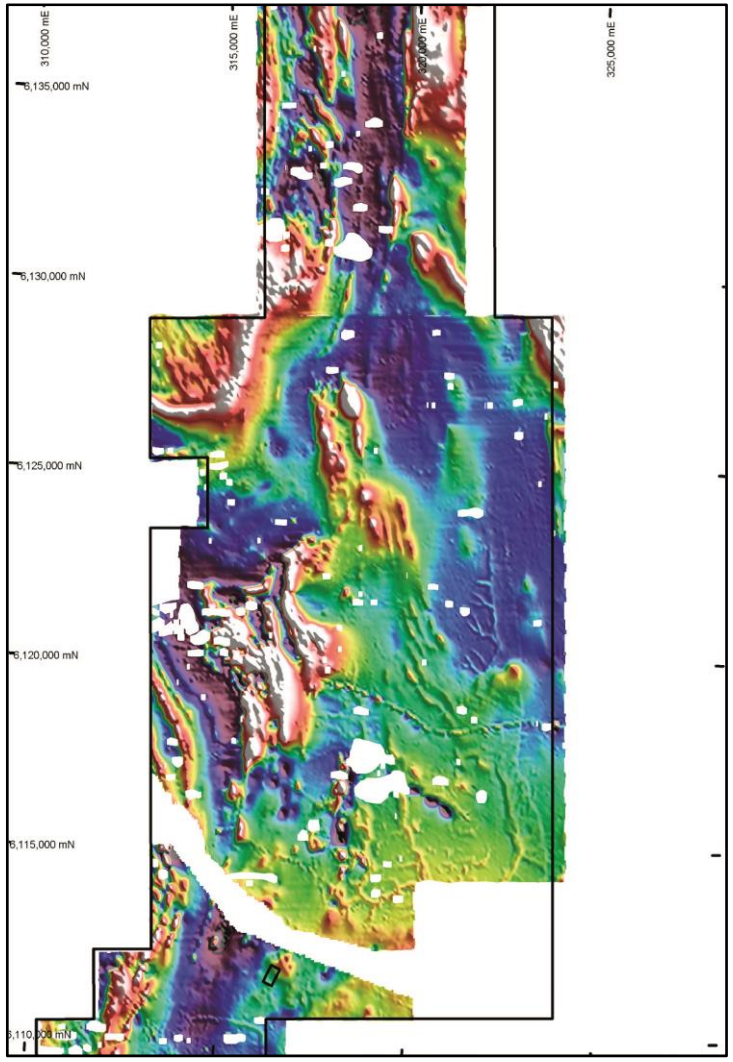


Close-up showing land allotments

Start | Grant Exploration Licence | 490 sq km

We have acquired airborne magnetics over ~450 sq. kms of the 490 sq. km area.

At no time did we step onto anyone's land, or interfere with anyone's activities.

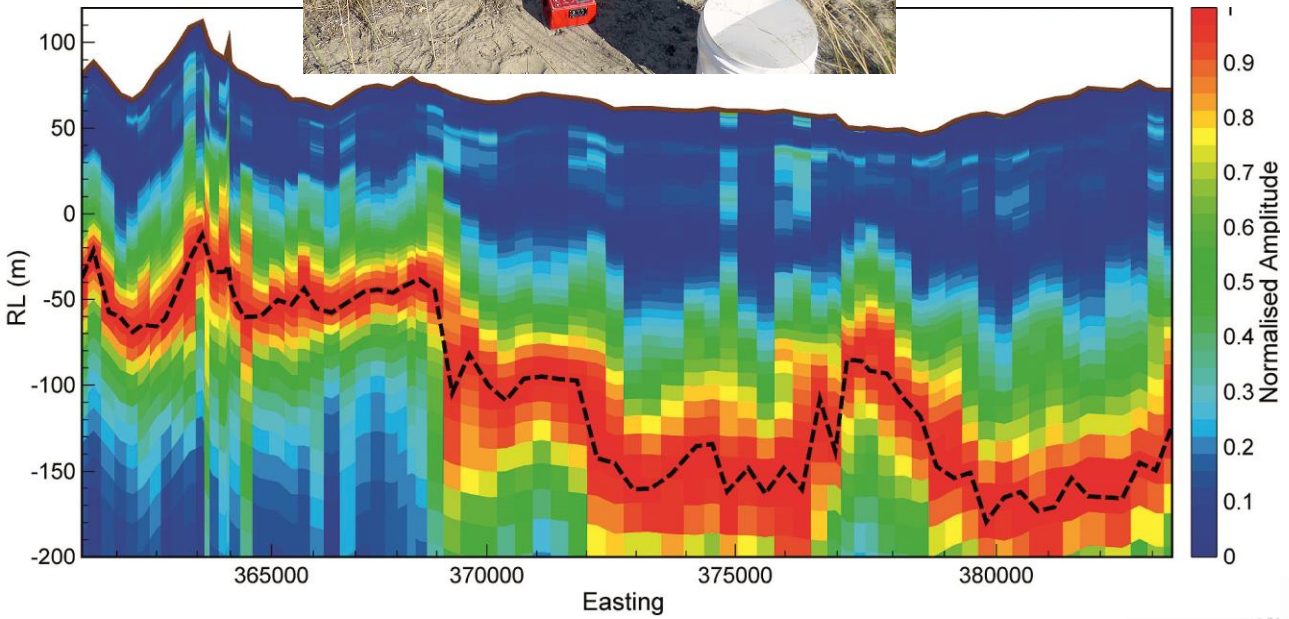


As a result of the survey, dark blue and green areas could be ignored

Year1 | Airborne Survey | 450 sq km

We acquired the depth of sand and limestone (the deep cover hiding the rocks) from along public roads.

At no time did we step onto anyone's land. Councils informed and safety protocols imposed.

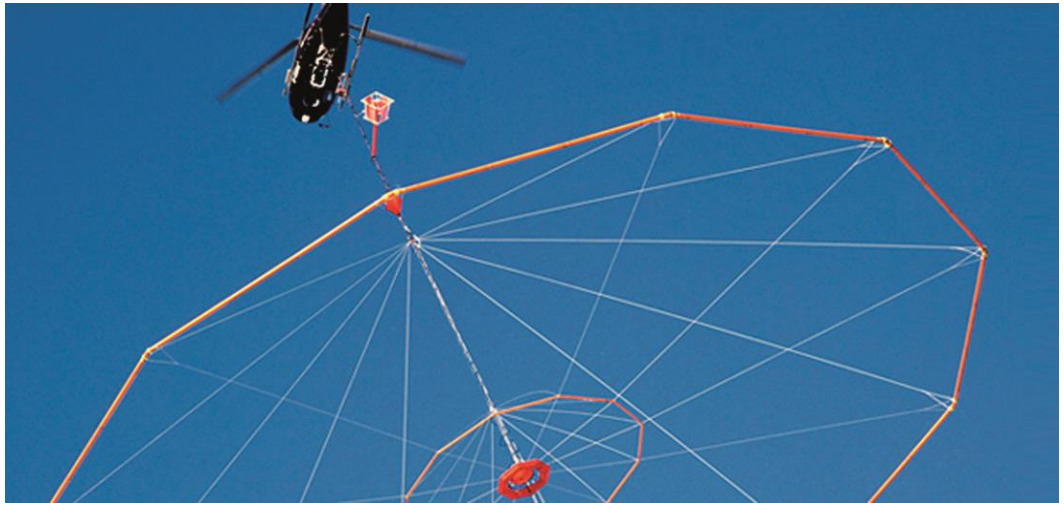


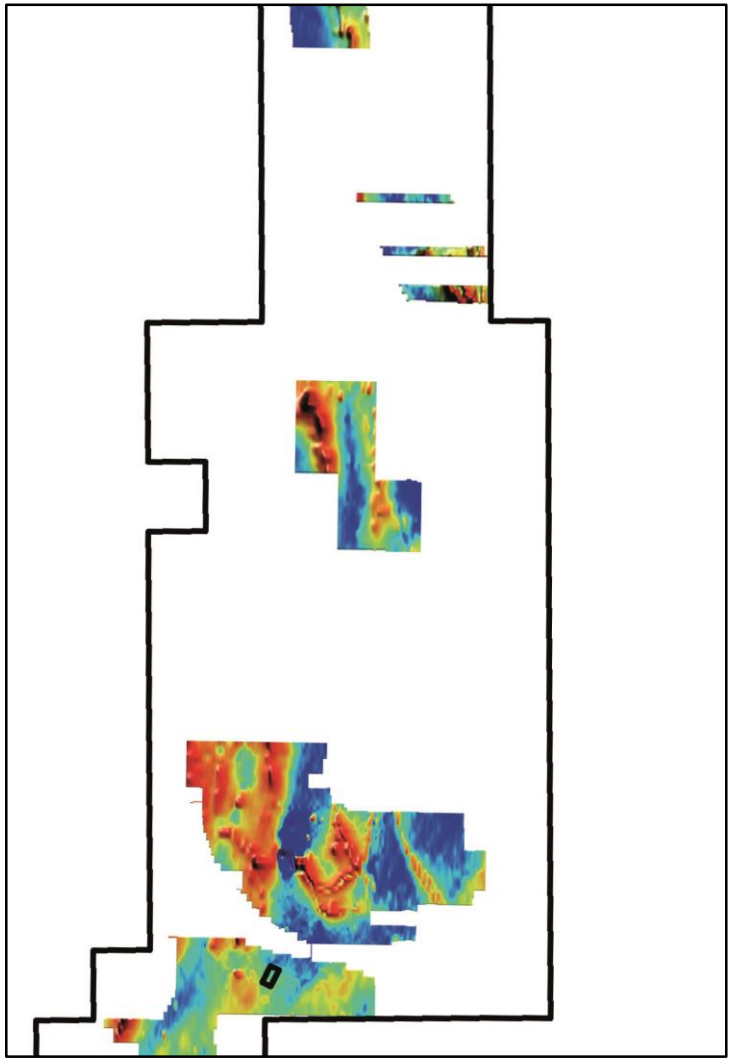
Deep cover hides the rocks of interest. It therefore masks the "signals" we get from the deep rocks, and reduces our confidence in the story of the rocks at depth.

Year 2 | Road side Survey | 320 sq km

We have acquired helicopter electro-magnetics over that portion of the magnetics that looks interesting (approx 95 sq. kms).

All landowners personally contacted, and program modified as required.





As a result, blue, green and yellow areas could be ignored

Year 2 | Heli-borne Survey | 95 sq km

Hillgrove collected samples of the soil and rocks from 50 sq. kms over 97 properties (Compared to the initial 2,900 properties!).

The original 490 sq. kms is now reduced to an area of interest around 10% of the original, and is the first entry to land.

All landowners were personally contacted prior to entry, both by phone and personal meetings, for their approval and establishing site entry conditions.

After the work was completed, we had a completion meeting with all landowners for feedback.

Hillgrove measured the ground magnetics over 25 sq. kms.

A *walking*, non-disturbance activity.

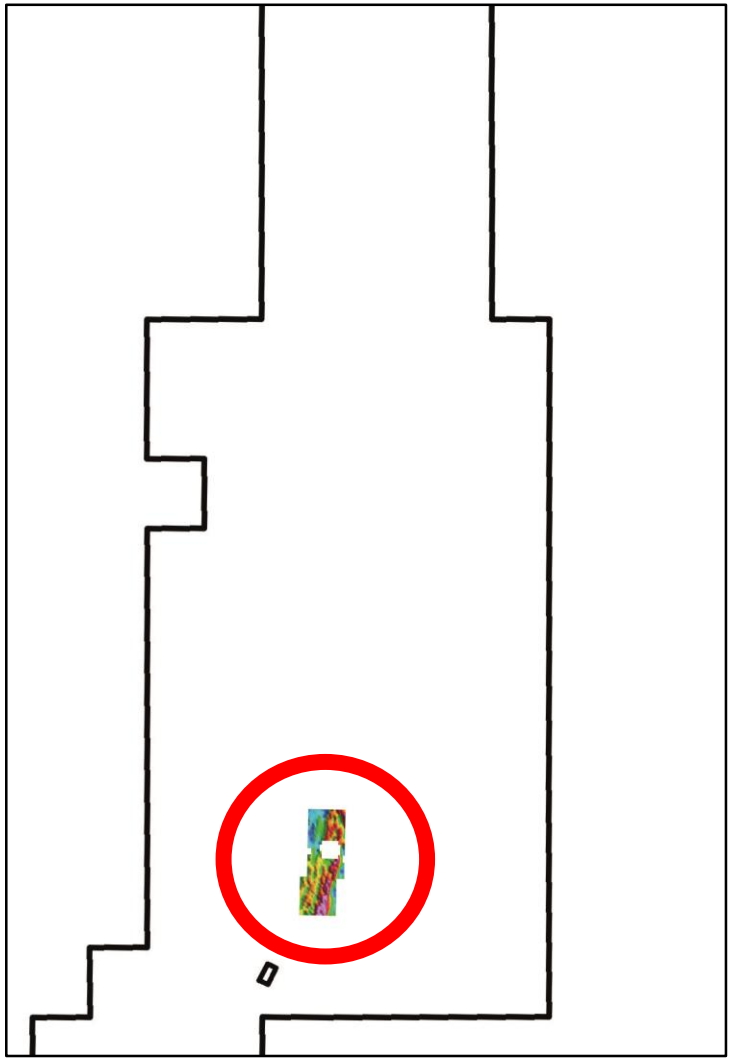
All landowners were personally contacted again prior to entry, both by phone and personal meetings for approval and establishing any specific conditions.

In future, drones will remove walking over cropping/grazing land.

We measured the electrical conductivity of the ground over 10 sq. kms.

All landowners were personally contacted prior to entry and approval given for our entry.

After the work was completed, we had a completion meeting with all landowners for feedback and continuous improvement.



As a result of all the previous work, 10 sq kms becomes the focus

Finally, after looking at 490 sq. kms in various ways, by flying, walking, sampling – Hillgrove decides on the locations to test drill the rocks.

Drilling activities in a number of areas total 0.5 sq. kms (50 ha) of disturbed land (0.1% of original land explored).

Again, all landowners gave permission prior to drilling.

Year 4 | Drilling | 0.5 sq km

We modified timing for drilling and location of drill holes to suit the landowner.

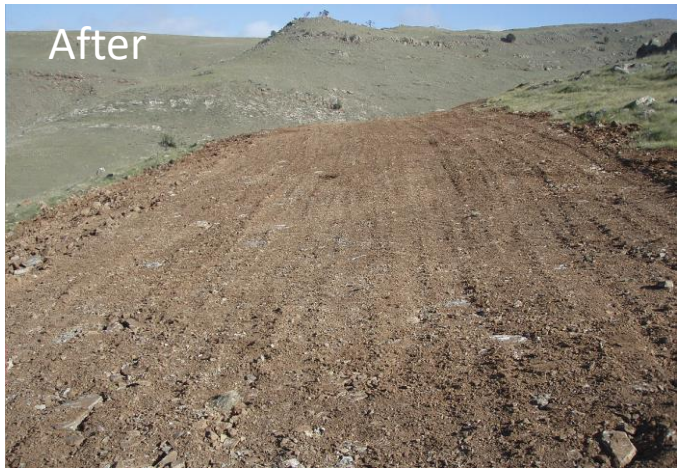
We contacted the landowners along the unpaved roads required for drill access, implemented alternative routes – where appropriate, watered the roads and travelled at certain times.

Revegetation plans are included in our negotiations

Year 4 | Drilling | 0.5 sq km

No loss of land-use as a result of drilling, and …

we have worked with the landholder to leave no evidence of the drilling other than as agreed.



IF, as a result of the Exploration Drilling no economic minerals are found,

Then we leave.

The Exploration Licence is surrendered back to the Government.

IF, as a result of the Exploration Drilling a mineral deposit is located.

A large number of drillholes in a small area over 4 years are completed.

This disturbed 2 sq. km (*200 ha)* of land.

Year 5 — 8

Drilling - Deposit

2 sq km

At Hillgrove, as a result of the drilling, a mining operation was assessed as being economically viable and in the best interest of the State.

The Mining Operation covers
4 sq kms (*440 ha)*

<1% of the original area of the Exploration Licence.

At all times communication with landholders was considered to be:

- *Critical*
- *A company priority*
- *Undertaken at the earliest stage of planning*

Communication included:

- *Listening*
- *Responding*
- *Providing feedback*

Community consultation keeps locals informed

That *440 ha* has paid:

~$200 million

to local employees and contractors within 1 hour drive of the mine site.

The *440 ha* has also paid:
Royalties, Taxes, and Rates to State and Local governments for local services.

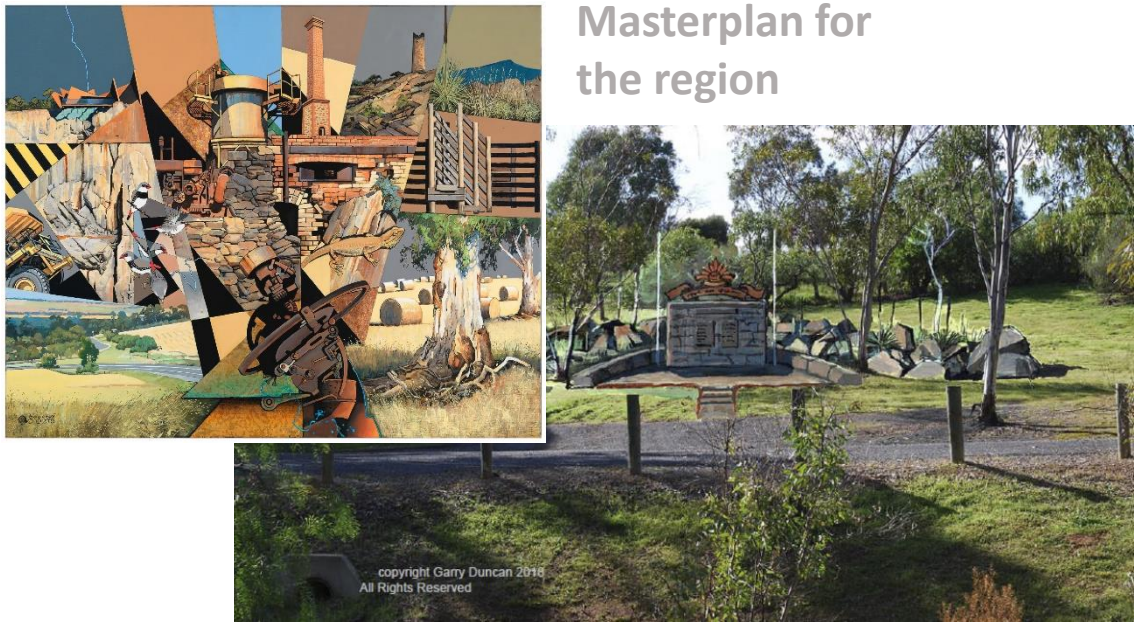
Hillgrove Mining operation covers *440 ha.*

This brings Mining Wages into a hub:

- *of local communities*
- *supporting – schools, shops, sports, volunteer services including CFS, St Johns Ambulance*

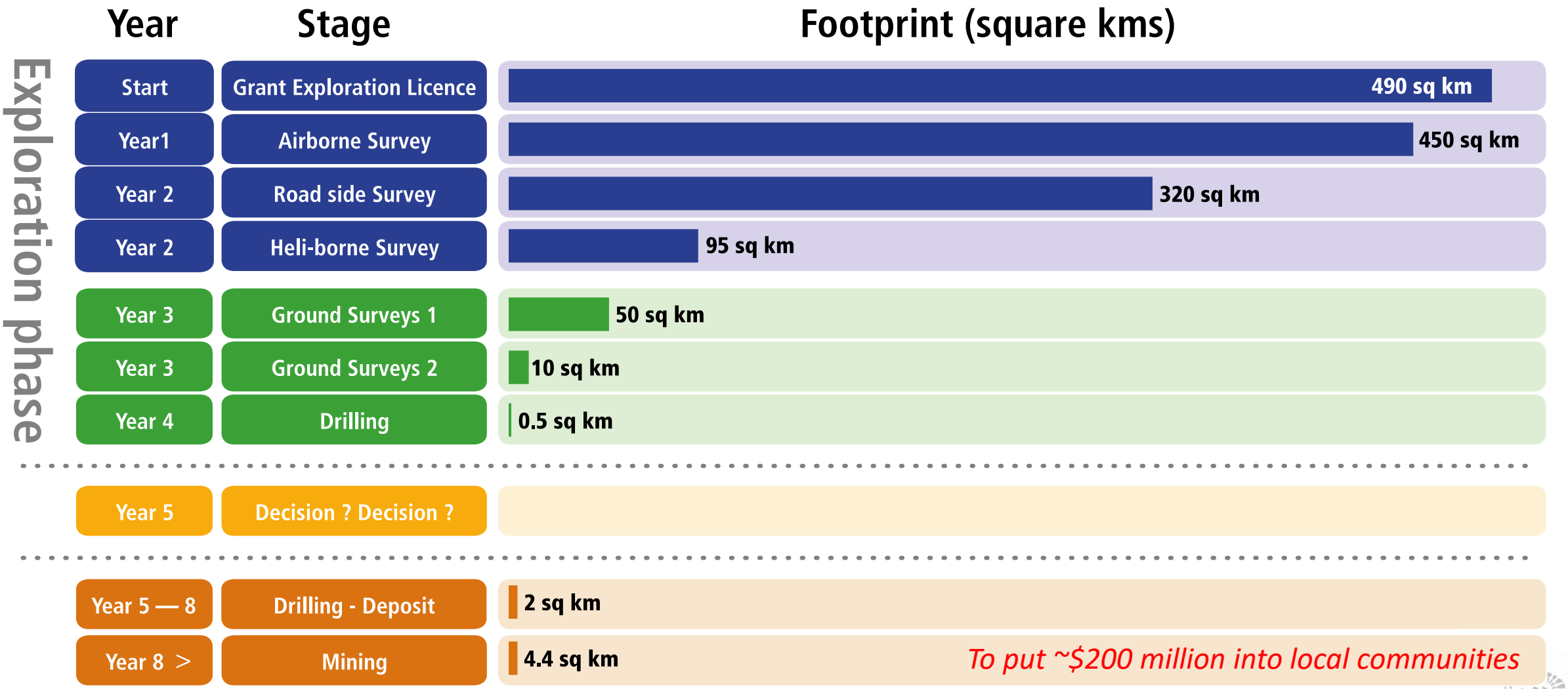
This small mining footprint can provide the HUB around which communities and community services can be supported.

HILLGROVE RESOURCES



Masterplan for the region

Positive long-term benefit to community hosting the mine



Please note, while Hillgrove has undertaken all these steps, they have not always followed this sequence.

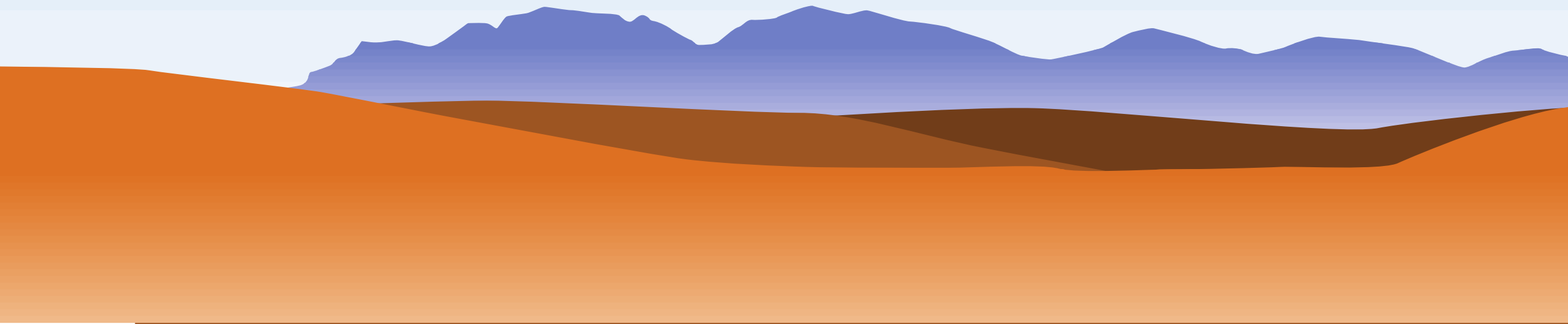
With land access …

we can generate *very significant benefits* for rural communities, and the State …

from a small footprint.

Thank you

HILLGROVE
RESOURCES



South Australian Chamber Of Mines & Energy

University of South Australia

Prof David Giles

Strand Leader and John Ralston Chair, University of South Australia

The Gambler's Game Breakfast

03 July 2019

University of South Australia | Future Industries Institute

Mineral Exploration: The Scourge of Cover

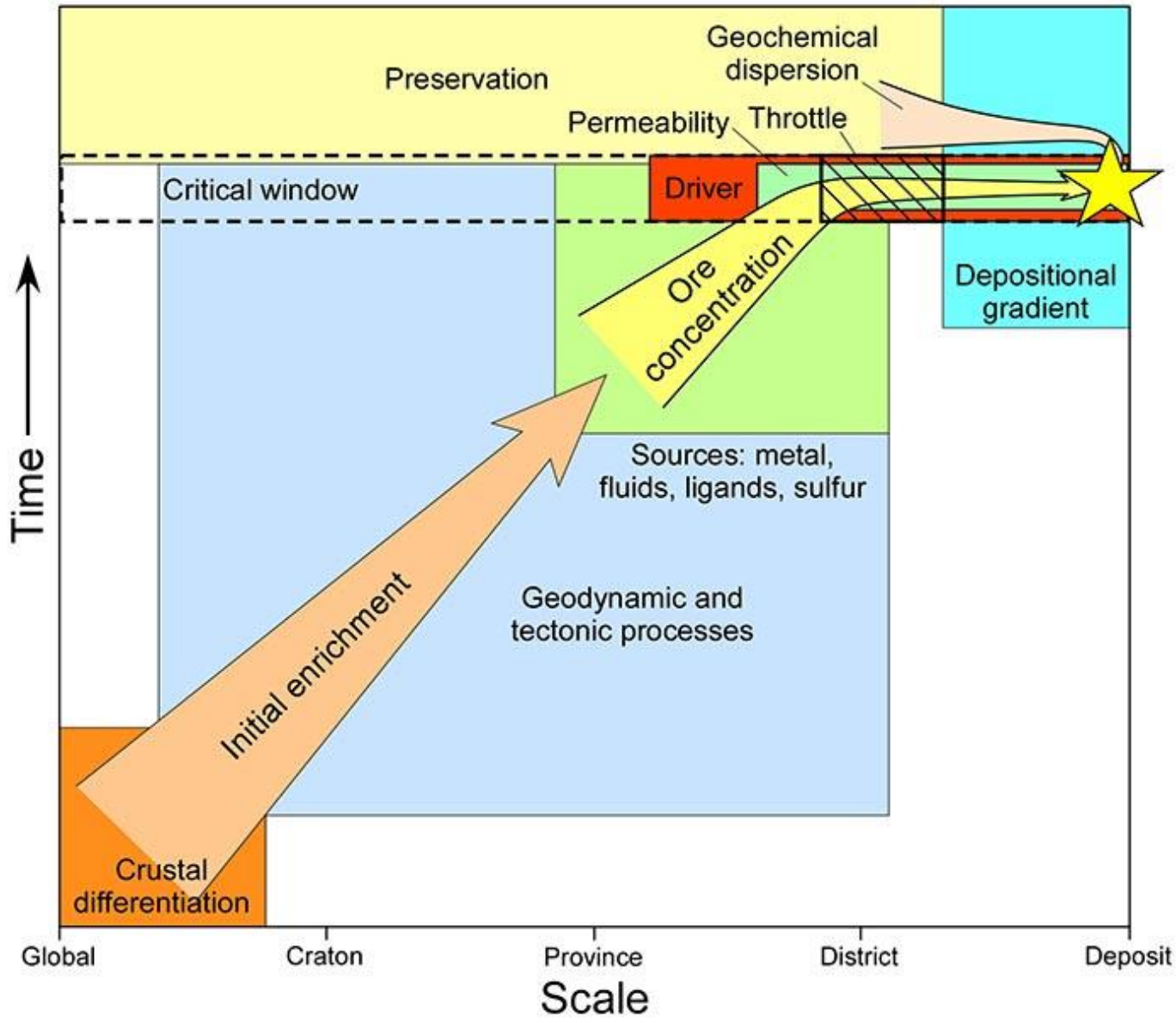
and how to get ~~over~~ under it

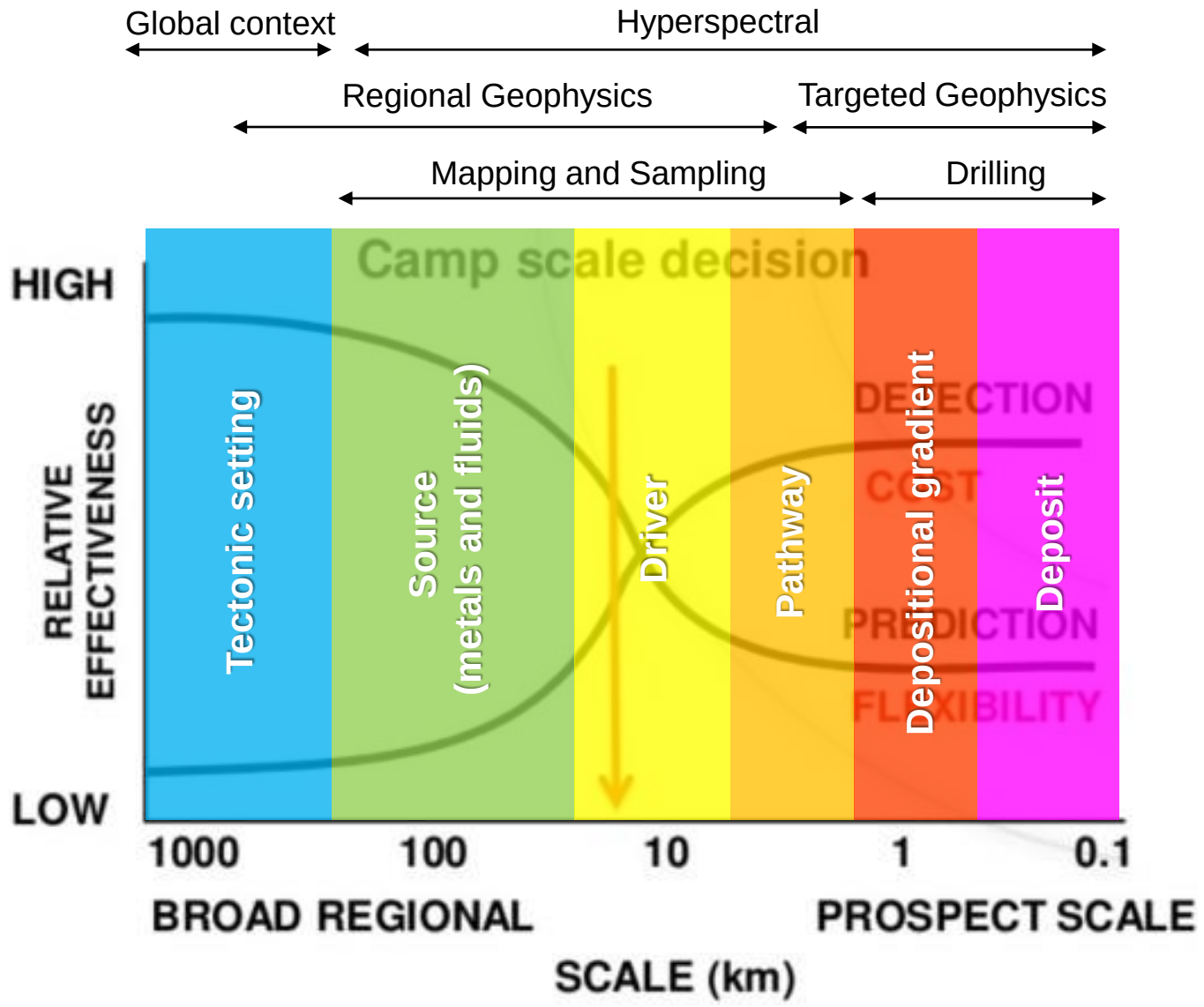
Prof. David Giles
Strand Leader and John Ralston Chair
in Minerals and Resources Engineering
Future Industries Institute | University of South Australia

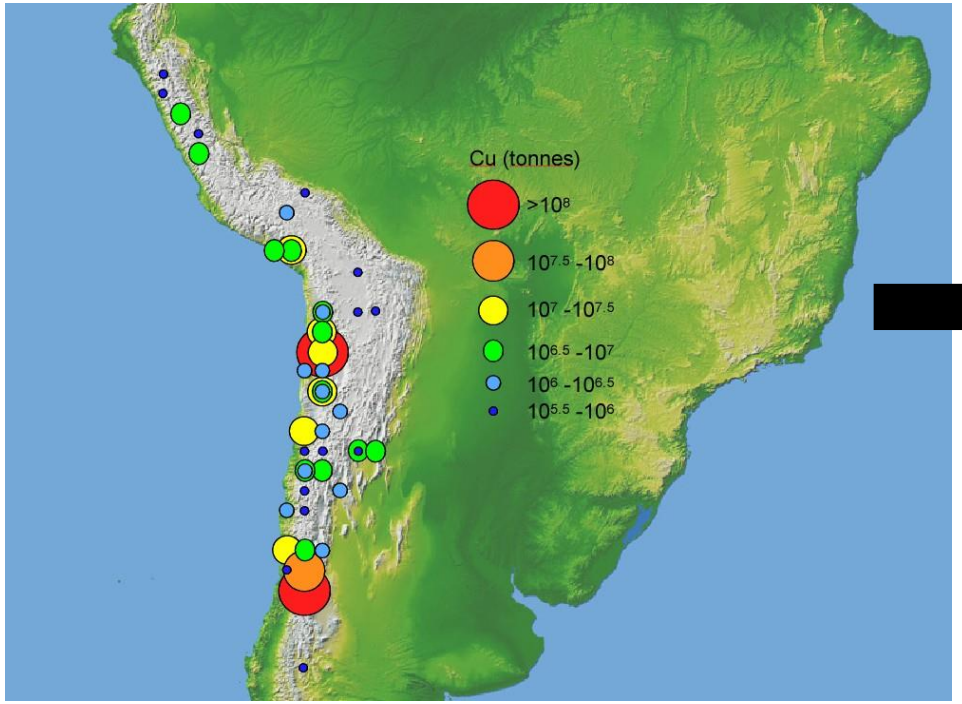
SACOME Breakfast, Wednesday 03 July 2019

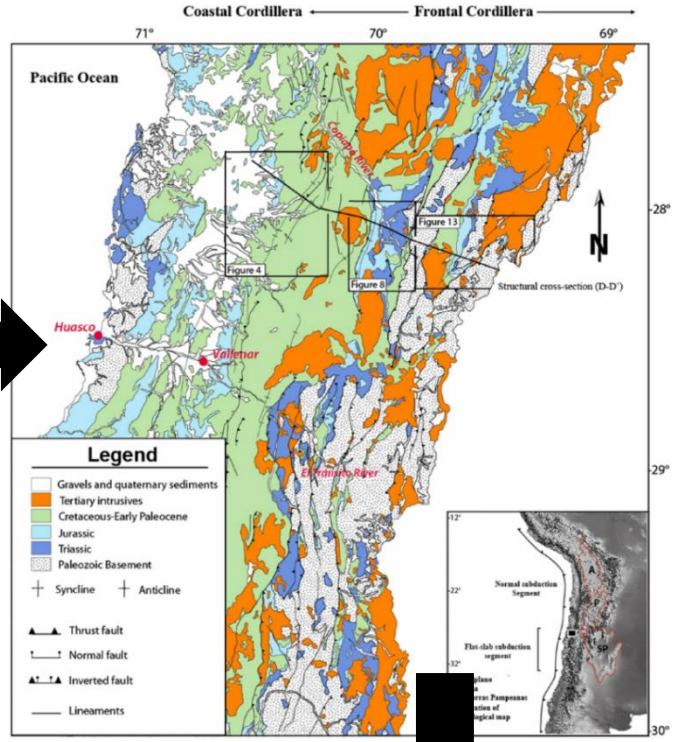
Structure of this talk

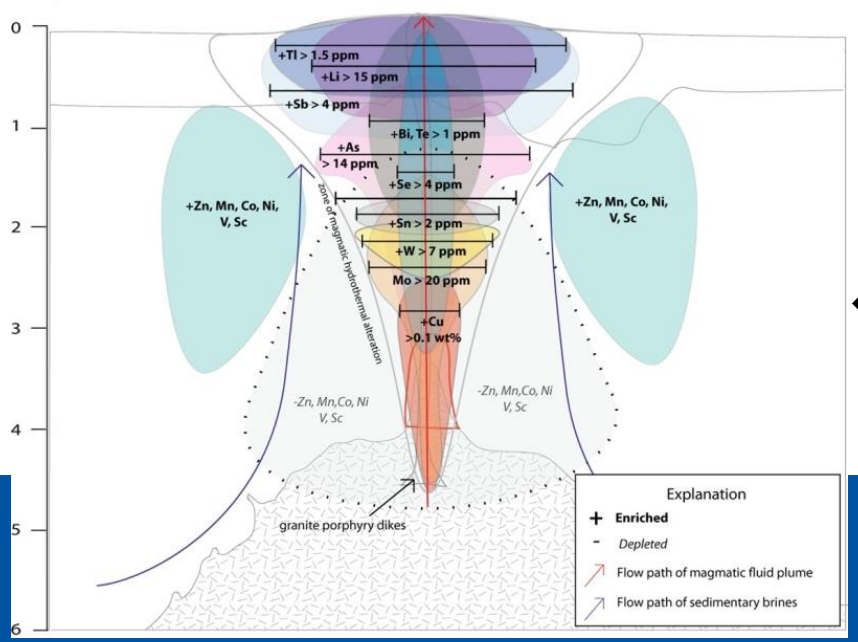
- Ore deposits and Mineral Systems
- What do we mean by “cover”
- Why is cover a problem
- How do we get under it?
  - Mineral exploration as a forensic science
  - Concept of scale reduction
  - Tools appropriate for the task


Preservation
Geochemical dispersion
Permeability
Throttle
Critical window
Driver
Depositional gradient
Ore concentration
Sources: metal, fluids, ligands, sulfur
Geodynamic and tectonic processes
Initial enrichment
Crustal differentiation
Time
Global
Craton
Province
District
Deposit
Scale


Global context
Hyperspectral
Regional Geophysics
Targeted Geophysics
Mapping and Sampling
Drilling
Camp scale decision
HIGH
LOW
RELATIVE EFFECTIVENESS
Tectonic setting
Source (metals and fluids)
Driver
Pathway
Depositional gradient
Deposit
DETECTION
COST
PREDICTION
FLEXIBILITY
1000
100
10
1
0.1
BROAD REGIONAL
PROSPECT SCALE
SCALE (km)







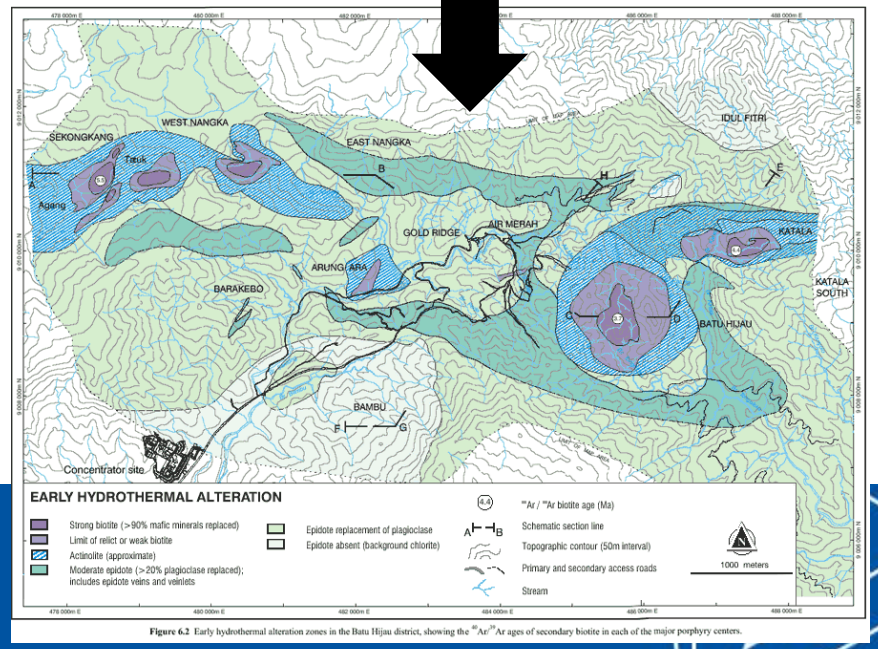


Figure 6.2 Early hydrothermal alteration zones in the Batu Hijau district, showing the $^{40}Ar/^{39}Ar$ ages of secondary biotite in each of the major porphyry centers.

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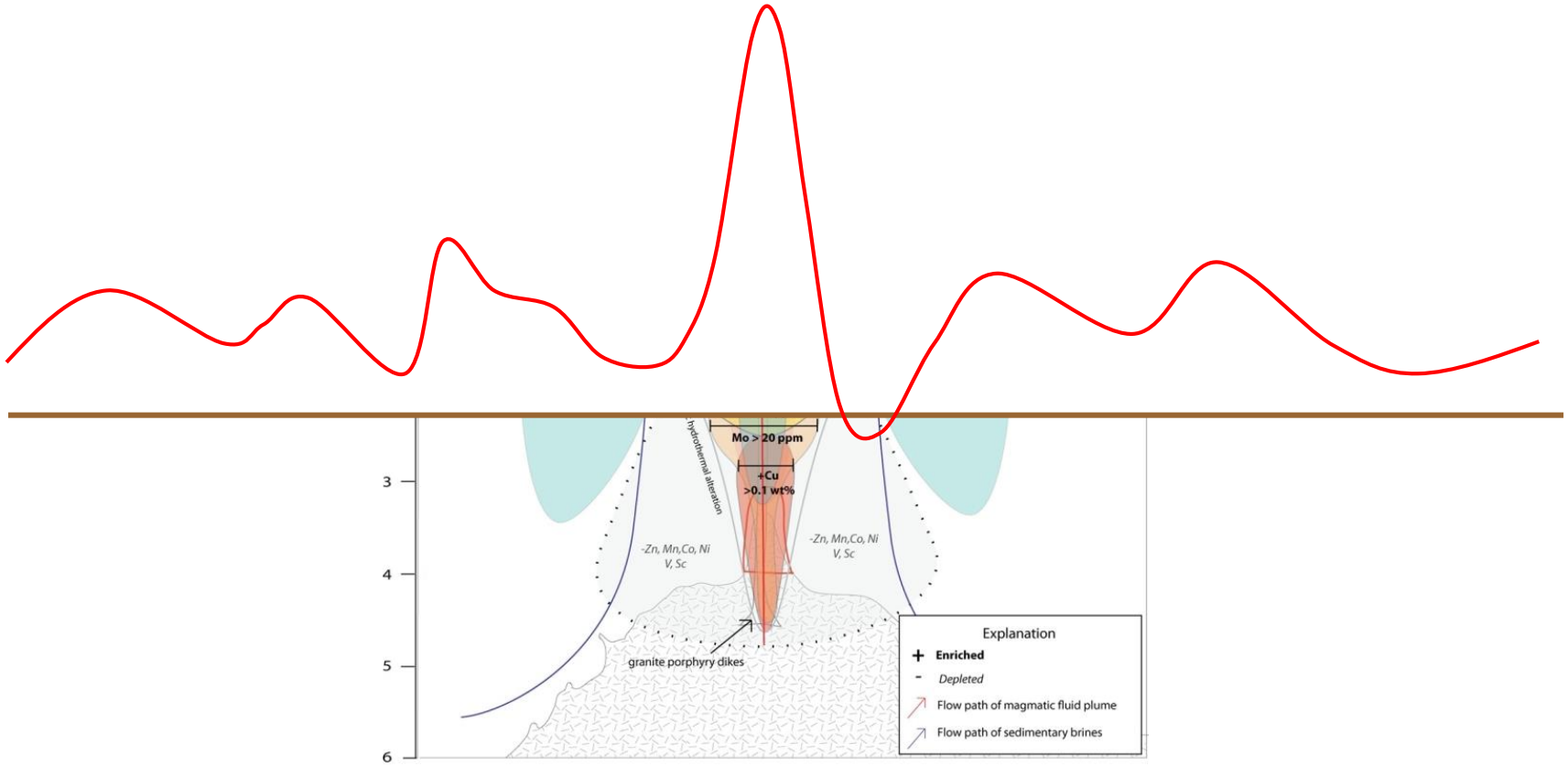
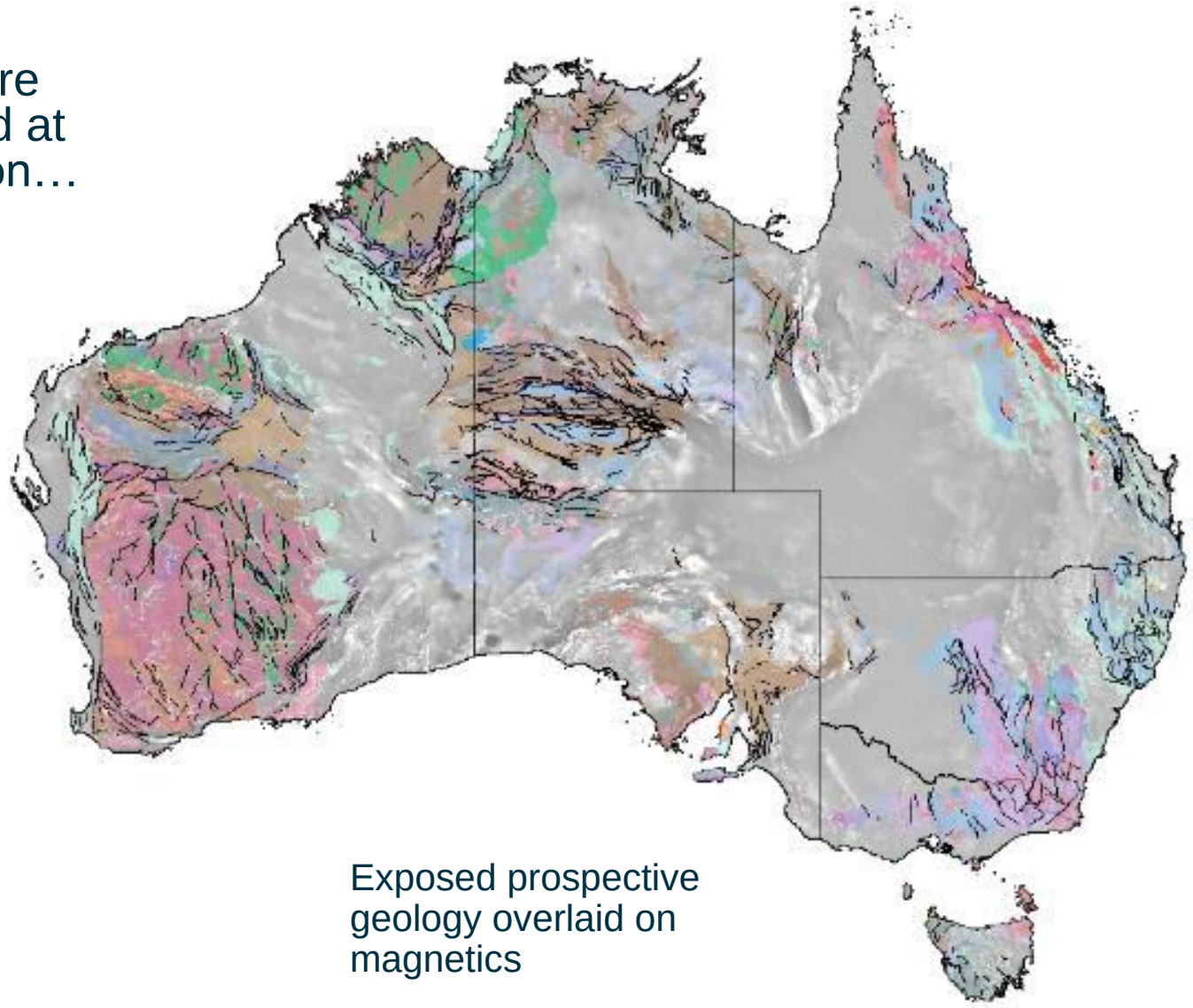
Exposed deposits



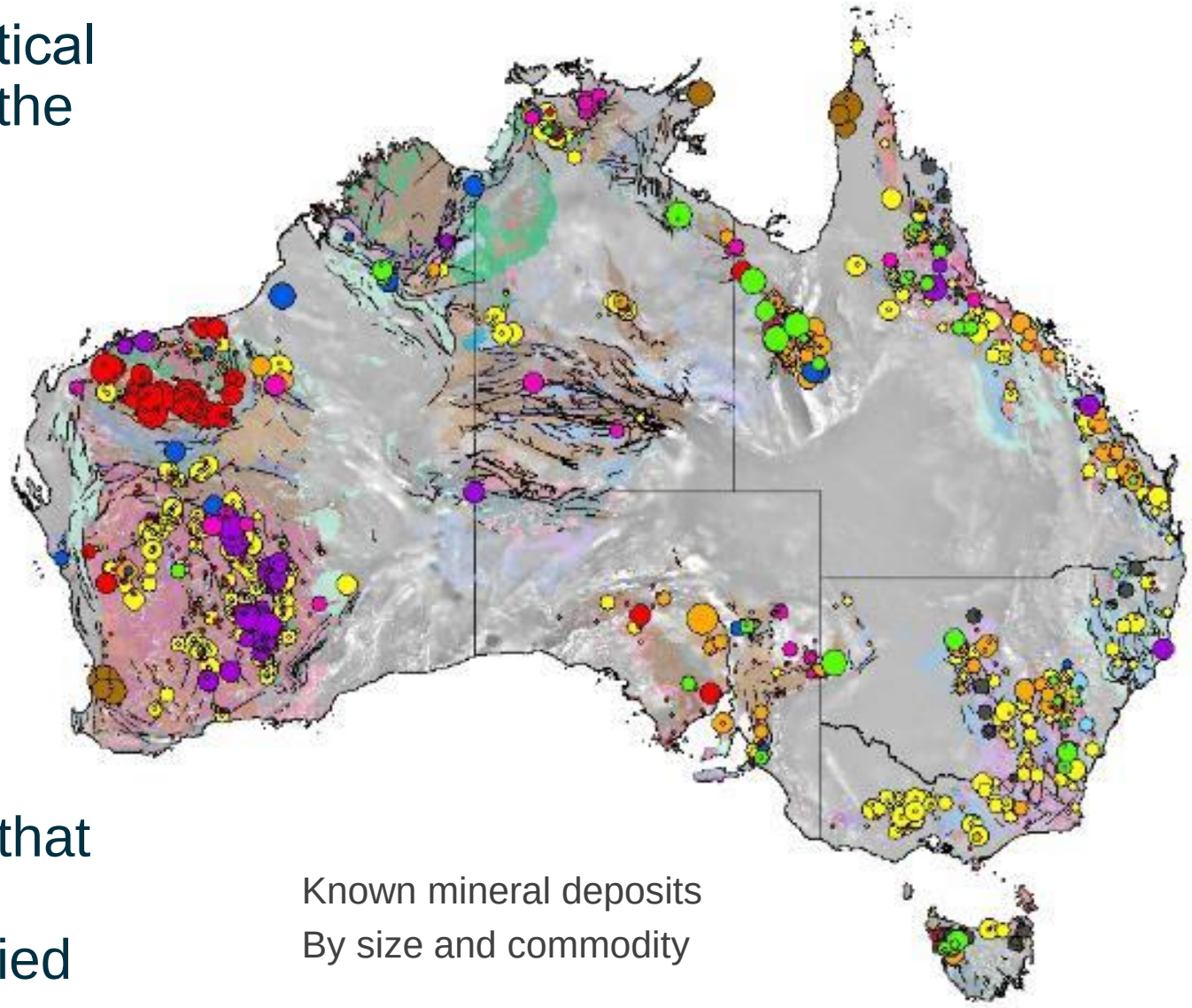
Surface observations + sampling + clear geophysical signal

Although it is challenging, we are actually very good at mineral exploration…



Exposed prospective geology overlaid on magnetics

…when the critical evidence is at the surface.



Known mineral deposits
By size and commodity

But we are not that good when the evidence is buried

The DISCOVERY challenge…

The covered minerals search space across 80% of South Australia!

Moon Plain, Stuart Shelf, SA (Photo S.Hill)

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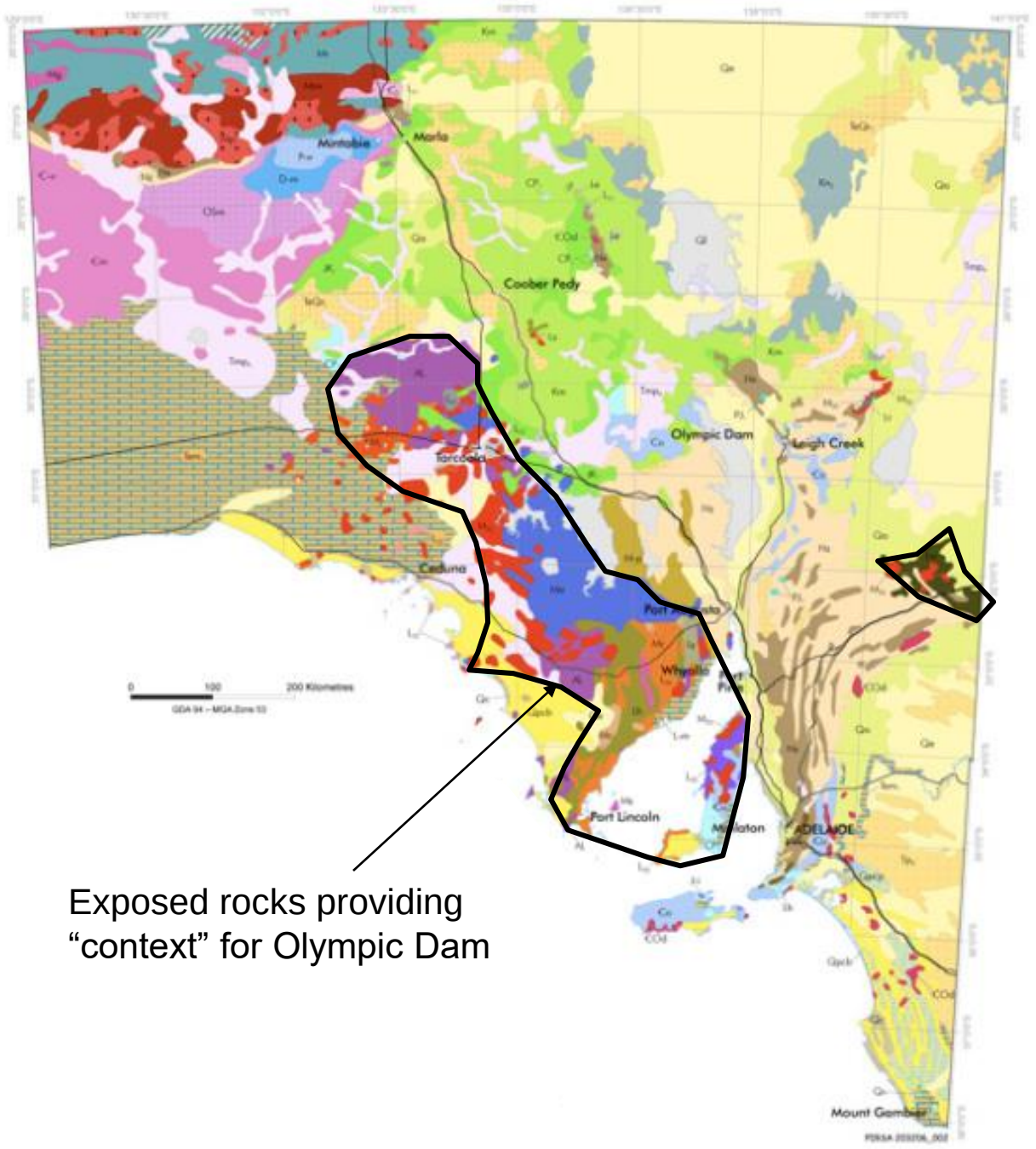

Exposed rocks providing "context" for Olympic Dam

Scale of the cover problem in South Australia

Geological Context can only come from Regional Geophysics + Drilling

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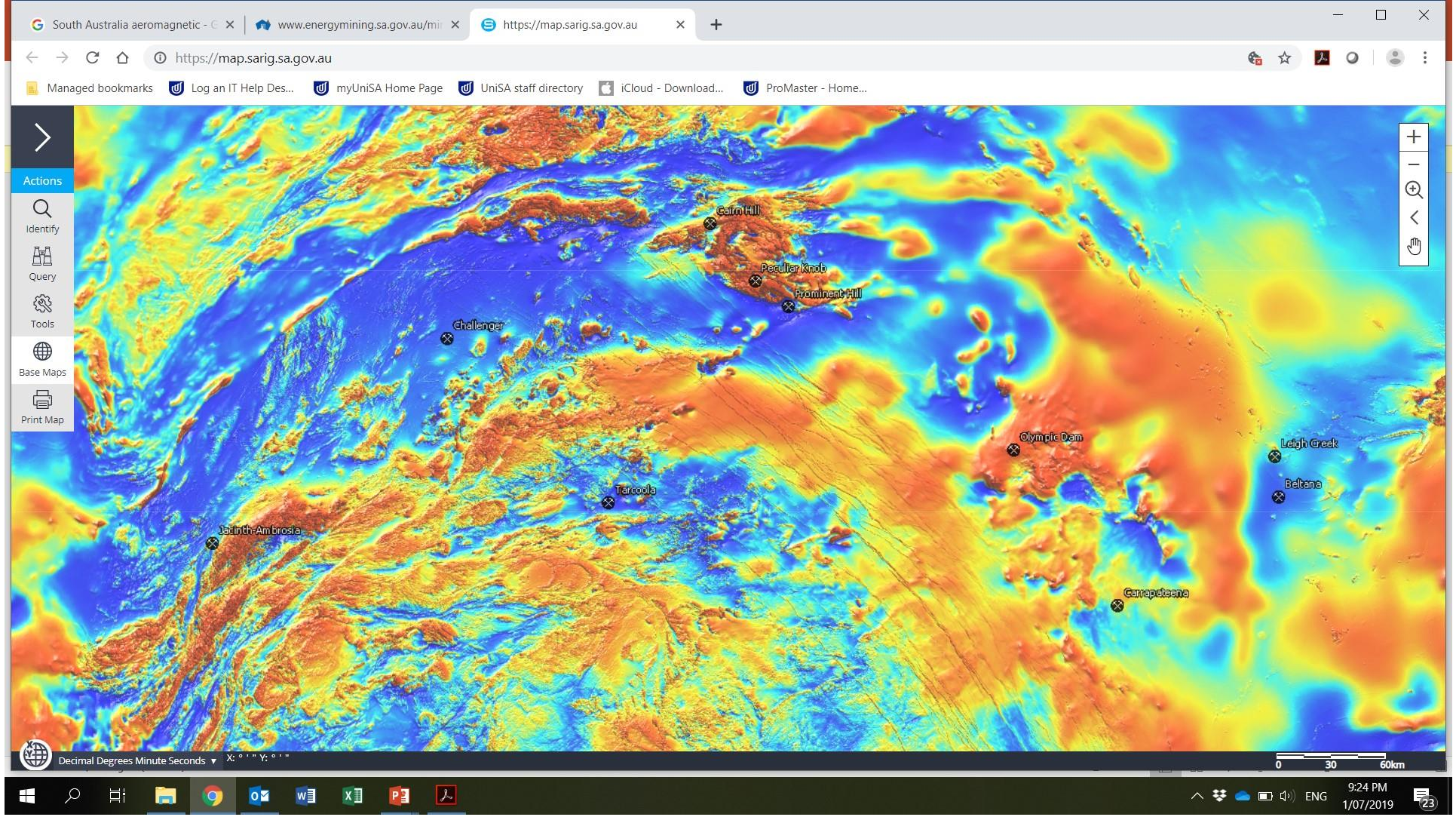
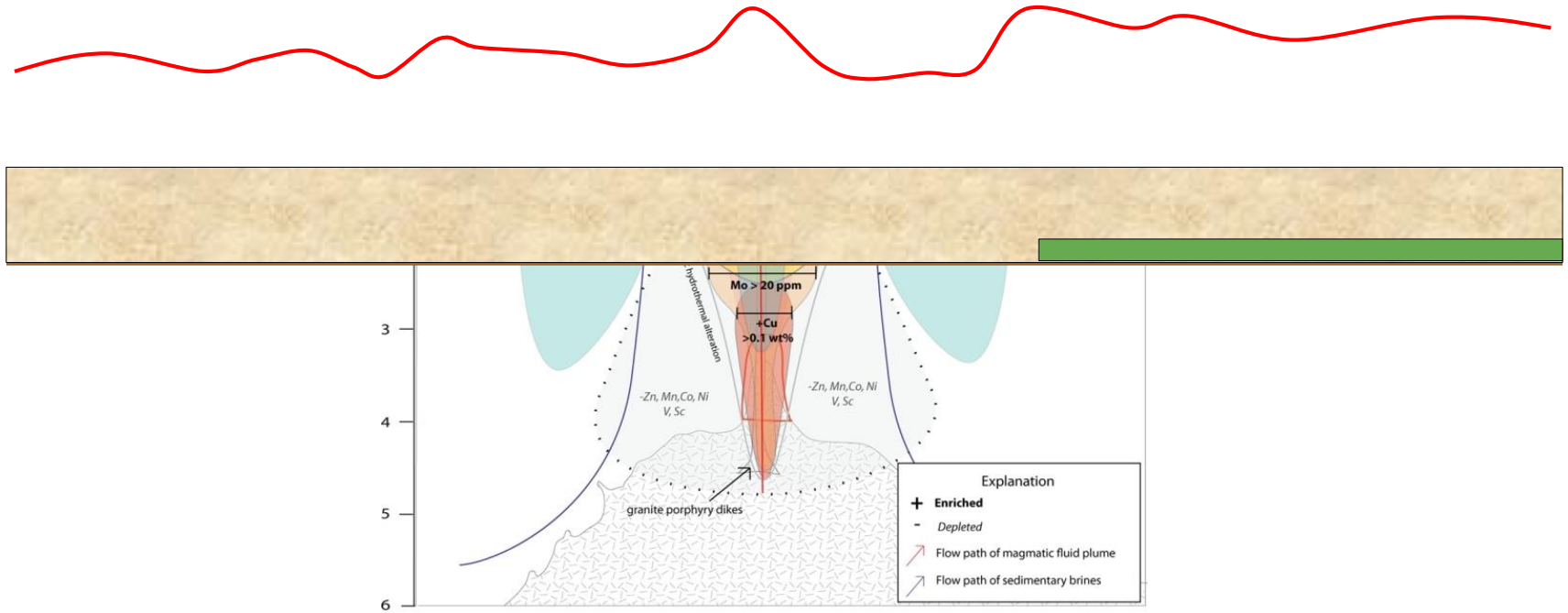


Regional geophysics is key to province-scale

Covered deposits



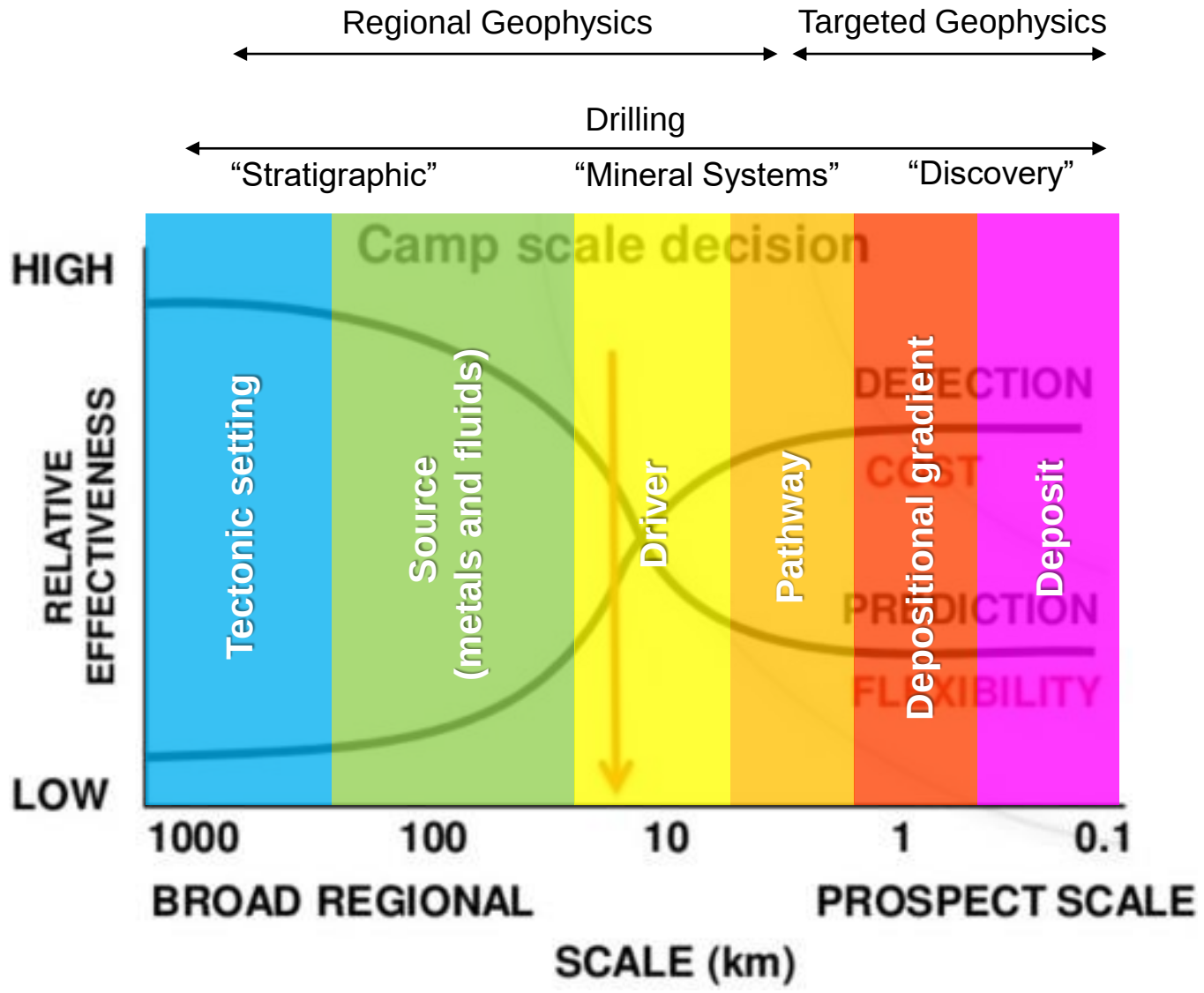
No observations or sampling without drilling, blurred geophysical signal

Princess and the Pea?

World beating, supersensitive, depth penetrating geophysical technique

Cover

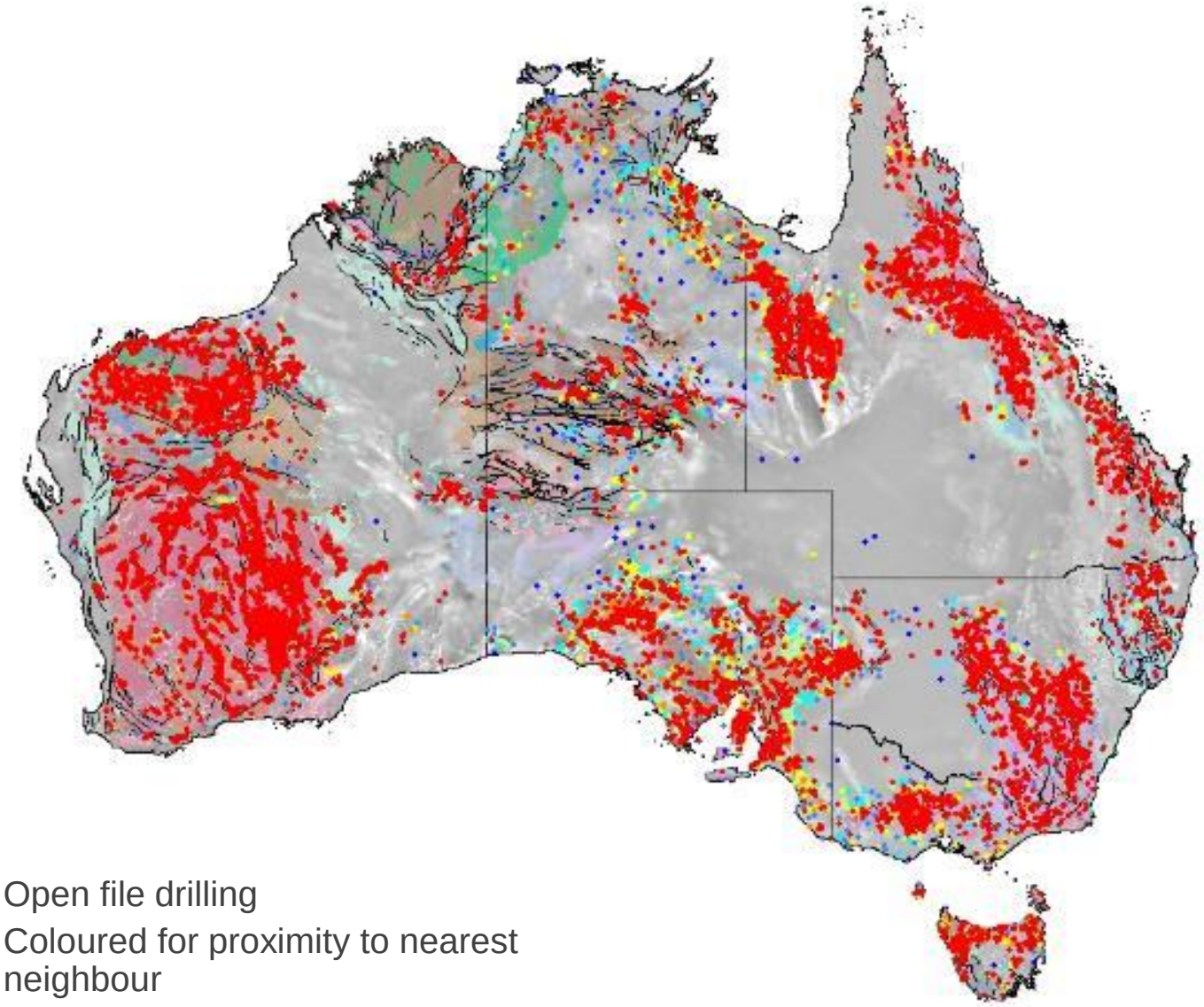
Mineral deposit



Under Cover the only way to sample is to Drill !

Where we drill we discover !

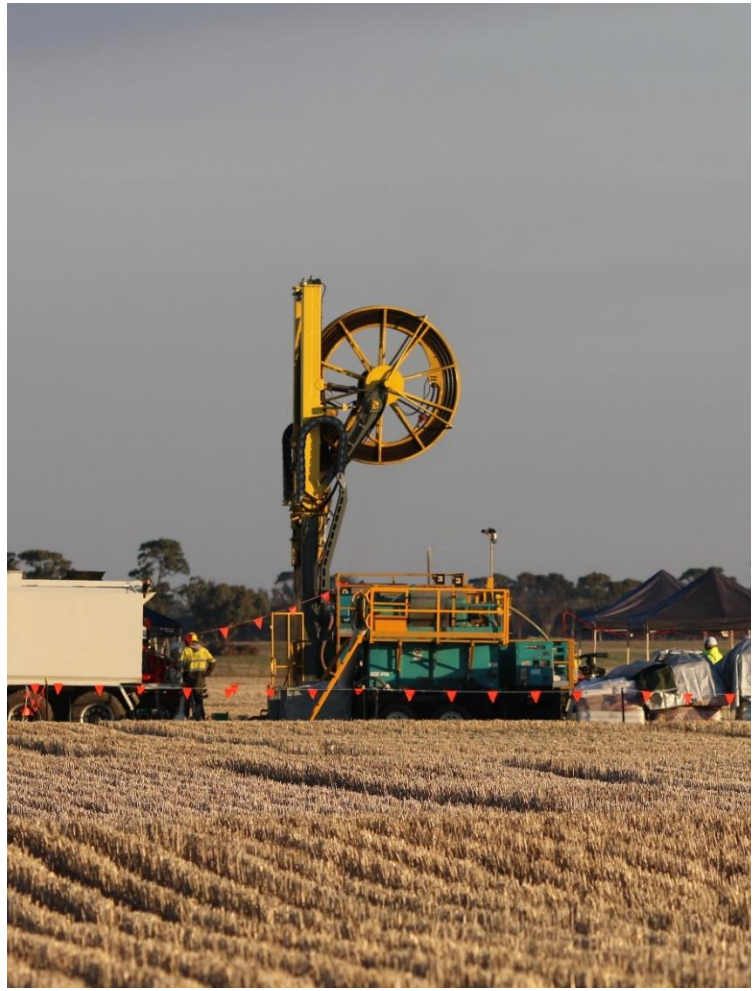
But drilling is expensive and (without other context) drilling is risky



Open file drilling

Coloured for proximity to nearest neighbour

DEEP EXPLORATION TECHNOLOGIES CRC
Uncovering the future

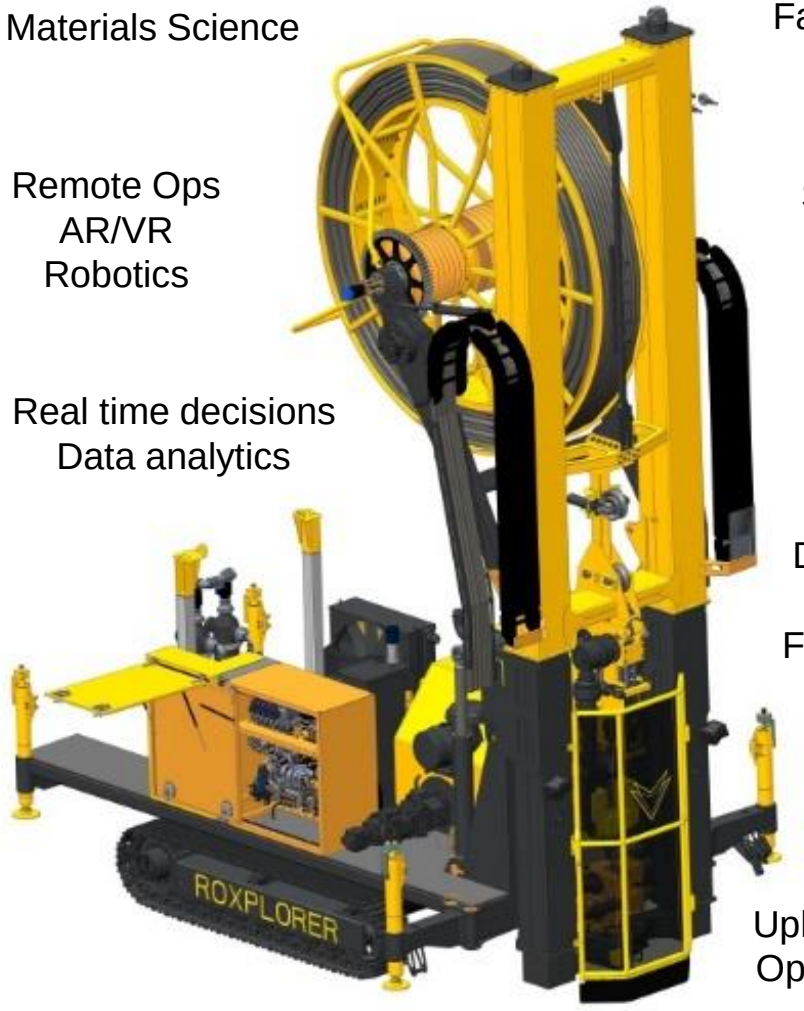


Drill Coil
Materials Science

RoXplorer®
Faster, cheaper, safer drilling.
Low energy
Low water
Small footprint

Remote Ops
AR/VR
Robotics

Real time decisions
Data analytics



Drill fluids and Sampling
Fluid Dynamics

Uphole Comms
Optic fibre tech

New Drilling Paradigm
Social Science and Law

Downhole sensors
Laser physics

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More efficient drilling is required

MinEx CRC

https://minexcrc.com.au/

10 year program

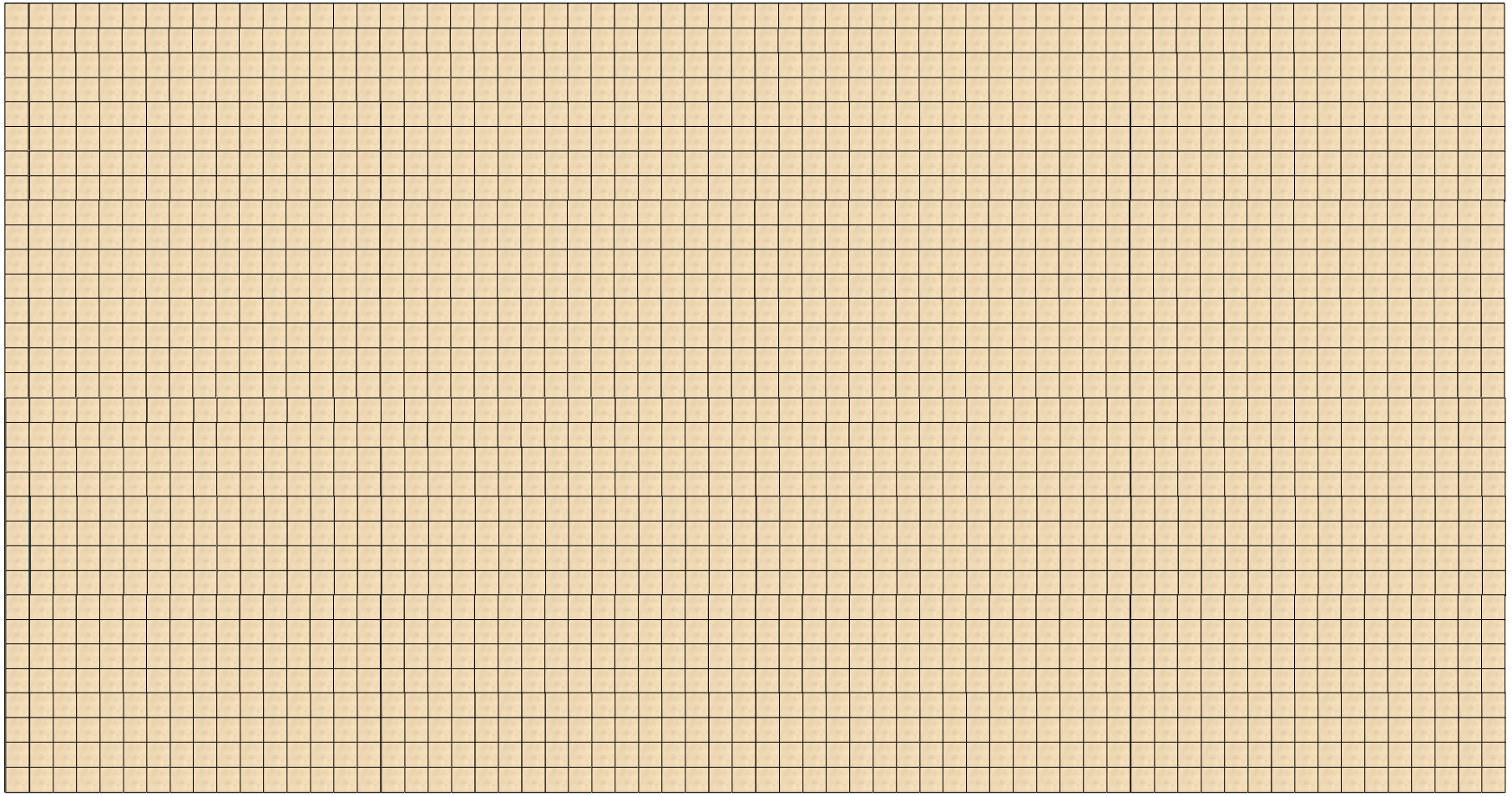
$218M cash / in-kind

60 PhD and MSc

HQ @ UniSA and WA

david.giles@unisa.edu.au

Chief Scientific Officer MinEx CRC



South Australian Chamber Of Mines & Energy

Question & Answer Session

Richard Schodde
Managing Director,
MinEx Consulting

Peter Rolley
Chief Geologist,
Hillgrove Resources

Prof David Giles
Strand Leader and John Ralston
Chair, University of South Australia

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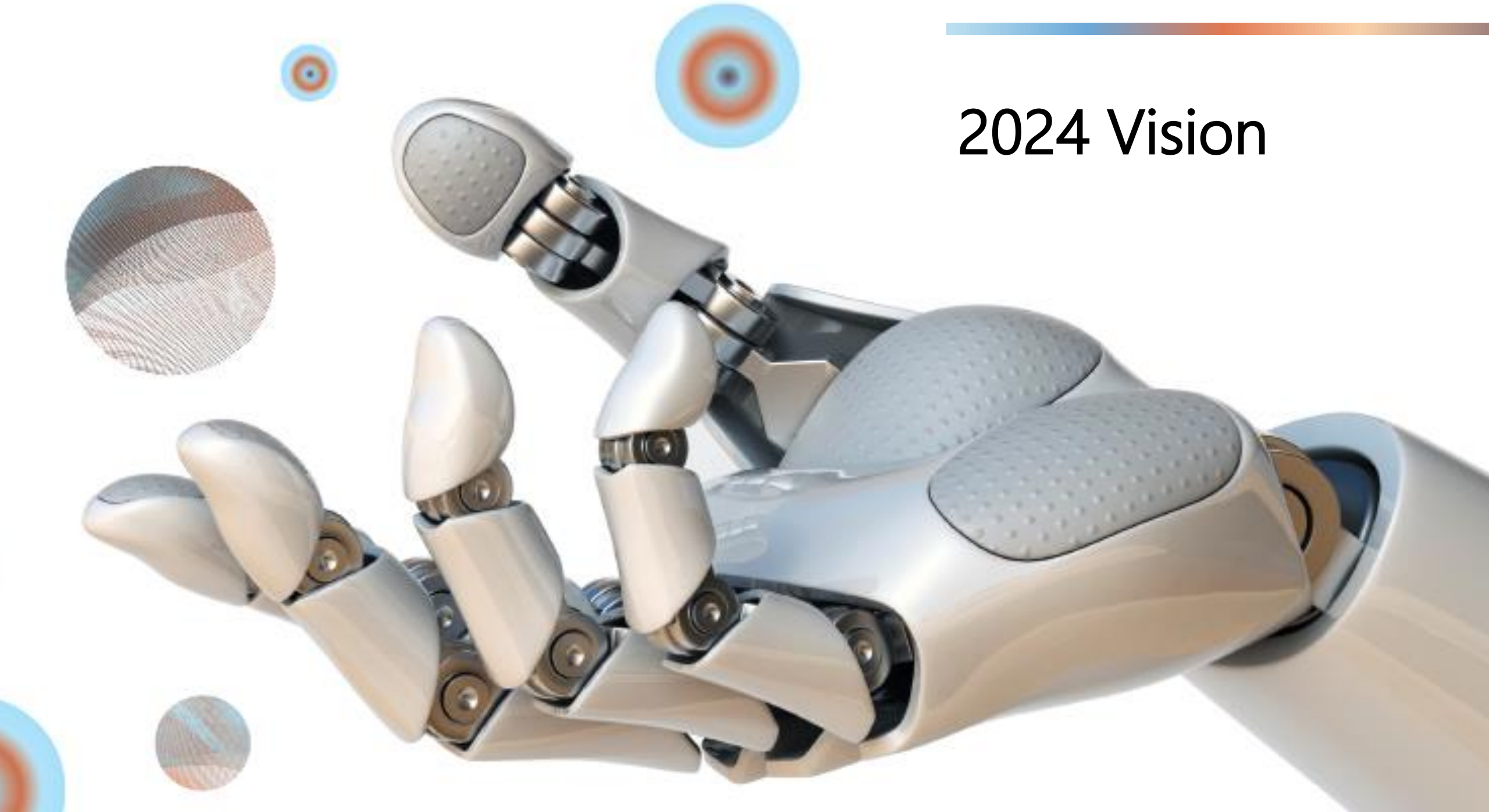

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The Gambler's Game
Breakfast

03 July 2019

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