Stepping off the edge:
MinEx CRC data acquisition in NSW

Discoveries in the Tasmanides
Wagga Wagga, 27 September 2019

Chris Yeats, Executive Director, Geological Survey of NSW

Contents

NSW GOVERNMENT

The mineral discovery challenge

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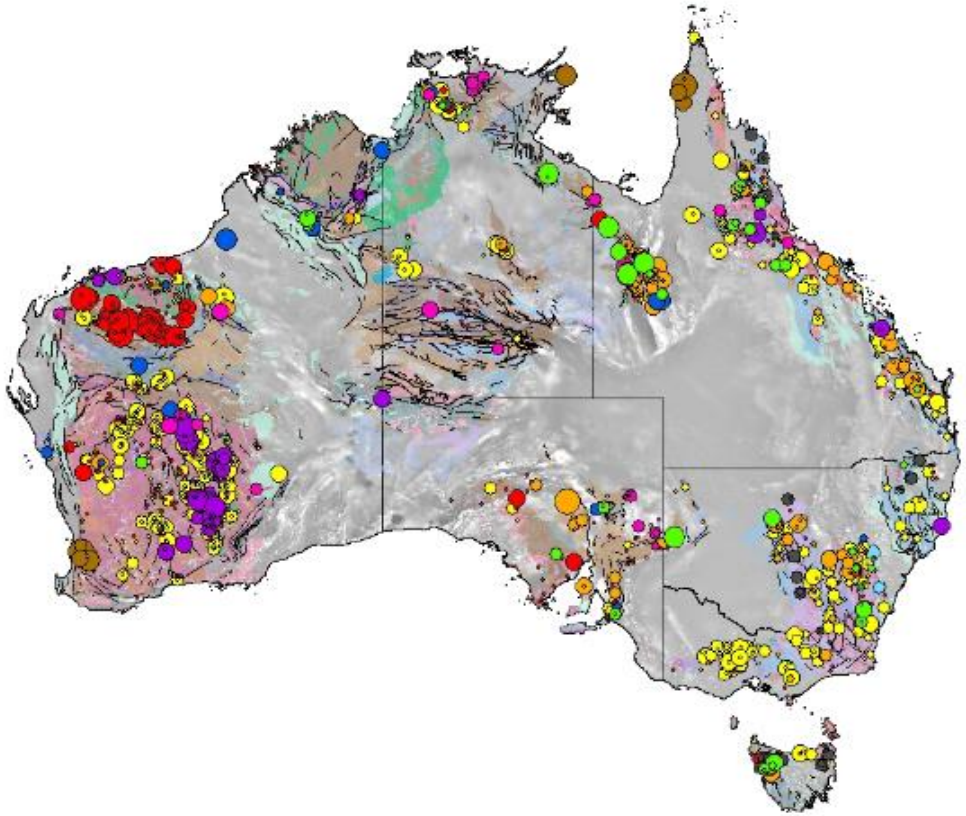
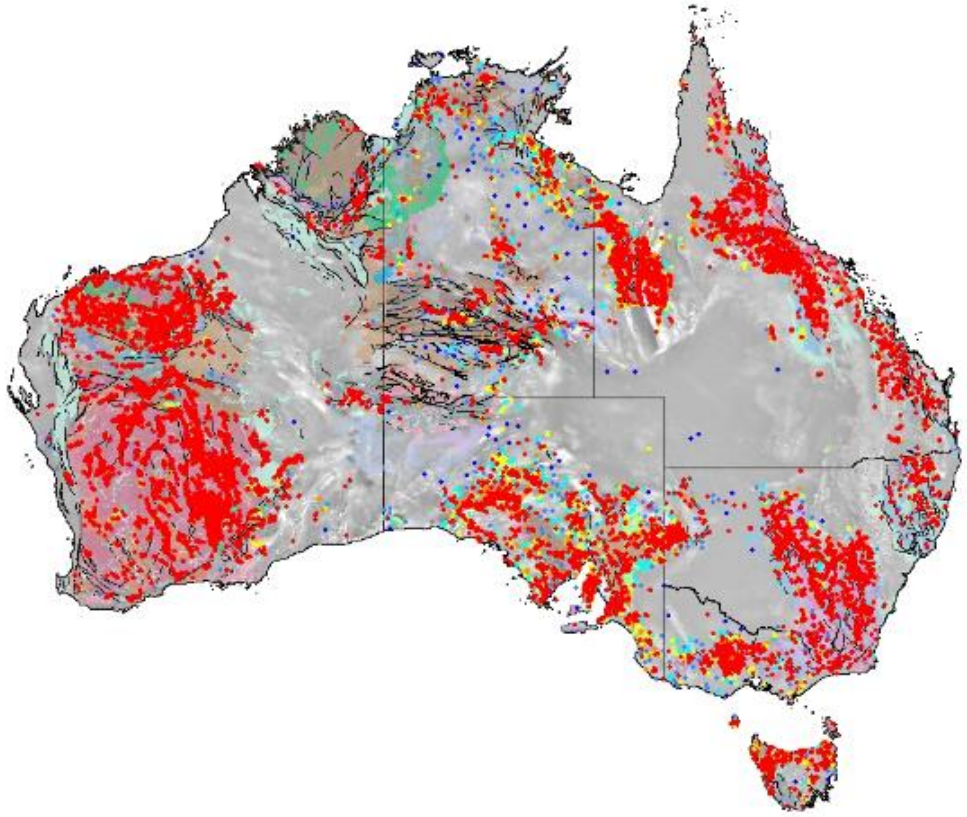
Australia’s metal deposits almost all occur in outcropping areas



Australia’s known mineral deposits



Publicly available drilling data

Courtesy, GA

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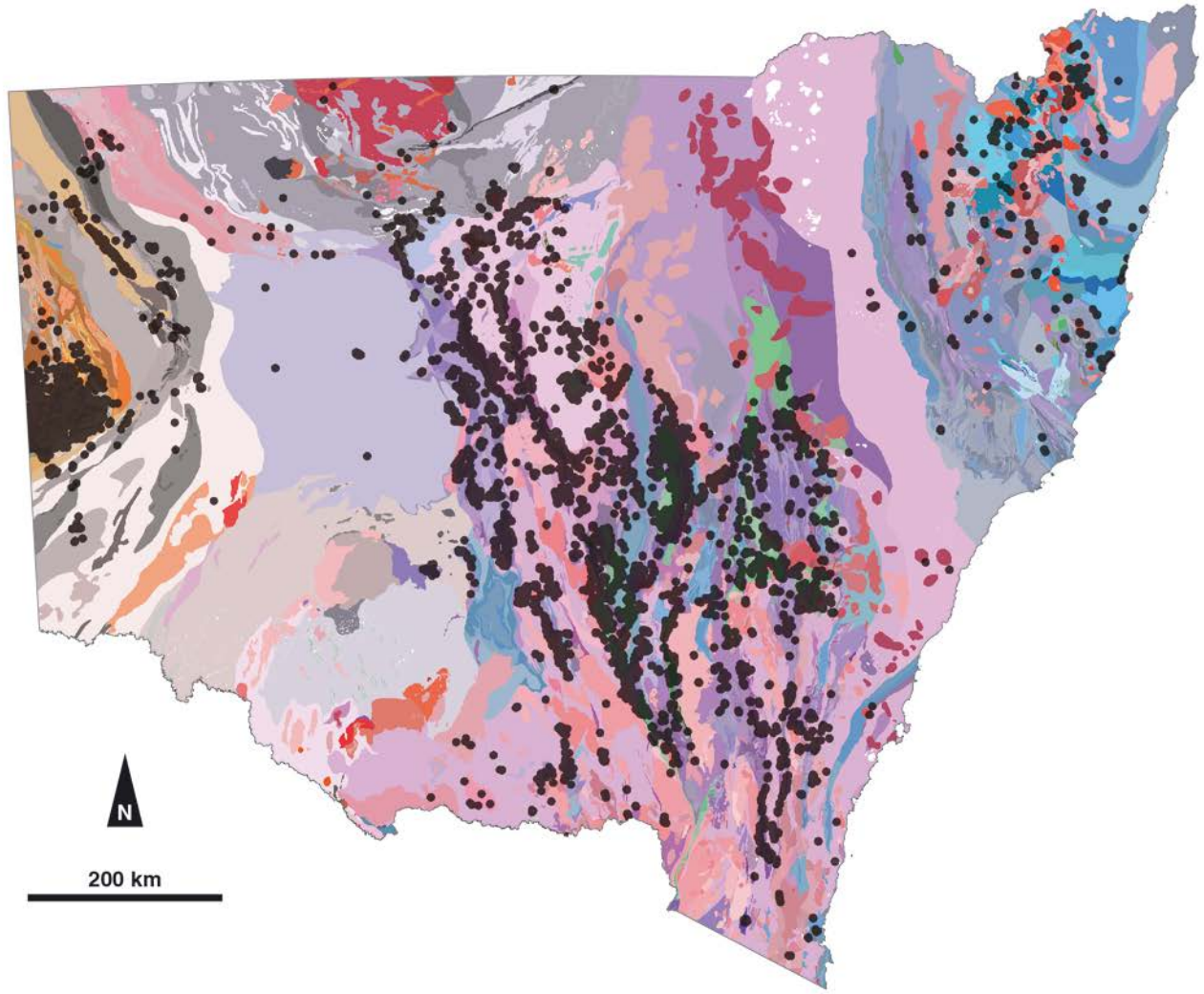
… because that’s where explorers have looked

The NSW discovery challenge

- NSW's known metal occurrences and deposits occur almost exclusively in areas where prospective basement is at or near-surface.
- Mineral exploration has also focussed almost exclusively on these areas.
- Explorers need new tools and new data to give them the confidence to explore in covered terranes.



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How can we ‘see’ the basement rocks under cover?

MinEx CRC

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MinEx CRC: 2018-2028

- **$218 million, 10 year investment in mineral exploration R&D**
  - $41 million cash contribution from “industry” partners
  - $127 million in-kind contribution from “industry” partners and research participants
  - $50 million cash contribution from Commonwealth Government Department of Industry, Innovation and Science CRC Program.
- 36 organisations involved, including:
  - major miners, juniors and METS providers
  - all Australian geological surveys (4 participants, 4 affiliates)
  - CSIRO, AuScope and 7 Australian universities.

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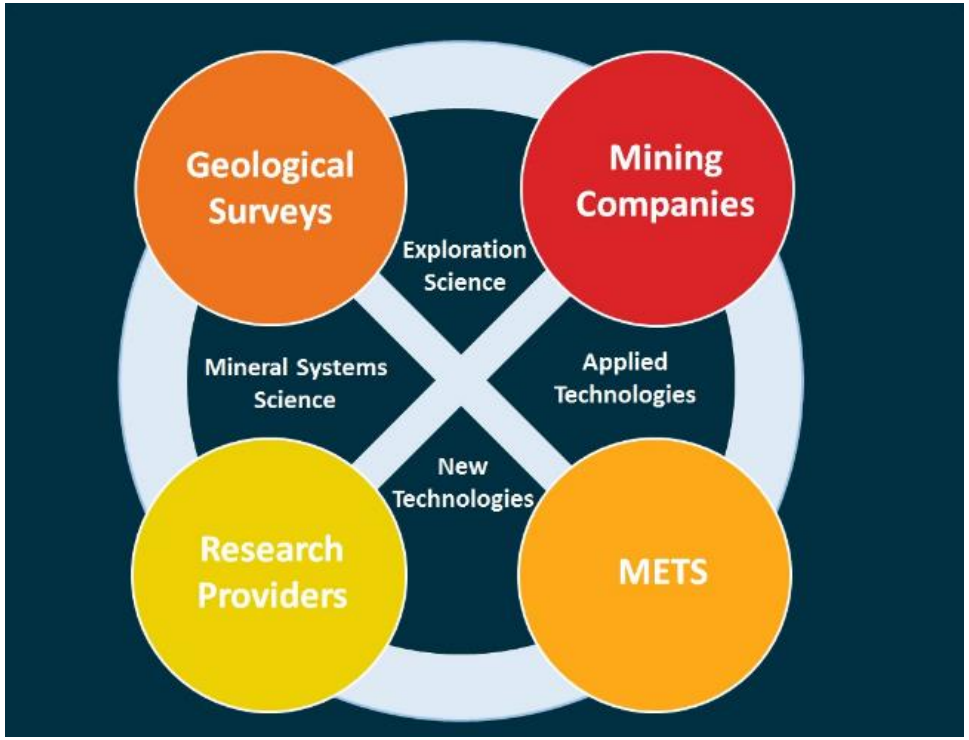
The world’s largest mineral exploration collaboration.

MinEx CRC 3D DRILLING

Three programs



- **Program 1 – Improved drilling efficiency**
  - Developing more productive, safer and environmentally-friendly drilling methods to discover and drill-out deposits, including coiled tubing drilling technology.
- **Program 2 – Real-time data collection and analysis**
  - Developing new technologies for collecting data while drilling, bringing forward mine production.
- **Program 3 – National Drilling Initiative (NDI)**
  - A world-first collaboration of Geological Surveys, researchers and industry that will undertake drilling in under-explored areas of potential mineral wealth in Australia.

  Project 7 – Maximising the value of data and drilling through cover

  Project 8 – Geological architecture and evolution

  Project 9 – Targeting mineral systems in covered terranes
- **Plus Education and Training – PhD/MSc/Hons/VET**

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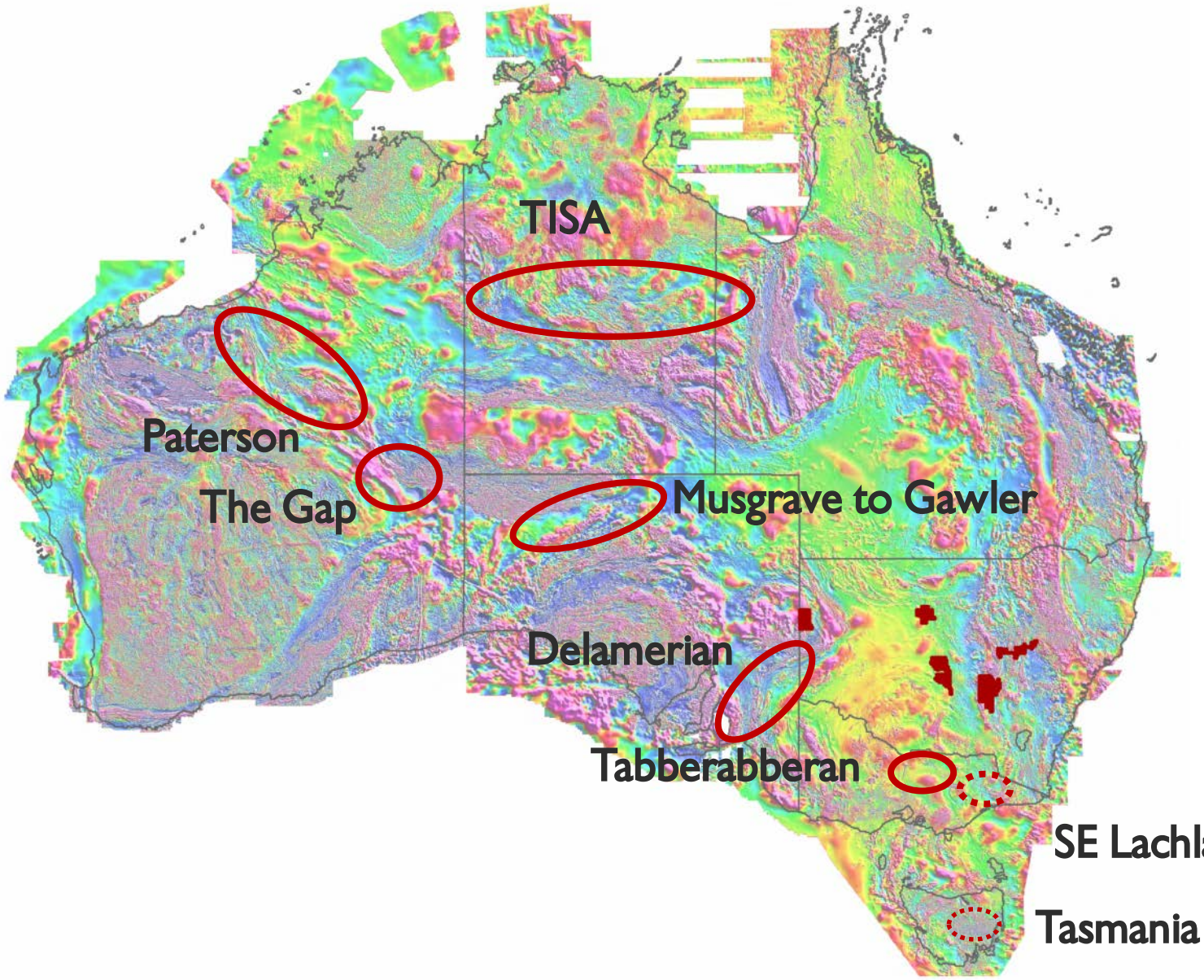
GSNSW involvement

NDI: a national collaboration



- **Participants**
  - GSNSW
  - GSSA
  - GSWA
  - GA
- **Affiliates**
  - GSV
  - MRT
  - NTGS
  - GSQ
- **Research Participants**
  - CSIRO
  - UoA
  - Uni SA
  - Curtin
  - UoN
  - UNSW
  - ANU

GSNSW strategy for the National Drilling Initiative

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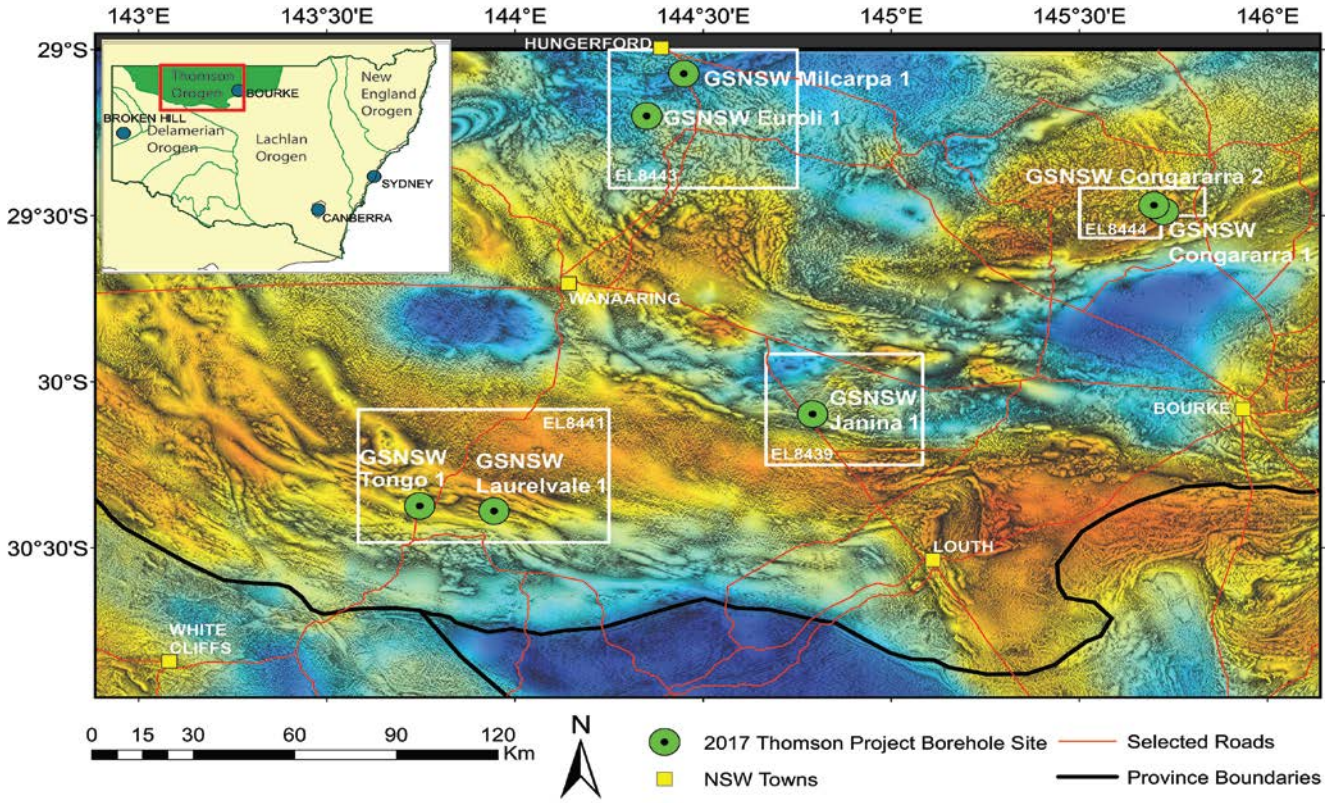
Learning from the Southern Thomson Orogen

- 5 year NCF project – GA, GSNSW, GSQ
- Related ARC Linkage – UoN, UQ, QUT
- Geophysics (AEM, MT, gravity, seismic), geochemistry, geochronogy and **drilling**
  - 7 drillholes in NSW (60,000 km^2)

A SUCCESSFUL PROJECT

- Refined understanding of depth and nature of cover (often < 250 m)
- Improved understanding of basement geology – tectonics, timing, setting
- Improved understanding of mineral potential and clear evidence of mineral systems



NSW Data pack released May 2018

No discernible exploration uptake

https://miro.medium.com/max/1200/1*7gAn0Zo3XrfVewCklJOGzg.jpeg

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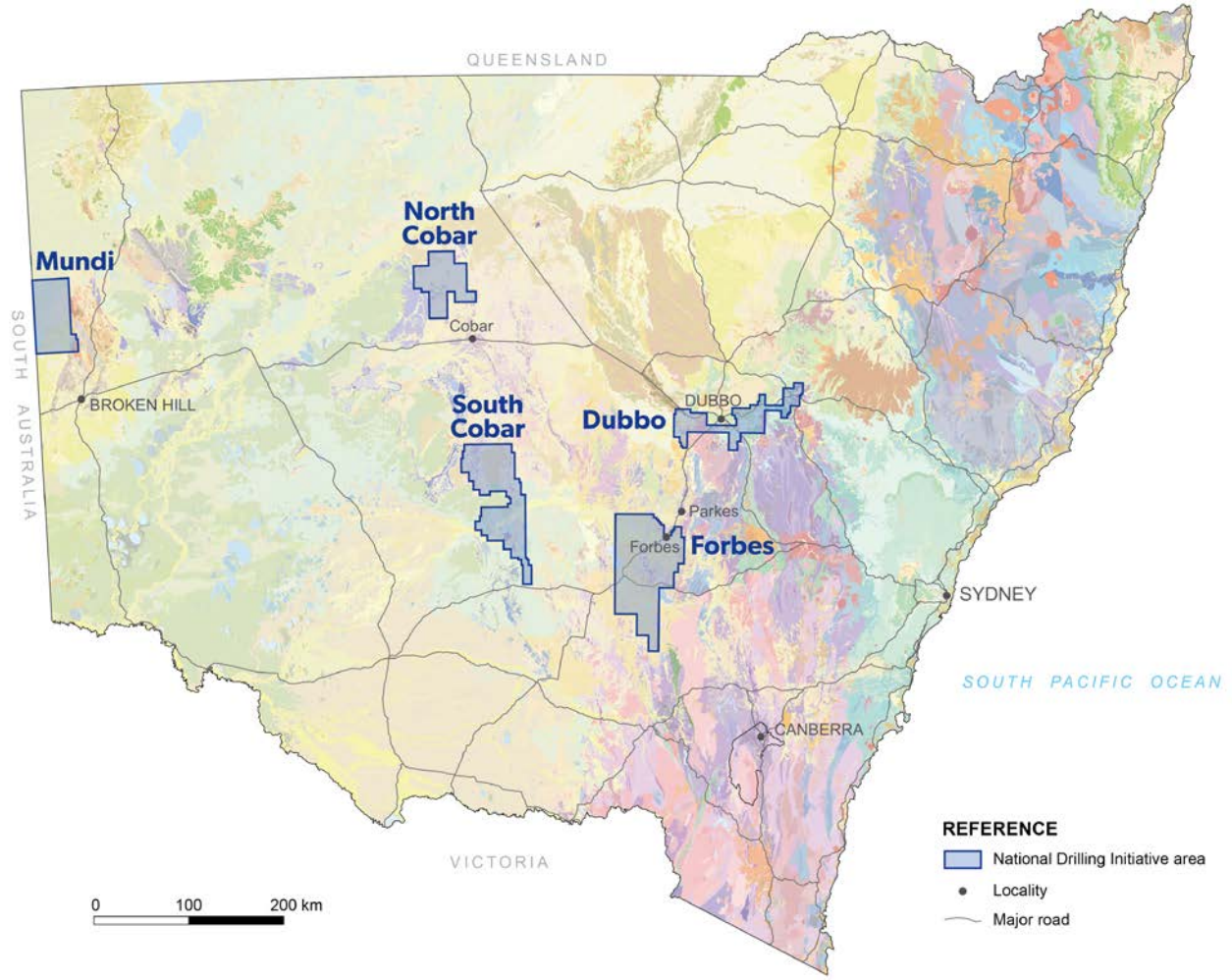
NDI in NSW

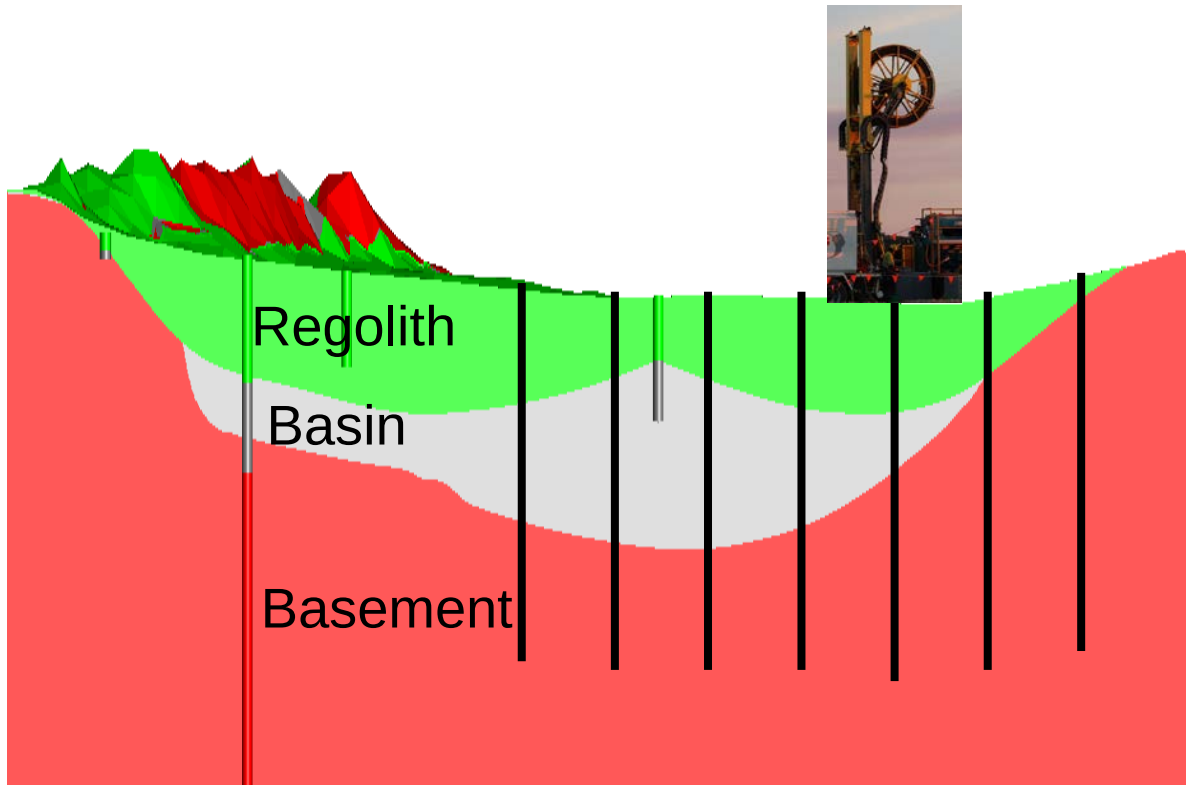
- Focus for GSNSW will be on pre-competitive data acquisition including drilling in five areas.
- These areas are undercover extensions to known mineralised terranes.
- GSNSW will assess legacy materials and data, and undertake targeted mapping, and geochemical and geophysical surveys prior to drilling.
- The data collected will also provide information on potential groundwater resources in the areas (collaboration with NSW Office of Water).



Seamless Geology of NSW v1.1

NSW area selection

- **First pass constraints**
  - Define cover and basement
  - <500m (all) cover to basement
  - Outcrop areas excised
  - Avoid sensitive land (National Parks, aquifers)
- **Initial grid costing**
  - ~ 5 x 5 km spacing
  - Max hole depth = 500 m (incl. 40 m into basement)
  - RoXplorer® cost of $50/m
  - Lab-at-Rig® cost of $25/m
- **Refine grid (current work)**
  - Legacy data audit and gaps, incl. existing drilling
  - New geophysics, geochemistry, geochron and mapping
  - Land clearances (environmental and cultural constraints, land access)



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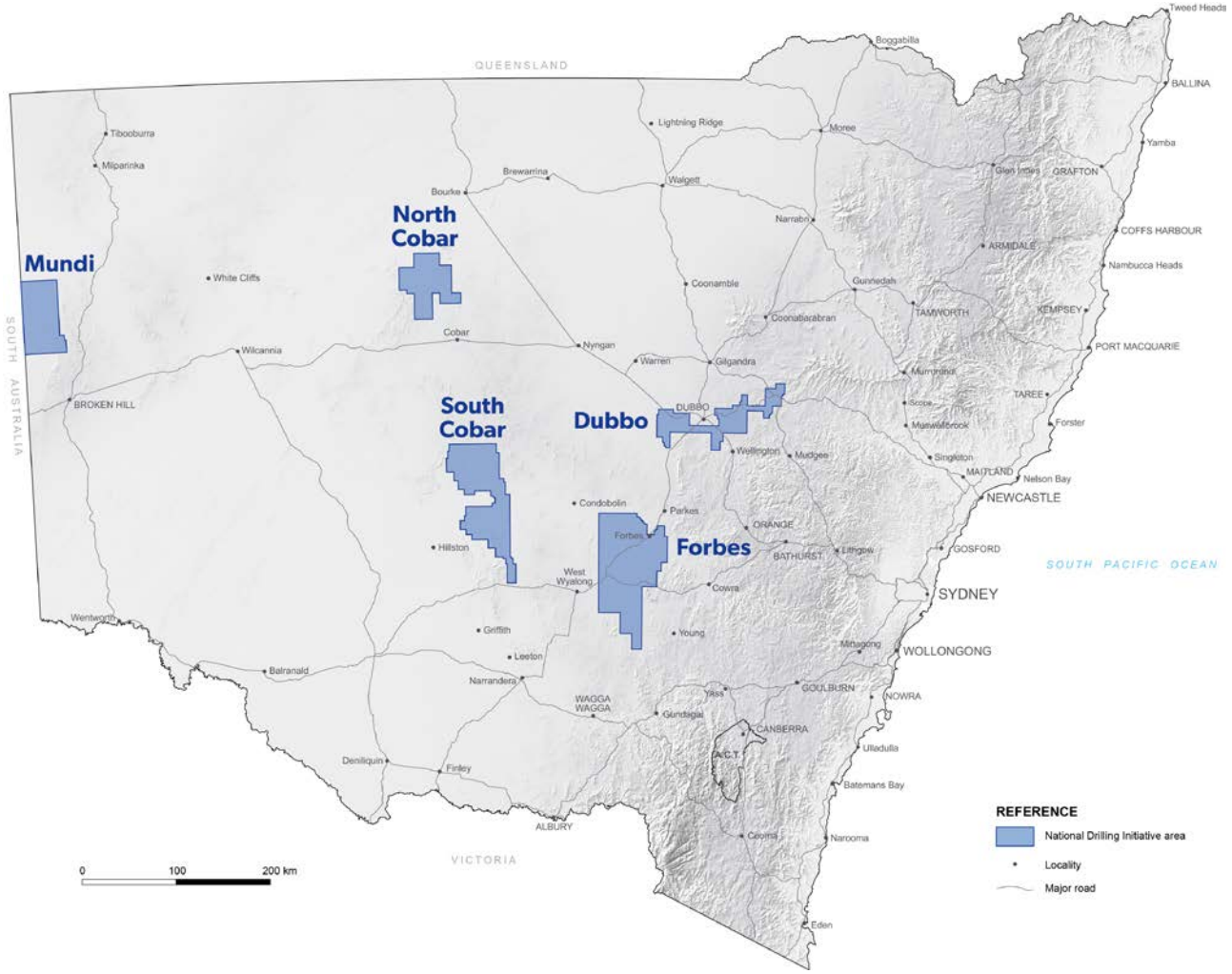
GSNSW NDI commitment - $15.9 million

- **$4.4 million cash**, to be invested in drilling in NSW
  - Based on first pass grid costing
- **$11.5 million in-kind**
  - $3.5 million new geophysics (AEM, mag/rad, gravity)
  - $0.6 million analytical costs (hydrogeochem, biogeochem, geochem, geochron, mineralogy)
  - $5.0 million staff in-kind
  - $2.4 million depreciated value of existing data
- Through MinEx, this investment leverages significant additional research



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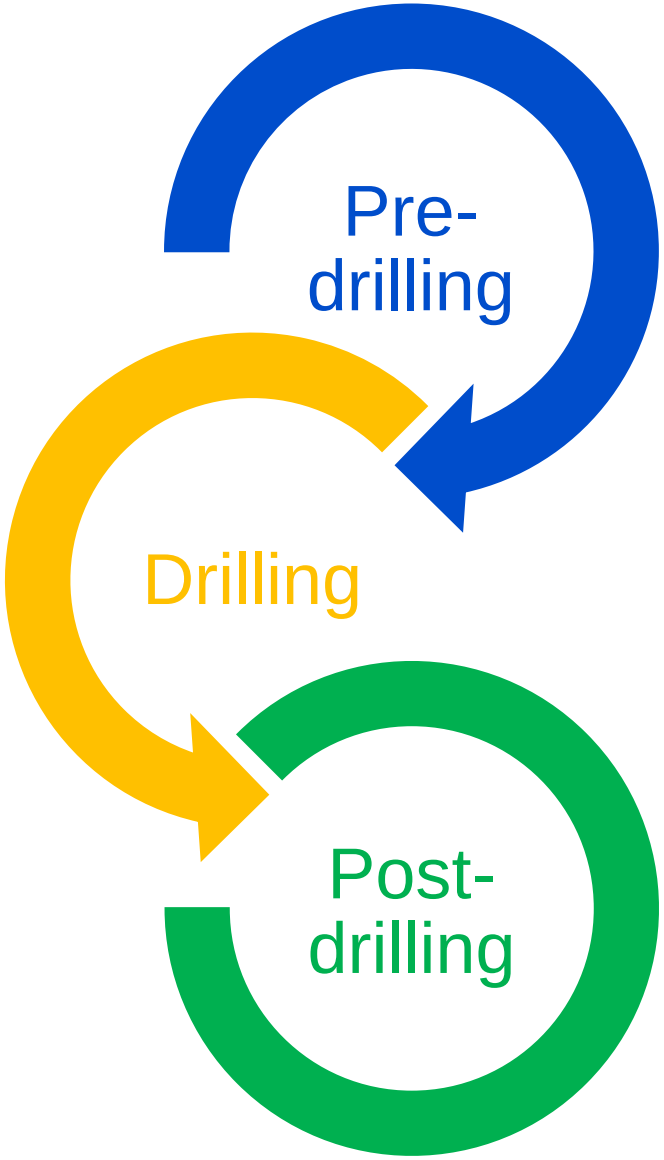
Three phases – key activities

- Pre-drilling phase
  - audit and gaps of legacy materials and data
  - geophysics acquisition and modelling
  - mapping, logging, sampling, analysis, geochron
  - biogeochemistry, hydrogeochemistry.
- Drilling phase
  - data handling, computation
  - analysis (e.g. HyLogger™, isotopic).
- Post-drilling phase
  - interpretation and 3D modelling.



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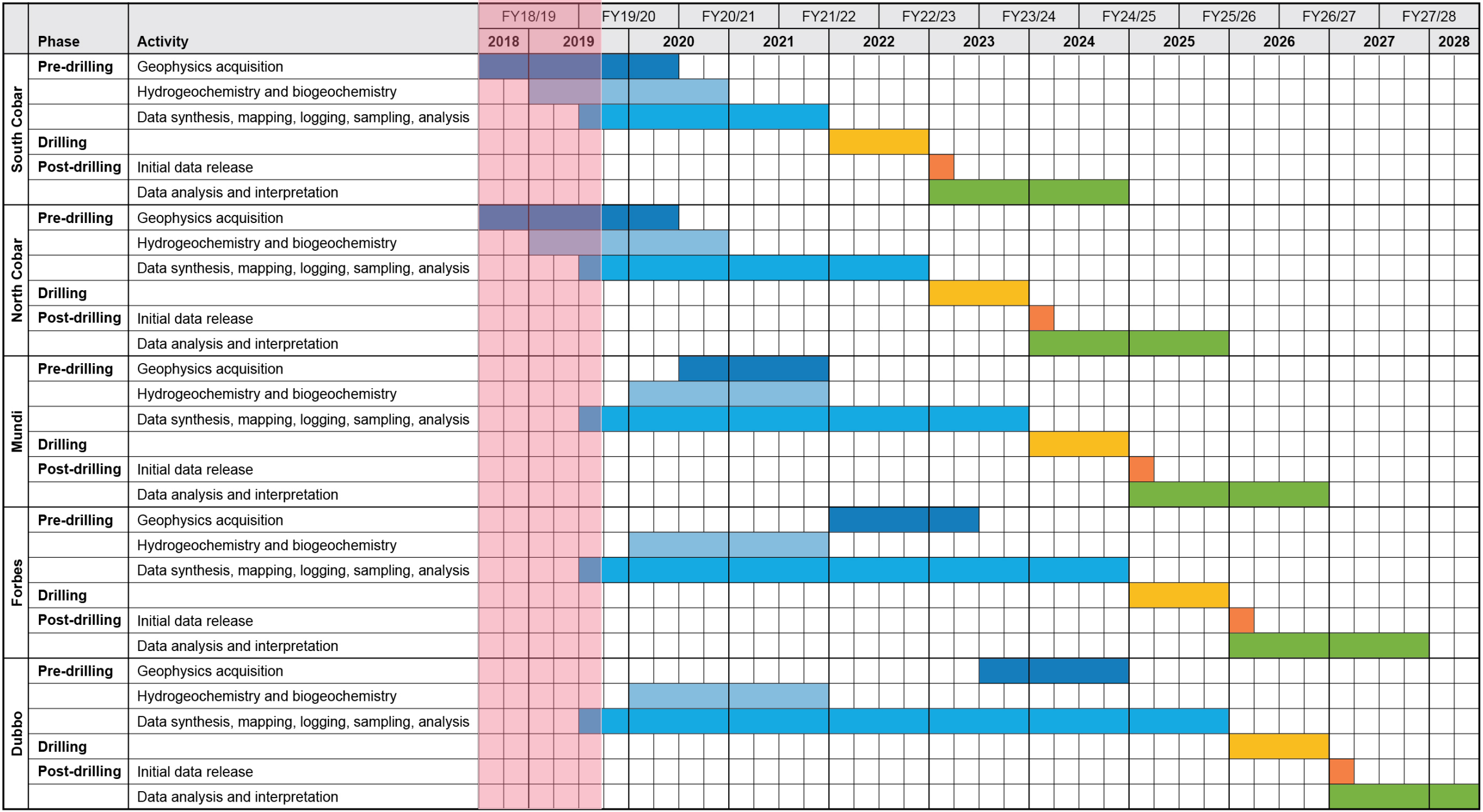

Correct as at 28/8/2019.

Area	Target basement	Cover	Potential mineralisation	Key scientific aims	Pre-drilling work program	NDI drilling
North and South Cobar	Siluro-Devonian basins, Ordovician basement.	Late Devonian and possible Mesozoic basins, Cenozoic regolith	Cobar style polymetallic, Besshi-style volcanic-hosted massive sulfides, possible magmatic systems.	1. Map the geology under cover, particularly key horizons. 2. Understand the geodynamic history – including thermal history, basin architecture, fill, deformation. 3. Understand controls and timing of mineralisation. 4. Understand the expression of basement geology and mineral systems in cover.	1. Resampling of legacy materials. 2. Geophysics: AEM, infill gravity, magnetics and radiometrics. 3. Improve existing mapping, including geochronology. 4. Soil, bio- and hydro-geochemistry.	2022–2023 232 holes 14,685 m
Mundi	Willyama Supergroup, ~1590 Ma igneous rocks, key Neoproterozoic horizons.	Neoproterozoic to Devonian basins, Mesozoic Eromanga Basin, Quaternary Eyre Basin, Cenozoic regolith.	Broken Hill type Pb-Zn-Ag, iron oxide Cu-Au, Mississippi Valley type Pb-Zn, unconformity U possible magmatic systems.	1. Map the geology under cover, including characterisation of key time slices and interfaces. 2. Understand the expression of basement geology and mineral systems in cover. 3. Correlate basement geology between NSW and SA. 4. Understand cause and effects of the Mundi MT conductivity anomaly. 5. Extend Curnamona mineral potential mapping under cover.	1. Resampling of legacy materials. 2. Geophysics: AEM, infill gravity, magnetotellurics. 3. Improve existing mapping, including geochronology. 4. Soil, bio- and hydro-geochemistry.	2024 65 holes 14,844 m
Forbes	Macquarie Igneous Province (MIP), Siluro-Devonian basins and igneous rocks.	Late Devonian basins, possible Mesozoic Great Australian Basin, Cenozoic regolith.	Porphyry Cu-Au, epithermal systems, volcanic-hosted massive sulfides, orogenic gold, possible magmatic systems.	1. Map the geology under cover, including phases of the MIP. 2. Understand the expression of basement geology and mineral systems in cover. 3. Understanding of the geodynamic history, e.g. structural controls, magmatic history, Siluro-Devonian basin fill, deformation. 4. Ordovician mineral chemistry to differentiate alteration vs metamorphism,	1. Resampling of legacy materials. 2. Geophysics: AEM, infill gravity, magnetotellurics. 3. Improve existing mapping, including geochronology. 4. Bio- and hydrogeochemistry.	2025 233 holes 22,735 m
Dubbo	Macquarie Igneous Province (MIP), Siluro-Devonian basins and igneous rocks.	Permo-Triassic Sydney Basin, Mesozoic Surat Basin and volcanic rocks, Cenozoic regolith and volcanic rocks.	Porphyry Cu-Au, epithermal systems, volcanic-hosted massive sulfides, orogenic gold, possible magmatic systems.	1. Map the geology under cover, including characterisation of key time slices/interfaces. 2. Understand the expression of basement geology and mineral systems in cover. 3. Identification, location and nature of MIP under cover. 4. Siluro-Devonian basin opening, fill, thermal history and inversion.	1. Resampling of legacy materials. 2. Geophysics: AEM, infill gravity, possible magnetotellurics. 3. Improve existing mapping, including geochronology. 4. Bio- and hydro-geochemistry.	2026 234 holes 17,172 m

Recent and current activities

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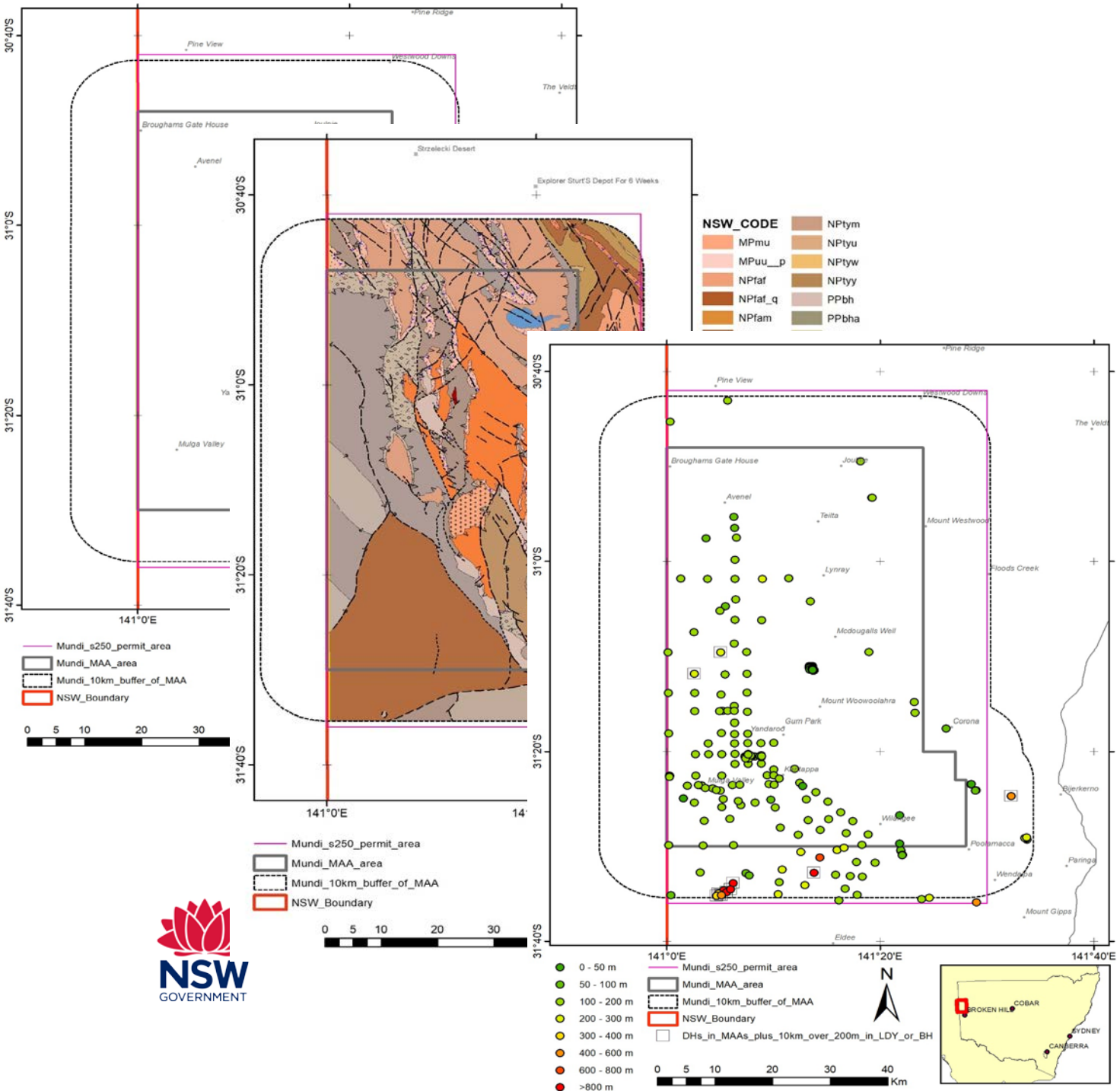

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Audit and gaps

- Report for each of the five focus NDI areas.
- Includes previous mapping, geophysics, geochronology, palaeontology, field observations, geochemistry etc.
- Inform work program and research opportunities for each NDI area.
- Underway, will be published by end of 2019.
- Examples from Mundi NDI report, by Chris Folkes

Initial focus on Cobar

- Northern and southern extensions of the Cobar Basin under cover, up to a depth of 500 m.
- Long history of mining, with limited current mine life.
- Recent advances in understanding from GSNSW mineral systems work.
- Exploration interest and significant potential for discovery.
- Community support for mineral exploration and mining.

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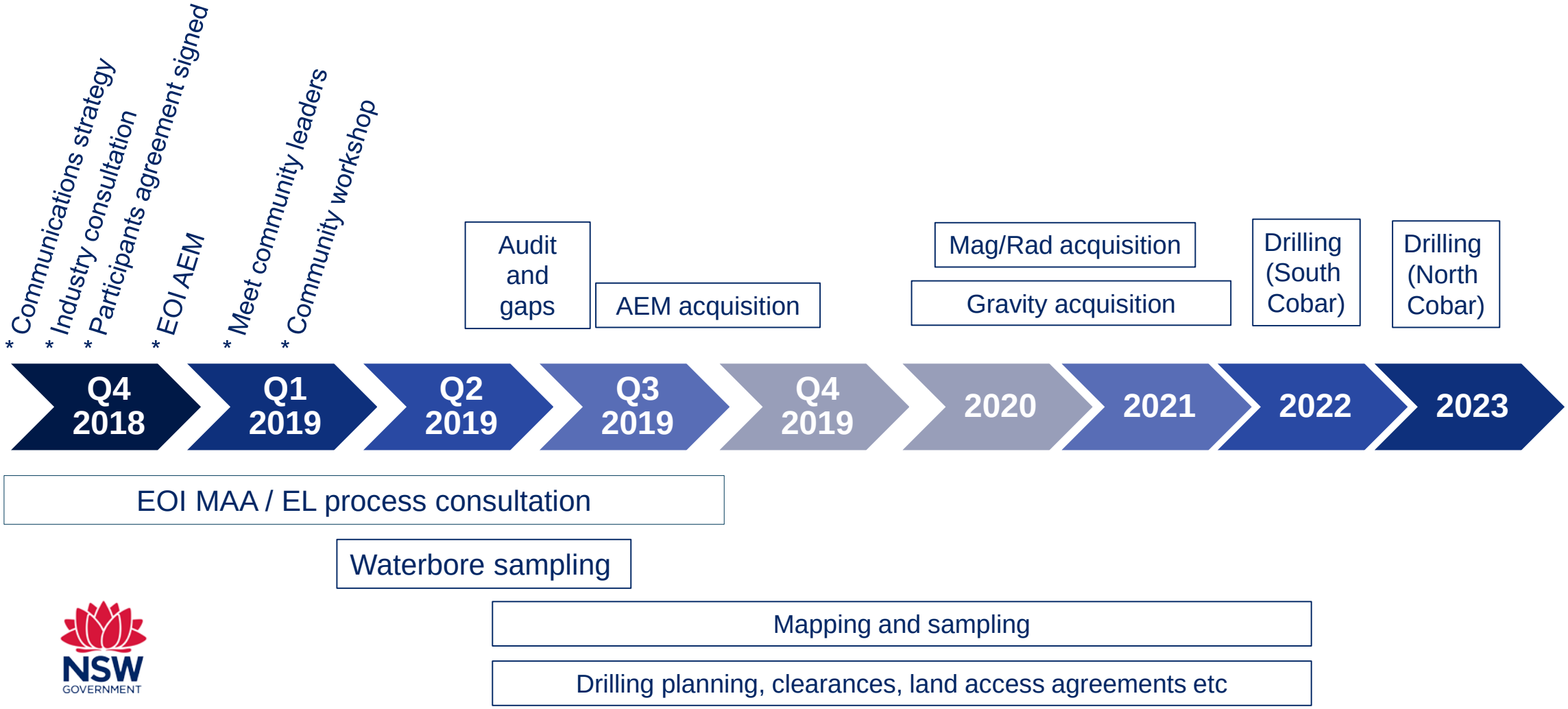
Cobar timeline



North and South Cobar

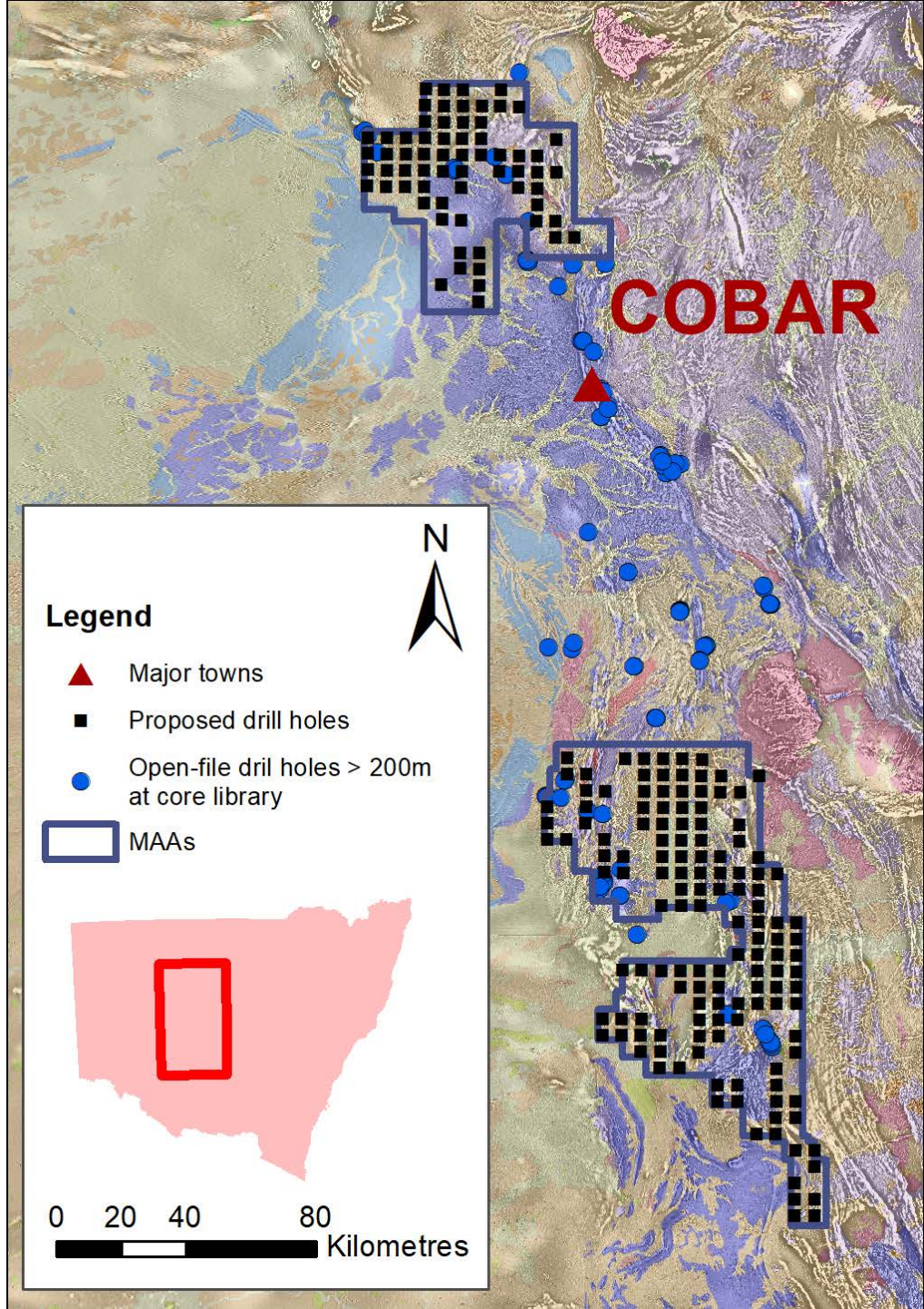
Target basement = Siluro-Devonian basin, Ordovician.

Cover = Cenozoic, Mesozoic, Late Devonian.

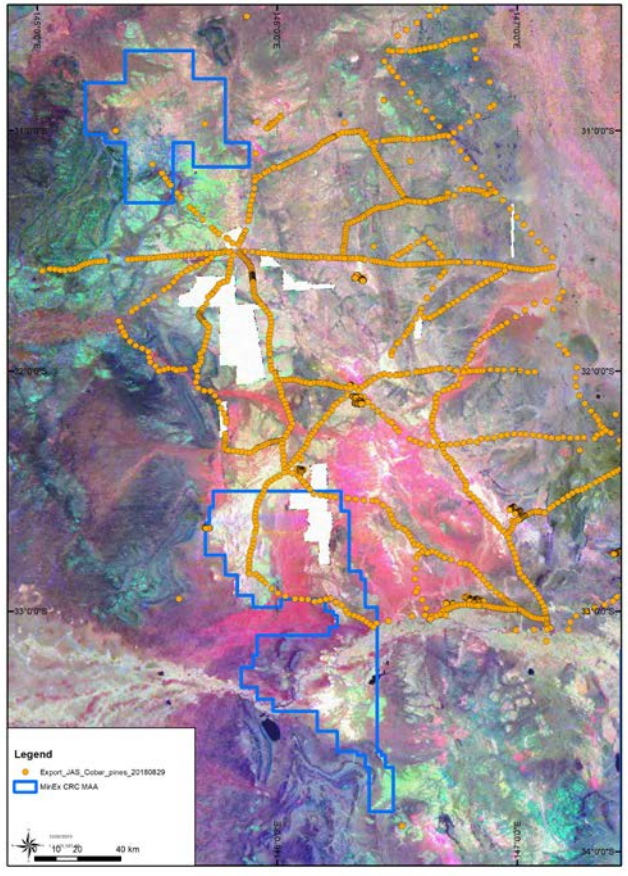
Potential mineralisation = ‘Cobar’ style (basin formation and inversion).

Key issues:

- Controls on mineralisation.
- Can we detect basement signatures in cover using:
  - biogeochemistry and/or
  - hydrogeochemistry?



Background image is a semi-transparent surface geology layer over a greyscale first vertical derivative of total magnetic intensity image.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MinEx CRC MAA
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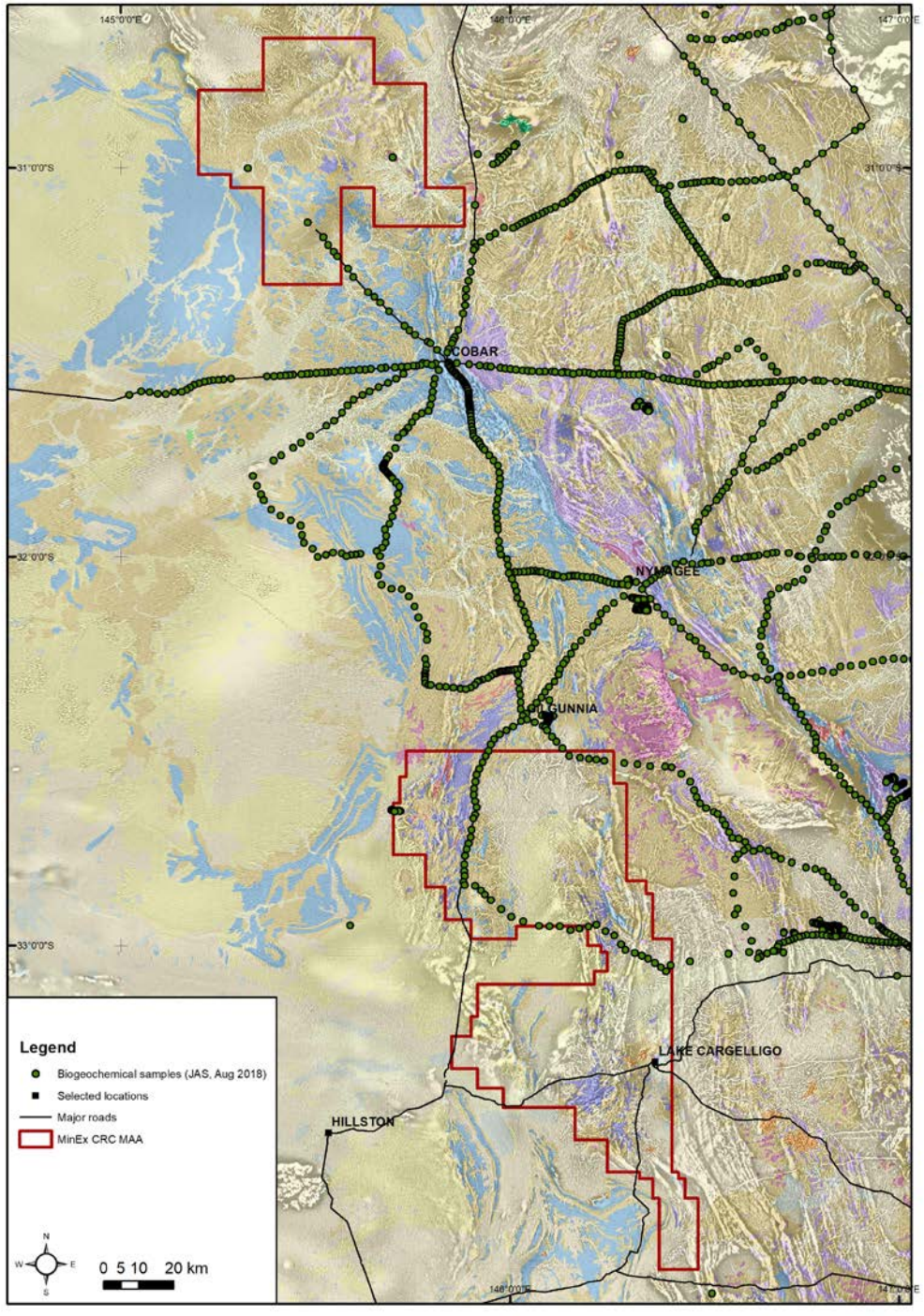
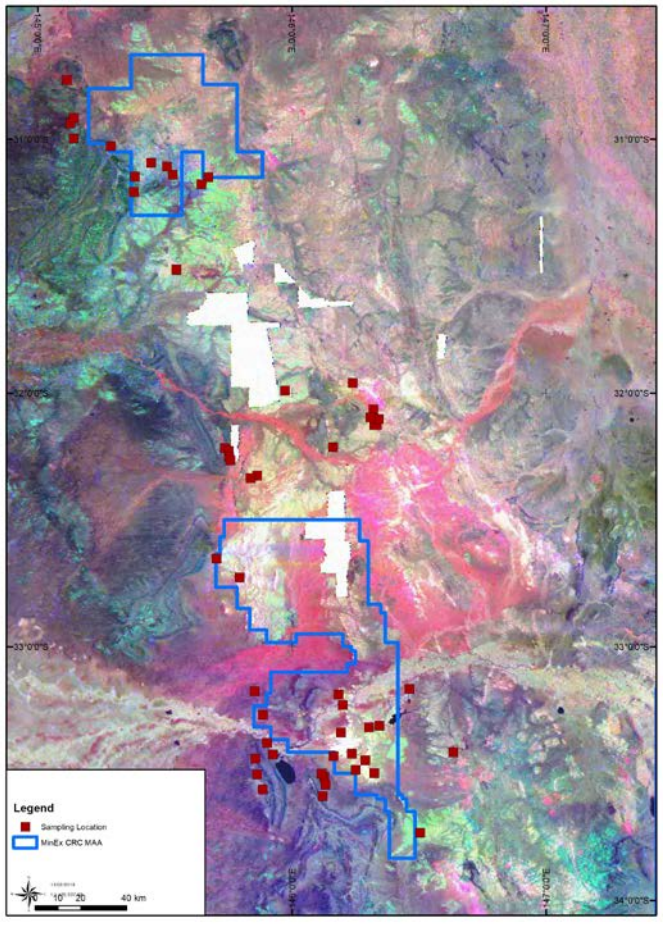
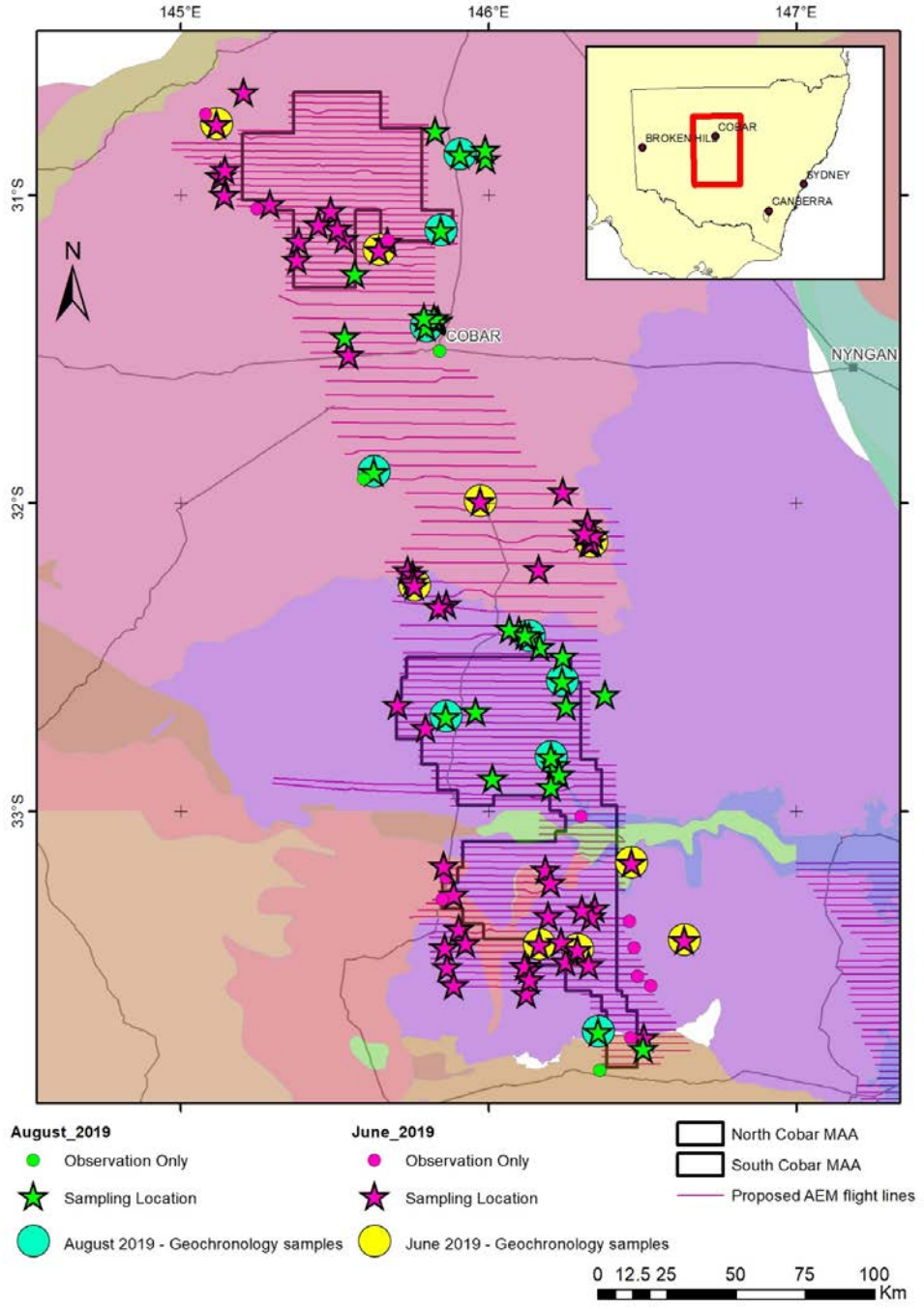
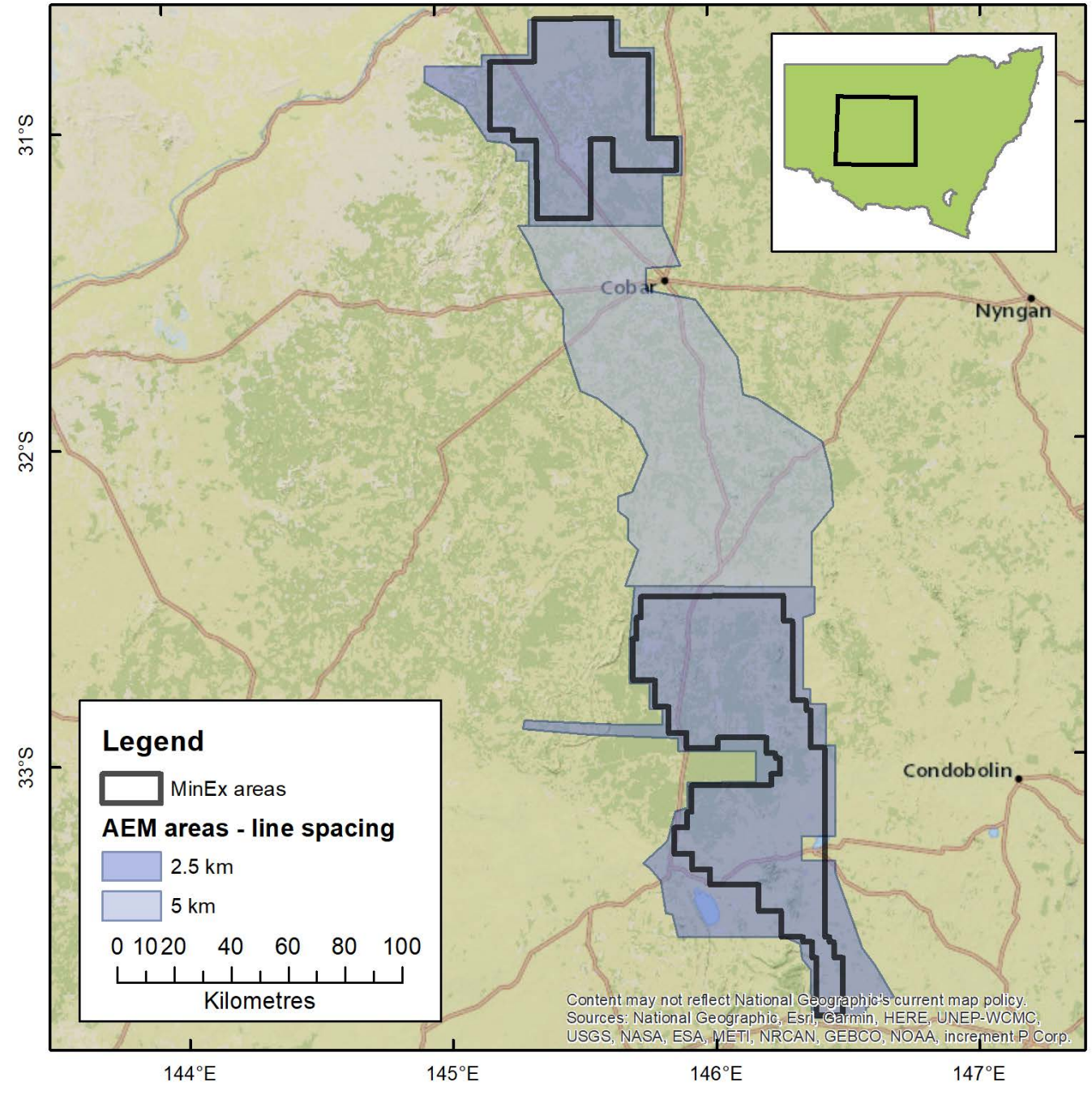
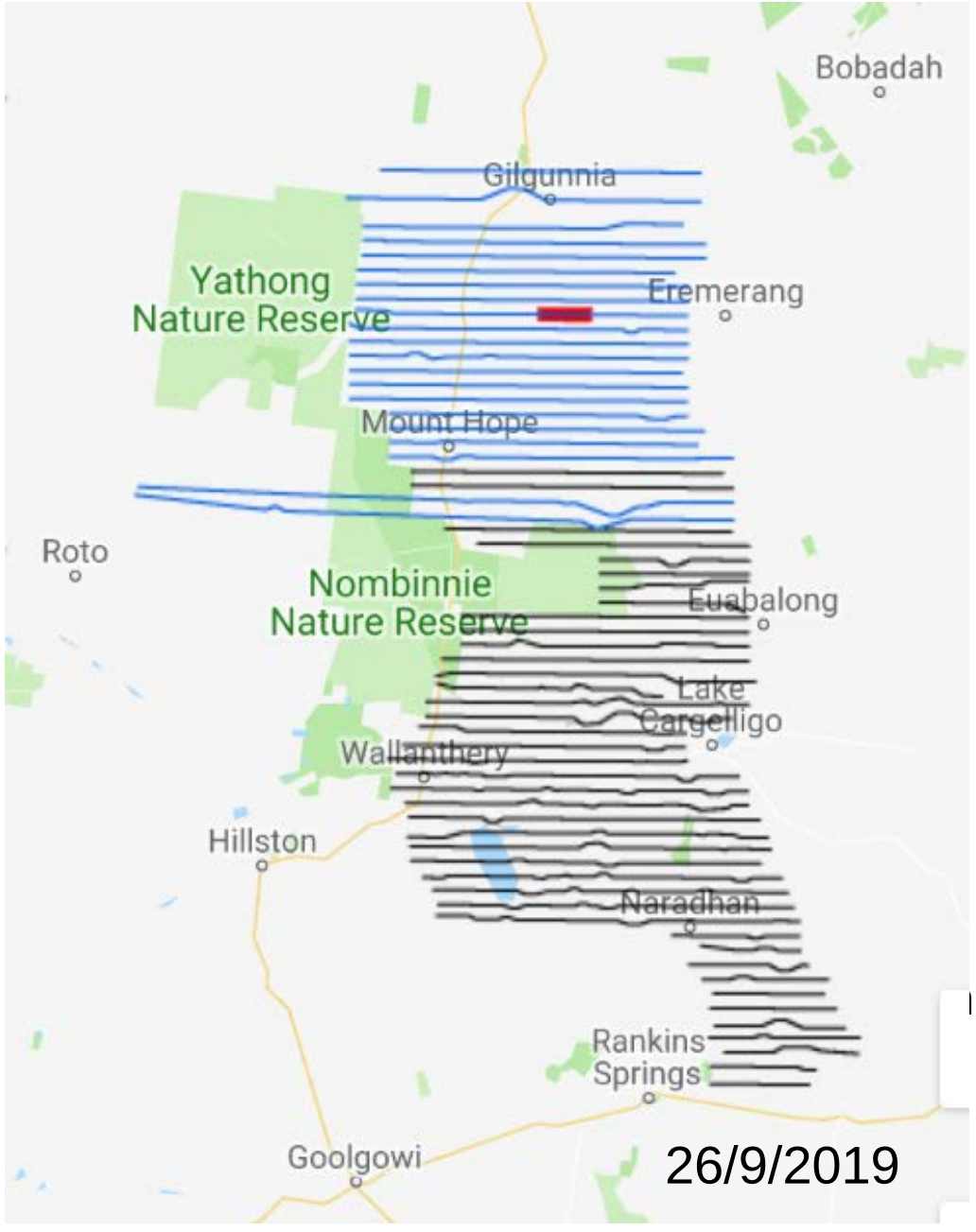

COBAR
NYNGAN
GUNNIA
LAKE CARGELLIGO
HILLSTON
Legend
Biogeochemical samples (JAS, Aug 2018)
Selected locations
Major roads
MinEx CRC MAA
0 5 10 20 km


Legend
Sampling Location
MinEx CRC MAA
40 km


145°E
146°E
147°E
31°S
32°S
33°S
N
COBAR
NYNGAN
BROKEN HILL
SYDNEY
CANBERRA
August_2019
Observation Only
Sampling Location
August 2019 - Geochronology samples
June_2019
Observation Only
Sampling Location
June 2019 - Geochronology samples
North Cobar MAA
South Cobar MAA
Proposed AEM flight lines
0 12.5 25 50 75 100
Km

Cobar AEM


31°S
32°S
33°S
144°E
145°E
146°E
147°E
Cobar
Nyngan
Condobolin
Legend
MinEx areas
AEM areas - line spacing
2.5 km
5 km
0 10 20 40 60 80 100
Kilometres
Content may not reflect National Geographic's current map policy.
Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.


Bobadah
Gilgunnia
Yathong Nature Reserve
Eremerang
Mount Hope
Roto
Nombinnie Nature Reserve
Euabalong
Lake Cargelligo
Wallanthery
Hillston
Naradhan
Rankins Springs
Goolgowi
26/9/2019

MinEx CRC MAAs

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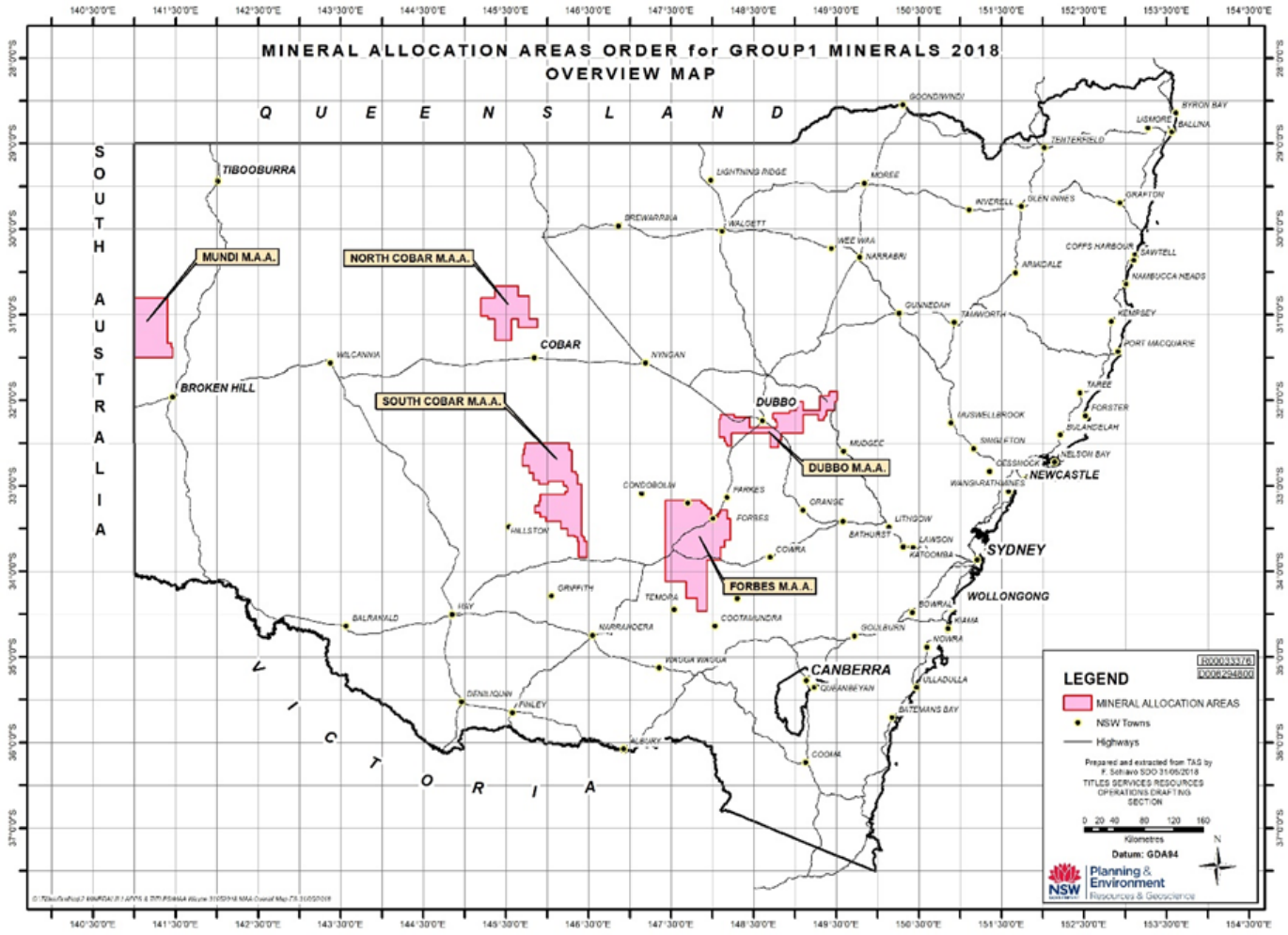
MinEx CRC MAAs

- Gazetted on 10 August 2018
  - Combined area represents 2.59% of NSW
- No new Group 1 ELAs within MAAs without Ministerial consent
- **NO IMPACT ON EXISTING ELs/ELAs**
- Constituted to allow open discussion of NSW MinEx CRC NDI program, without the risk of speculative exploration title applications and land banking
- GSNSW has worked with industry to develop an agreed process for grant of Group 1 ELs within the MAAs



Expression of interest process

- Opened on Friday 16 August, **will close on Monday 30 September 2019**.
- **Competitive assessment only for overlapping applications.**
- Assessment will be undertaken by a joint industry-GSNSW panel supervised by an independent probity advisor:
  - Quality/effectiveness of the proposed work program (50%)
  - Experience in the region (20%)
  - Experience with similar exploration targets (20%)
  - Innovation (10%).
- **Once consent is given, the ELA process will be identical to the Group 1 process elsewhere in the State.**
- Process will run every two years for the life of the CRC.
- **Industry nominees for the assessment panel welcome.**

Media Release

Department of Planning, Industry and Environment

NSW GOVERNMENT

Friday 16 August 2019

New exploration opportunities for NSW minerals

Explorers are invited to submit expressions of interest for new Group 1 mineral exploration licence applications in five Mineral Allocation Areas (MAAs) in NSW.

This opportunity will allow explorers to access the MAAs – Dubbo, Mundi, Forbes and North and South Cobar – while the Government continues MinEx CRC activities in these regions.

Executive Director of Geosurvey NSW Dr Chris Yeats said a new process has been created to allow explorers to apply for Group 1 exploration licences in these areas, which are underexplored geological extensions of areas known to have significant mineral deposits.

"Under the MinEx Cooperative Research Centre's (MinEx CRC) National Drilling Initiative, the NSW Government is participating in a nation-wide project to map regional geology and seek out potential new mineral and groundwater systems," Dr Yeats said.

"NSW is already producing gold, copper, zinc and silver, all vital components of our high-tech economy and booming renewable energy industry.

"In 2017/18 we produced more than 230,000 tonnes of zinc – an equivalent weight to four and a half Sydney Harbour bridges – and more than 180,000 tonnes of copper – or three and a half harbour bridges.

"Metalliferous mining contributes billions annually to the NSW economy and directly employs around 7600 people, mostly in regional NSW.

"We want to continue to build on the economic and social contribution of minerals in regional NSW, so we're encouraging high-quality explorers to take up ground within the MAAs and work with us while MinEx CRC activities are ongoing."

Explorers are invited to lodge an expression of interest between Friday 16 August and 5pm on Monday 30 September 2019.

Successful applicants will then be invited to lodge an application for a standard Exploration Licence.

For more information visit www.resourcesandgeoscience.nsw.gov.au/minexcrc-explorers

MinEx CRC:

Expanding the frontiers of mineral exploration in NSW

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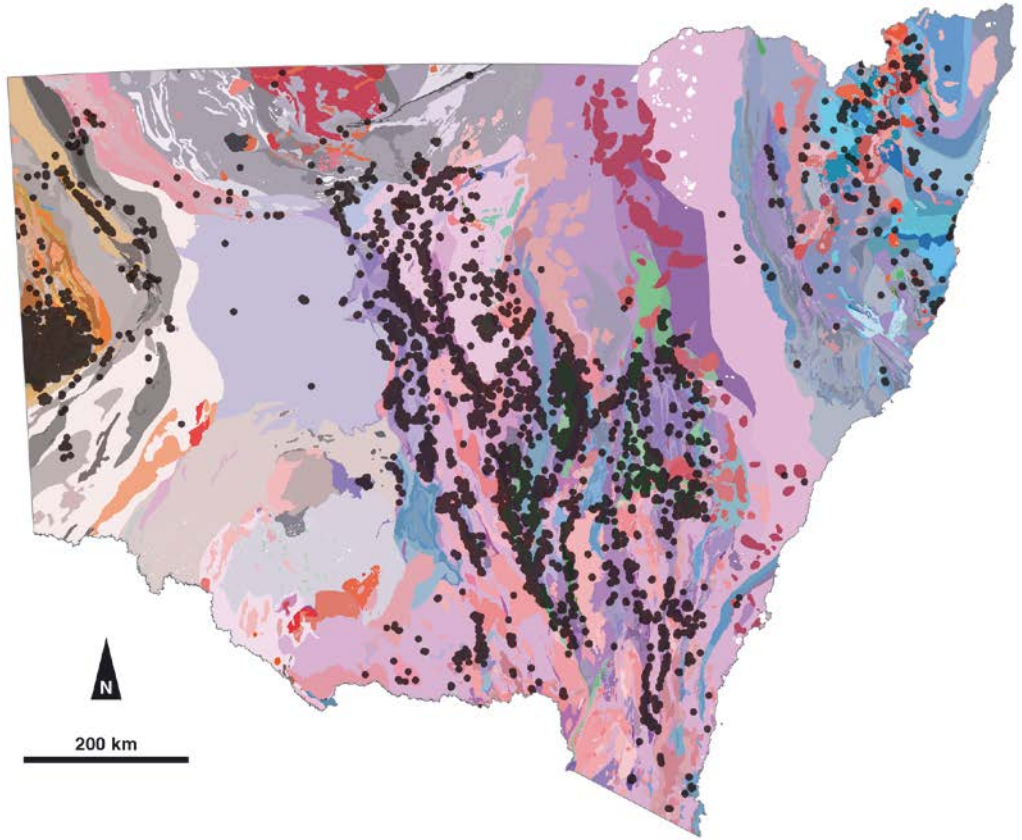
The UNCOVER imperative

- The future of the Australian mineral industry hinges on its ability to successfully explore the 70% of the continent that lies undercover.
- To do this the industry needs new tools, technologies and data.
- Just as geological surveys mapped the surface geology to provide a framework for mineral explorers in the 20th century, we need to map the undercover geology to create a framework for 21st century mineral discovery. “**Mapping with a drill rig”**
- MinEx CRC NDI is a significant first step on that path.
- 10 years is just the start of a long road.



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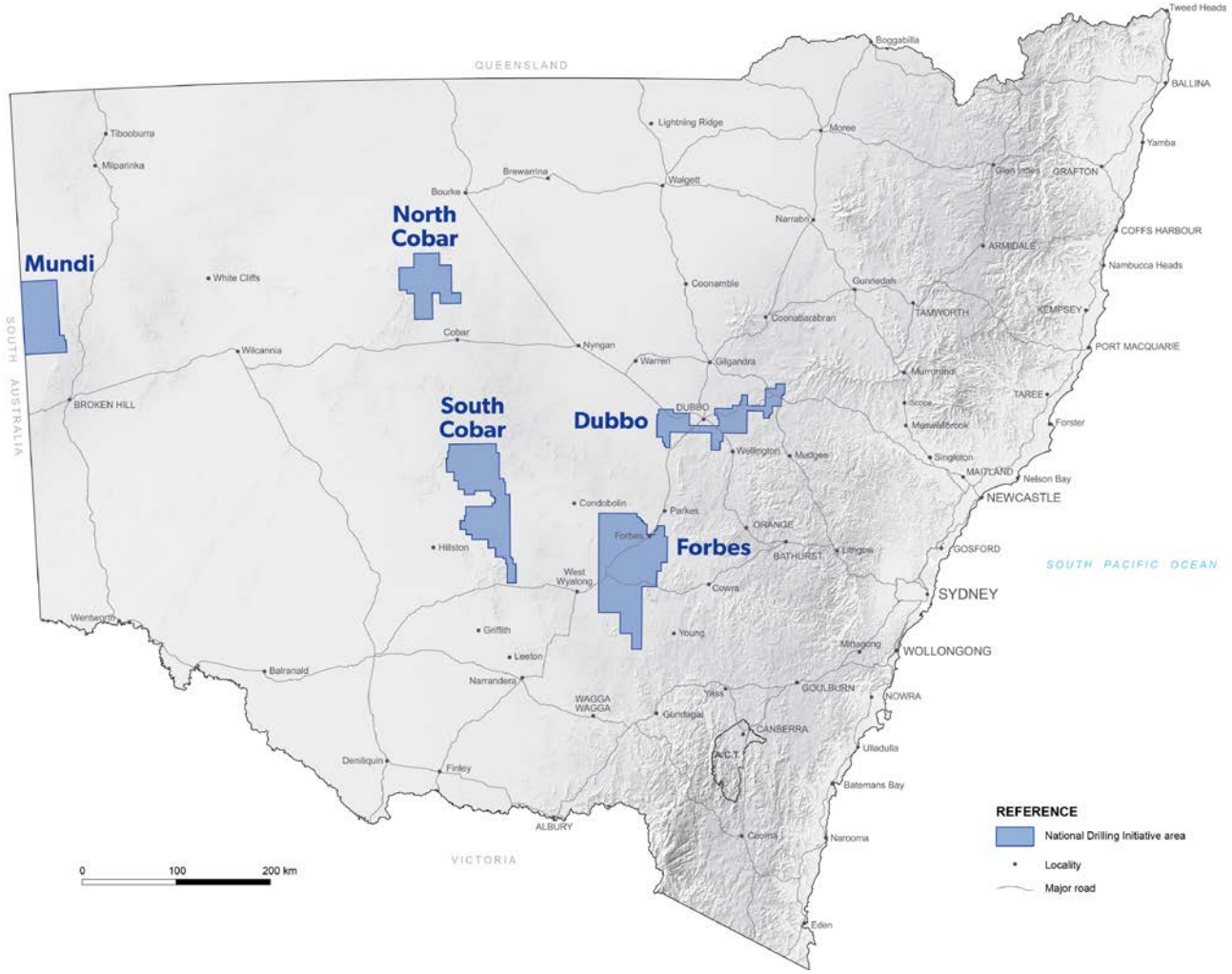
Outcome of the NDI in NSW

Improved understanding of the basement geology and its expression in cover sequences across five areas of the state …

… supporting development of new tools and methodologies for successful exploration undercover…

… to **open up vast new frontiers for explorers, generating a wave of discoveries that will underpin a strong mineral industry and economy for future generations of Australians.**



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