The LAWN HILL PROJECT

DIGGING DEEPER 9

BEN JUPP

Greenfields Prospectivity Unit

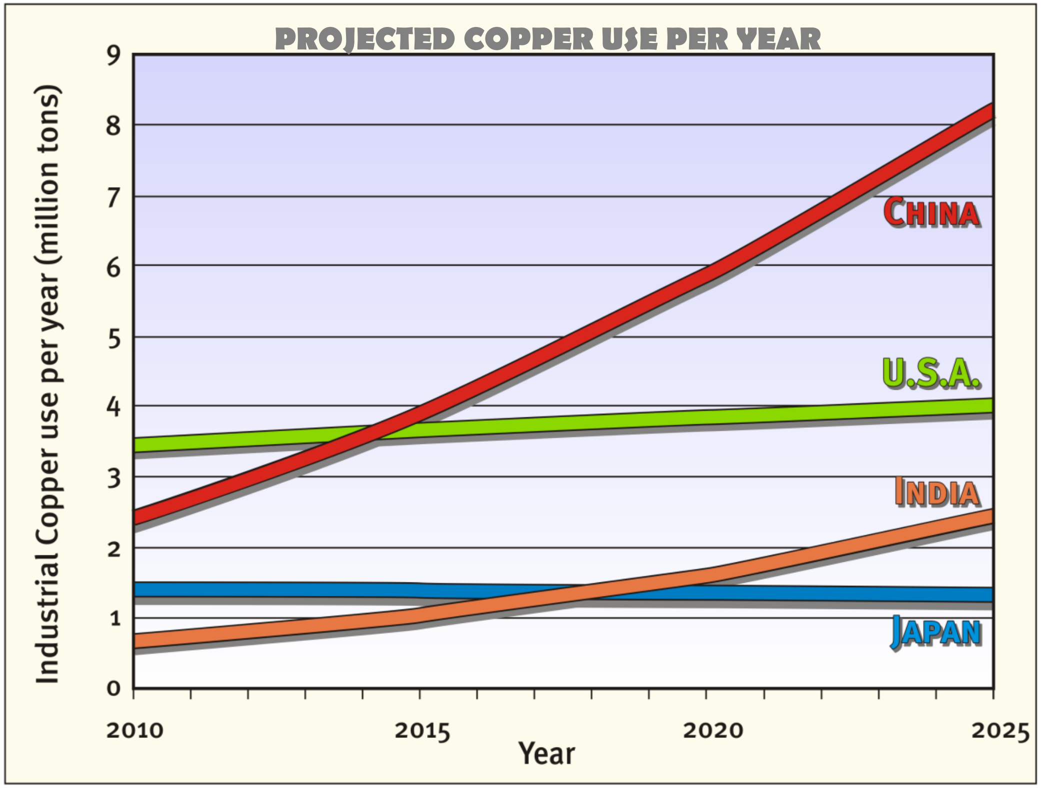
Geological Survey of Queensland
Department of Employment, Economic Development and Innovation

Queensland Government

An Uncertain Resource Future

The minerals and energy sectors remain Australia's largest export earner

$125 Billion 2009-2010 → $148 Billion projected in 2010-2011



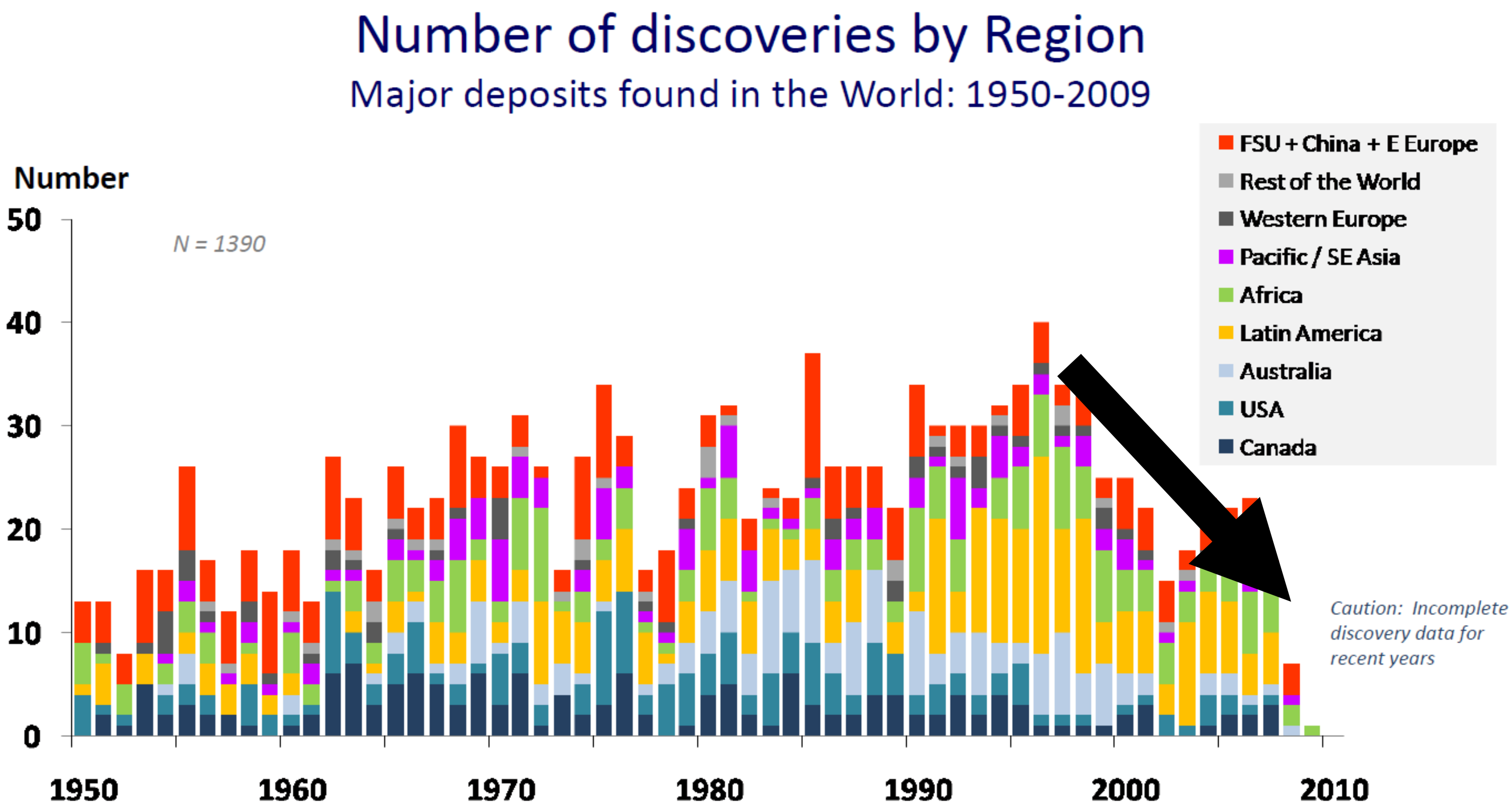
After Singer, 2009

Resources Demand Will Continue To Grow

It Is Critical We Continue To Meet This Demand…

Global Discovery Trends Decrease

major resource discoveries have decreased…



Source: MinEx Consulting March 2010

Note: "Major" defined as >1 mt Cu-equiv, > 1 Moz Au-equiv, > 100 kt Ni, > 10 m carats >25 kt U_3O_8

Excludes bulk and industrial mineral discoveries

New discoveries are required to meet demand & maintain Queensland's share of the resource market

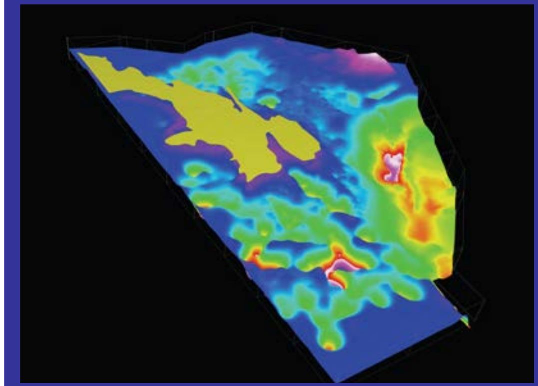
Greenfields Exploration is Critical

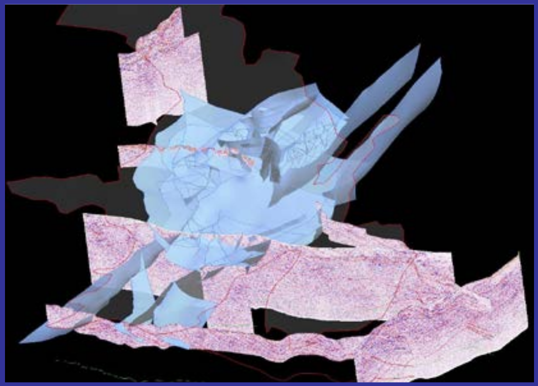
- ***Can define new mining districts***
- ***Has potential for large resource tonnages/volumes***

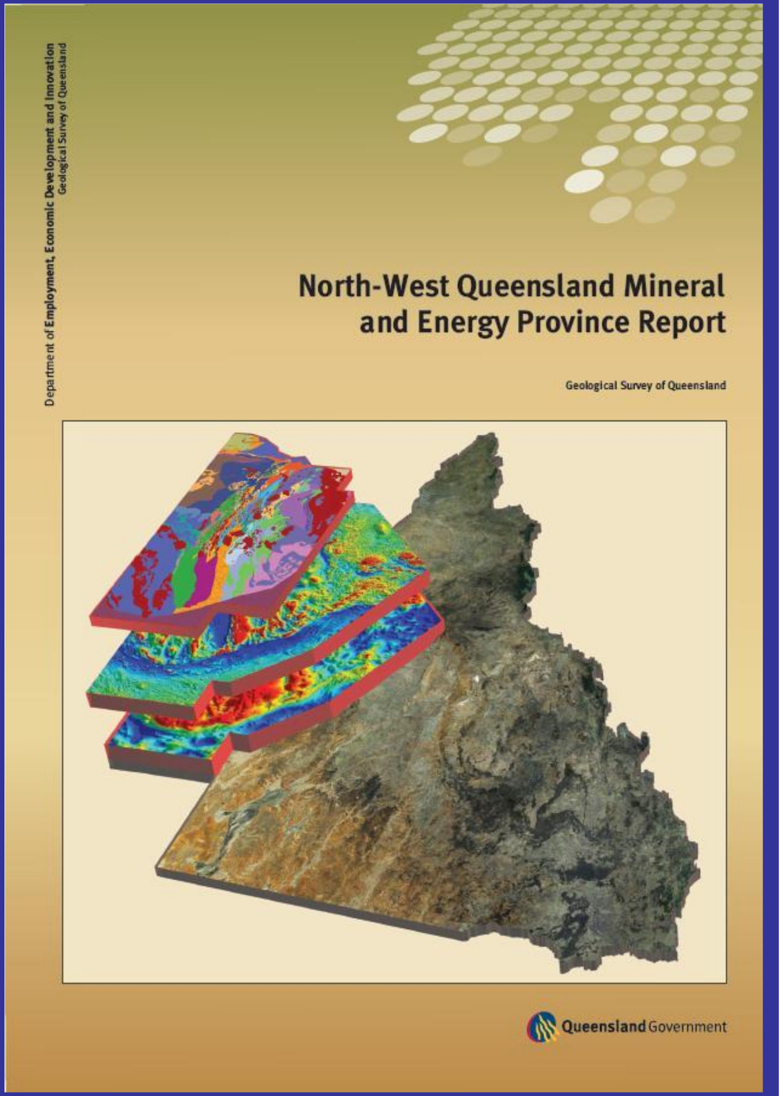
Extending The Search Area

GSQ are developing new targeting concepts by applying a range of technologies & expertise in geoscientific processing, interpretation, interrogation and modelling.

The NWQMEP Study is one such study which integrates understanding at a range of scales to better support predictive studies in Greenfields terranes





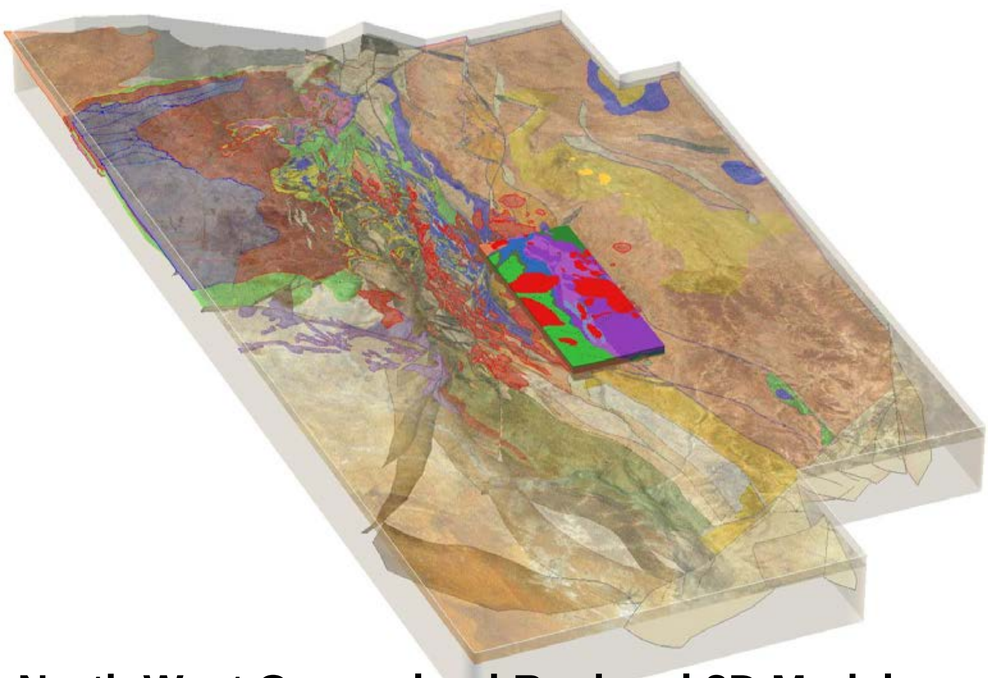


SCALING IN FROM REGIONAL UNDERSTANDING

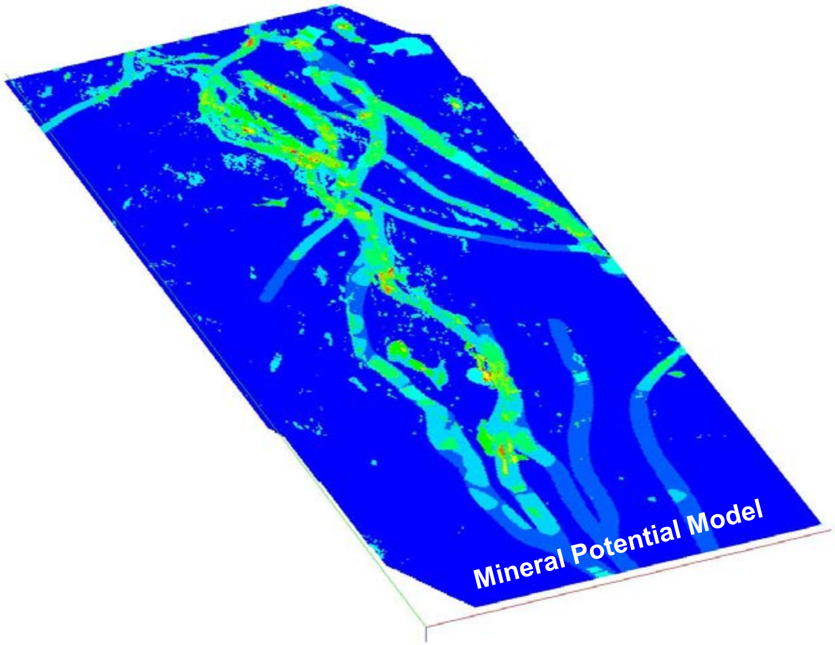
- The Greenfields Prospectivity Unit (GPU) are now narrowing the search window by applying regional understandings to district scale studies (i.e. Mount Dore, 2010)

- Focussed studies are utilizing area specific exploration criteria

- Applying modelling techniques and workflows which target areas of high mineral potential



North West Queensland Regional 3D Model



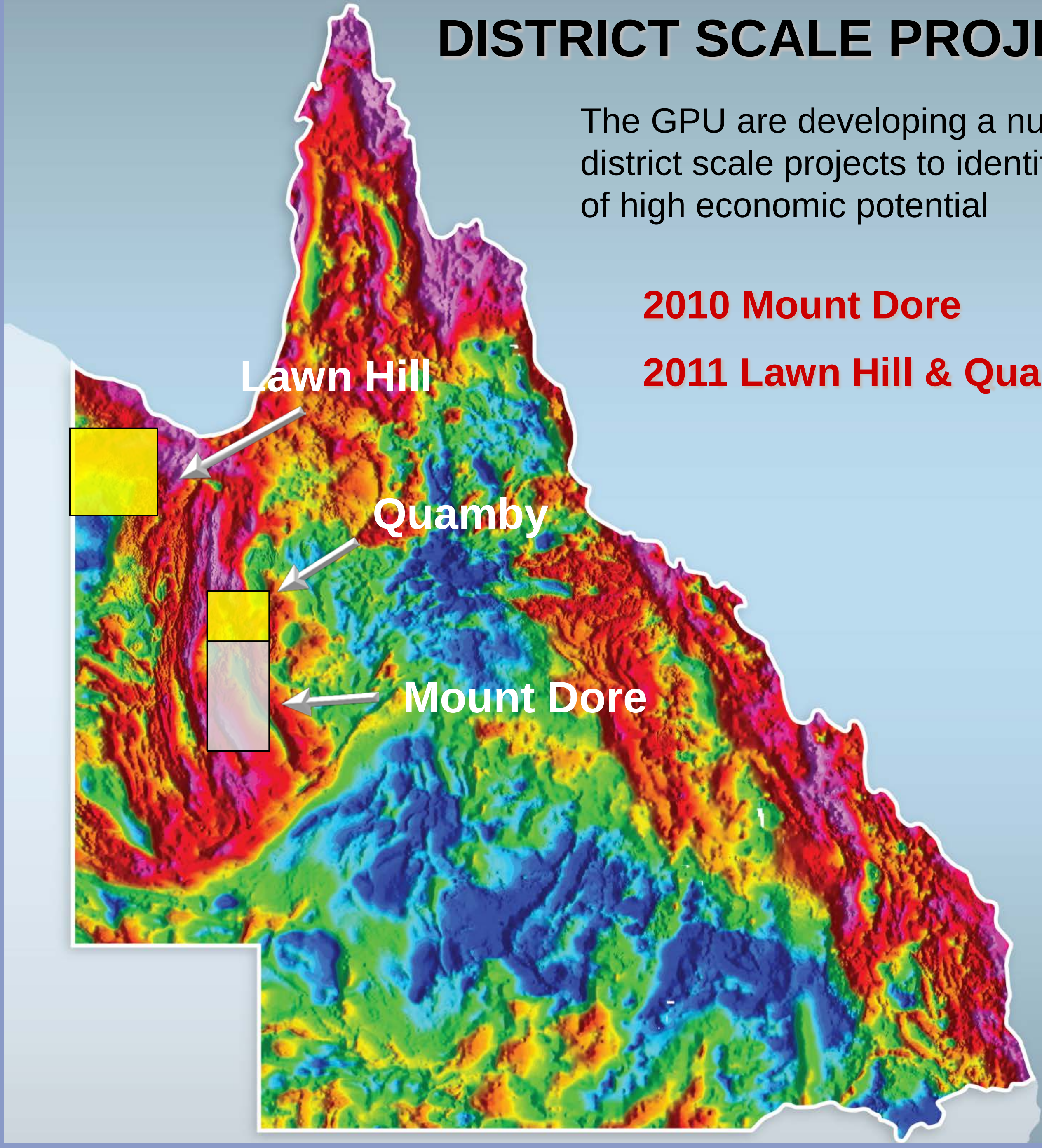
Mount Dore Mineral Potential Modelling

DISTRICT SCALE PROJECTS

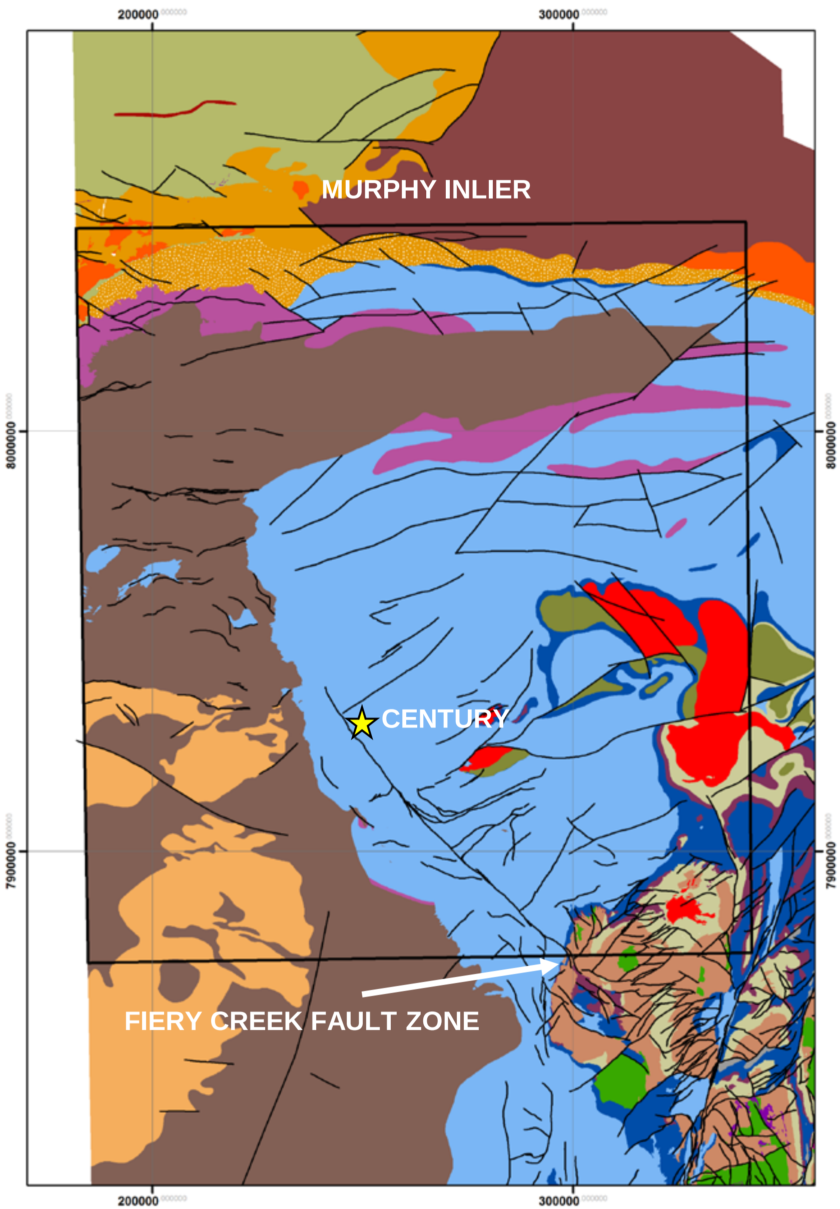
The GPU are developing a number of district scale projects to identify areas of high economic potential

2010 Mount Dore

2011 Lawn Hill & Quamby



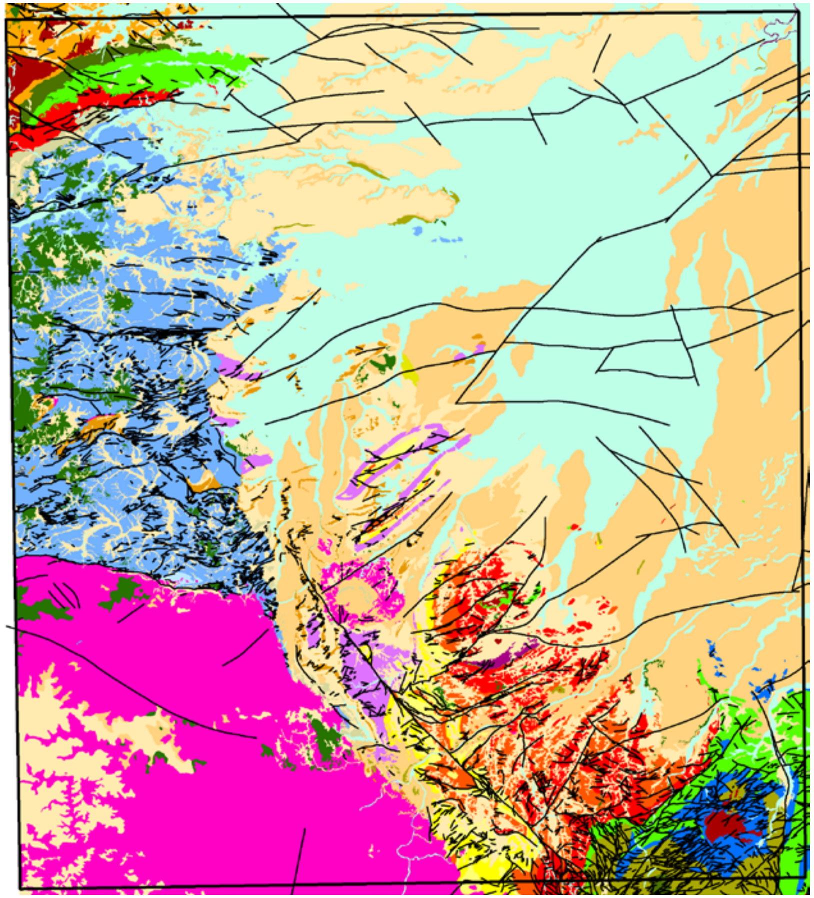
LAWN HILL



LAWN HILL

- The Proterozoic Lawn Hill Platform lies within the northern Mount Isa Inlier and is host significant base metal mineralization including the world class Century Pb-Zn-Ag deposit
- The potential to host additional substantial base metal reserves as well as oil and gas is significant
- The project area covers approximately 28,000sqkm
- Extends from the Murphy Inlier in the north to the Fiery Creek Fault in the south
- Overlain by over 70% cover

Lawn Hill has had a complicated history involving several tectonic cycles and consists of several stacked superbasins which overlie a Pre-Baraumndi Orogeny metamorphic basement



SOUTH NICHOLSON BASIN (1500-1400Ma)

- deposited after 85MY depositional hiatus and unconformably overlies ISB
- equivalent to the Roper Superbasin of the McArthur Basin, NT

ISA SUPERBASIN (1690 – 1595Ma)

- initial NNE-SSW extension followed by sag phase sedimentation
- widespread distribution across Lawn Hill
- Two main sequences: (*Upper McNamara* 1670-1640Ma / *Lower McNamara* 1640 – 1590Ma) includes Fickling Group equivs
- *Lower:* shales, carbonates and cherts
- *Upper*: deep water clastics & host significant mineralization (i.e. Century Deposit)
- sedimentation ceased with onset of the Isan Orogeny (1595-1500Ma)

CALVERT SUPERBASIN (1730 – 1670Ma)

- consist of coarse clastics, extension related bimodal volcanics & coeval Weberra granite
- overlain by shallow marine sediments deposited during sag phase sedimentation

LEICHHARDT SUPERBASIN (1790-1740Ma)

- formed in an active continental rift
- comprises conglomerates, volcanics, and metasediments
- distribution is uncertain across Lawn Hill Platform

PRE-1870 BASEMENT (>1870Ma)

- metasedimentary, volcanics and granitoids (Nicholson Granites)
- Deformed and metamorphosed during the **1870-1850Ma Baramundi Orogeny**
- 1800-1820Ma Yeldham Granite

The complex tectonic history has imprinted a distinct architecture on the Lawn Hill Platform (LHP)

Unlike Mount Isa, (N-S fault architecture), LHP is dominated by NE trending features bound by major NW striking faults (Termite Range and Riversleigh Faults)

This shift in the stress regime occurs across the Fiery Ck Fault system

Multiple step-like half graben faults are interpreted across the central & northern LHP with the NE trending faults partition depositional systems into local sub basins

Basement architecture defined during the Barramundi Orogeny (1870-185Ma) has been interpreted to have had a strong influence on current structural architecture, with younger faults reactivating and tapping into deep seated structures.

These faults play a significant role in the mineralizing story, focussing fluids at depth into half graben sub-basins during inversion episodes

MINERALIZATION

- A diverse range of mineralization types and styles exist in Lawn Hill, however Lawn Hill is largely known for the giant Century Zn-Pb-Ag deposit
- Mineralization is largely but not exclusively hosted within the McNammara Group (ISB) and equivalents

Sediment-hosted Zn-Pb-Ag deposits

i.e. **Century Deposit, Kamarga and Grevillea Prospects**

Mineralization occurs within the McNamara Group within half grabens where hot metal bearing brine fluids sourced from deep within the basin are focussed through reactivated faults to shallow depths where they spread laterally into the surrounding sedimentary rocks.

Sediment-hosted Pb-Zn-Ag Cu deposits

Walford Creek prospect; occurs on the major Fish River Fault within the Mount Les Siltstone, a lateral equivalent of the Upper MacNamarra Group

Bluebush Prospect; extensive and highly pyritic, weakly Zn-Pb-Cu mineralized silt shale and chemical sedimentary rocks (average ~1wt% Zn over 10's of metre intervals)

Brecciated sediment-hosted copper deposits

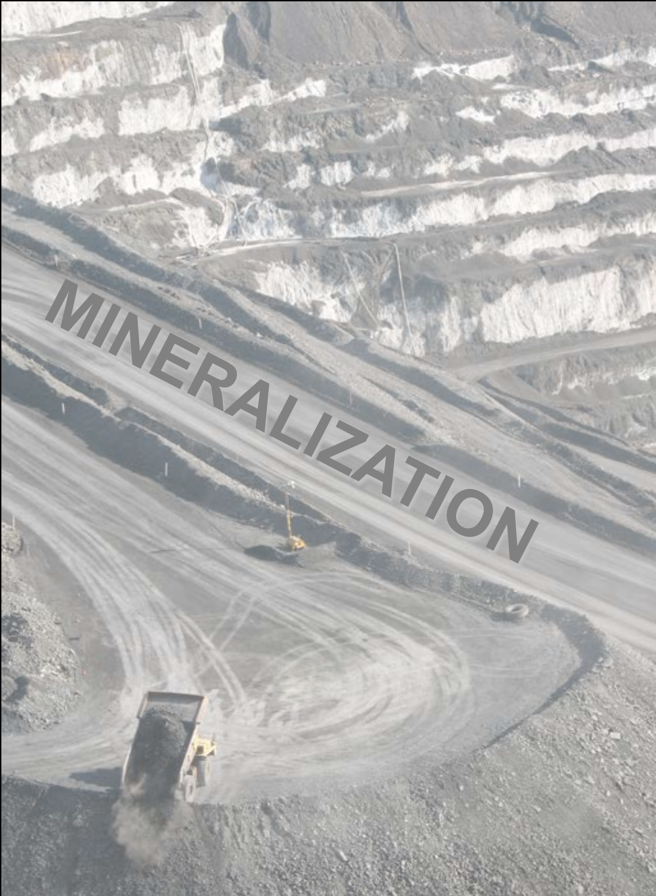
i.e. **Musselbrook, Kingfisher Prospect**

These deposits often discordant, structurally controlled, breccia-hosted, generally associated with silicification and occur as chalcopyrite in fault zones with fracturing, brecciation and recrystallisation of dolomitic sediments.

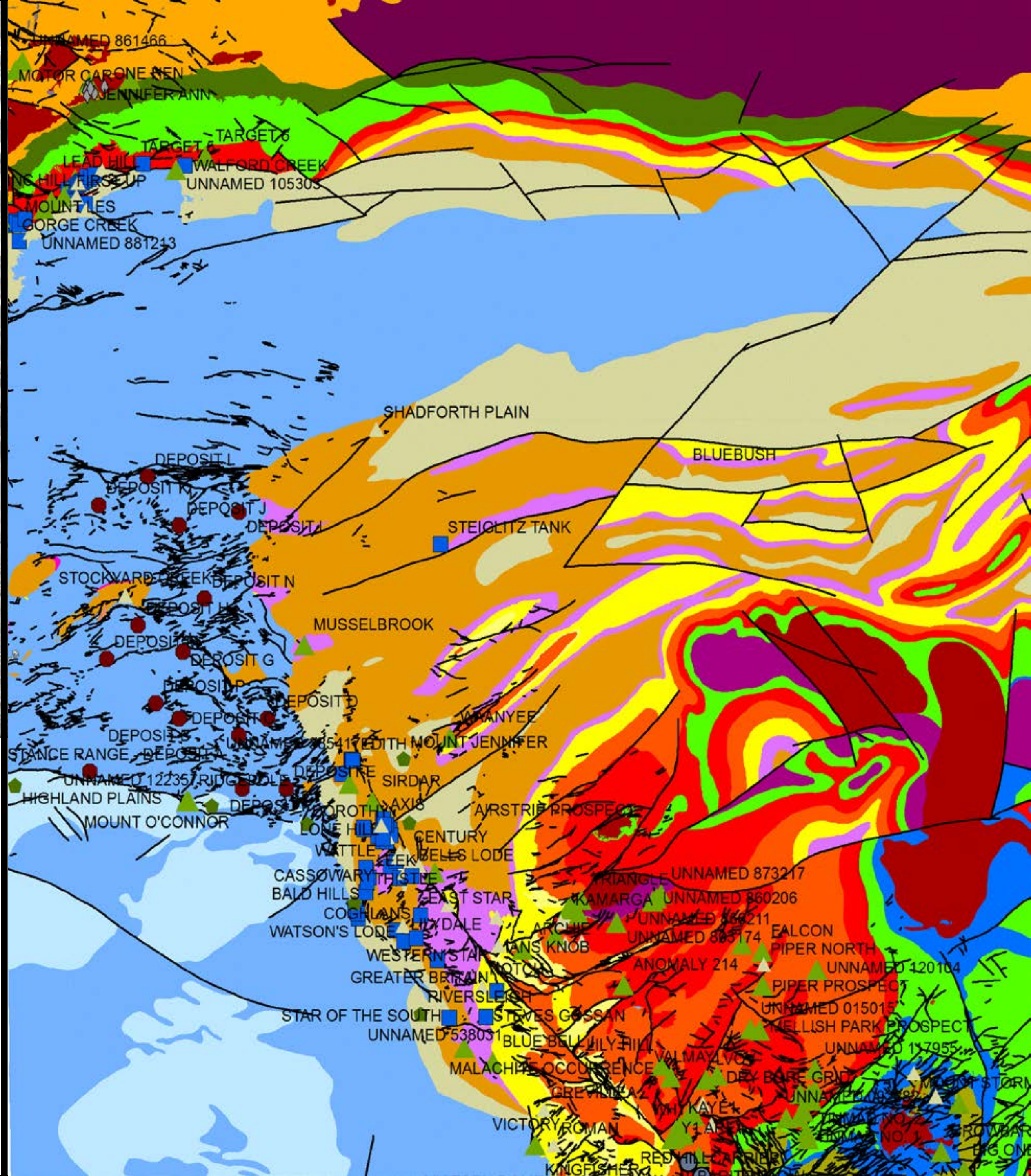
Usually occur proximal to major, deep-seated regional faults or shear zones and scattered locations proximal to Ag-Pb-Zn concentrations

Other Mineralization Occurs as:

- Skarn-hosted zinc-lead
- Oolitic Iron Formations
- Stratabound red-bed style copper mineralisation
- Mafic volcanic-hosted copper mineralisation
- Unconformity-related uranium



- BARITE
- COPPER
- IRON
- LEAD
- PHOSPHATE ROCK (PHOSPHORITE)
- SILVER
- TIN
- URANIUM
- ZINC



LAWN HILL PROJECT AIMS:

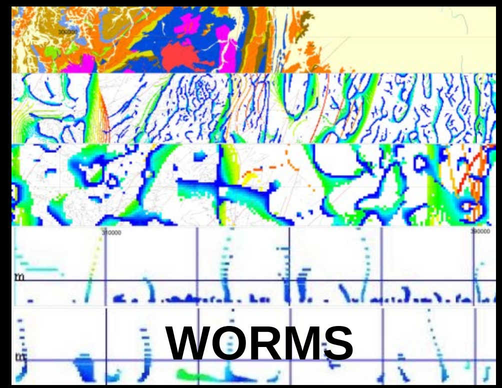
- Investigate the geological and structural architecture of the Lawn Hill region

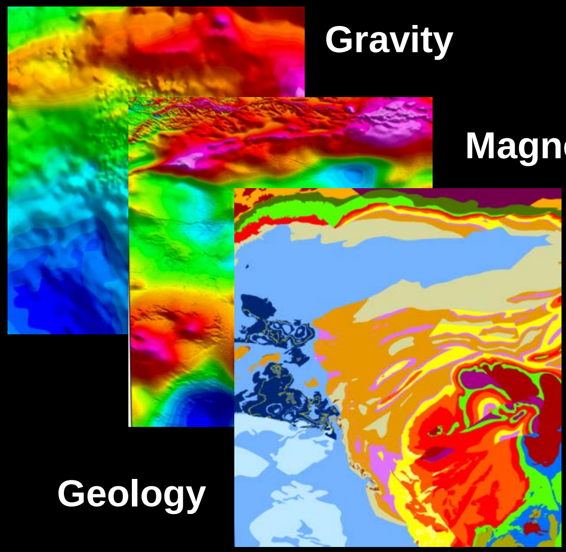
- Develop geologically and geophysically consistent interpretations of the subsurface and undercover regions utilising all currently available data and literature.

- Develop geophysically and geologically robust 3D models (Common Earth Model)

- Explore the mineral potential of the Lawn Hill regions using a data driven (WofE) approach and develop region specific 3D mineral potential maps

Seismic

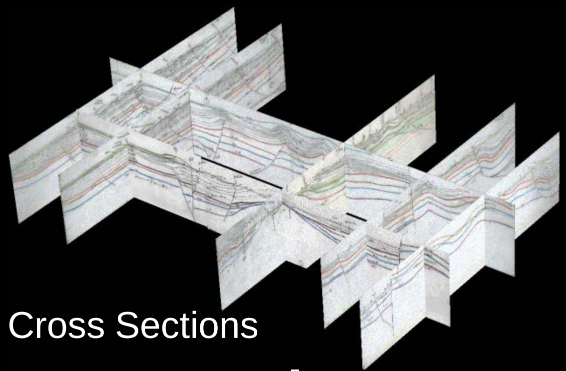




Gravity

Magnetics

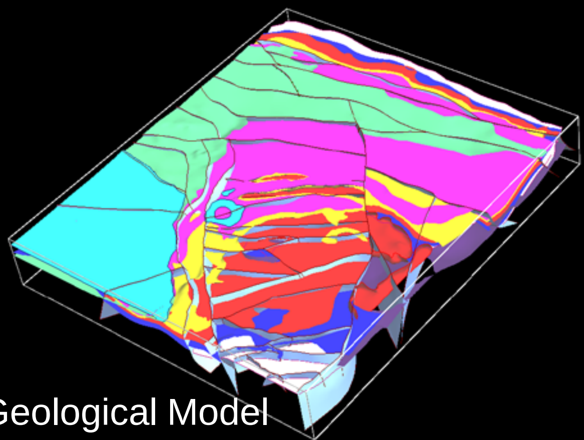
Geology



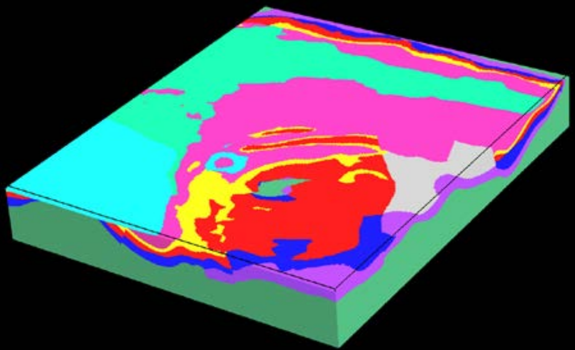
Cross Sections

The Lawn Hill work plan involves using modern modelling techniques to integrate all available datasets at a variety of scales

Ultimately this project aims to increase regional understanding and define the resource potential of Lawn Hill



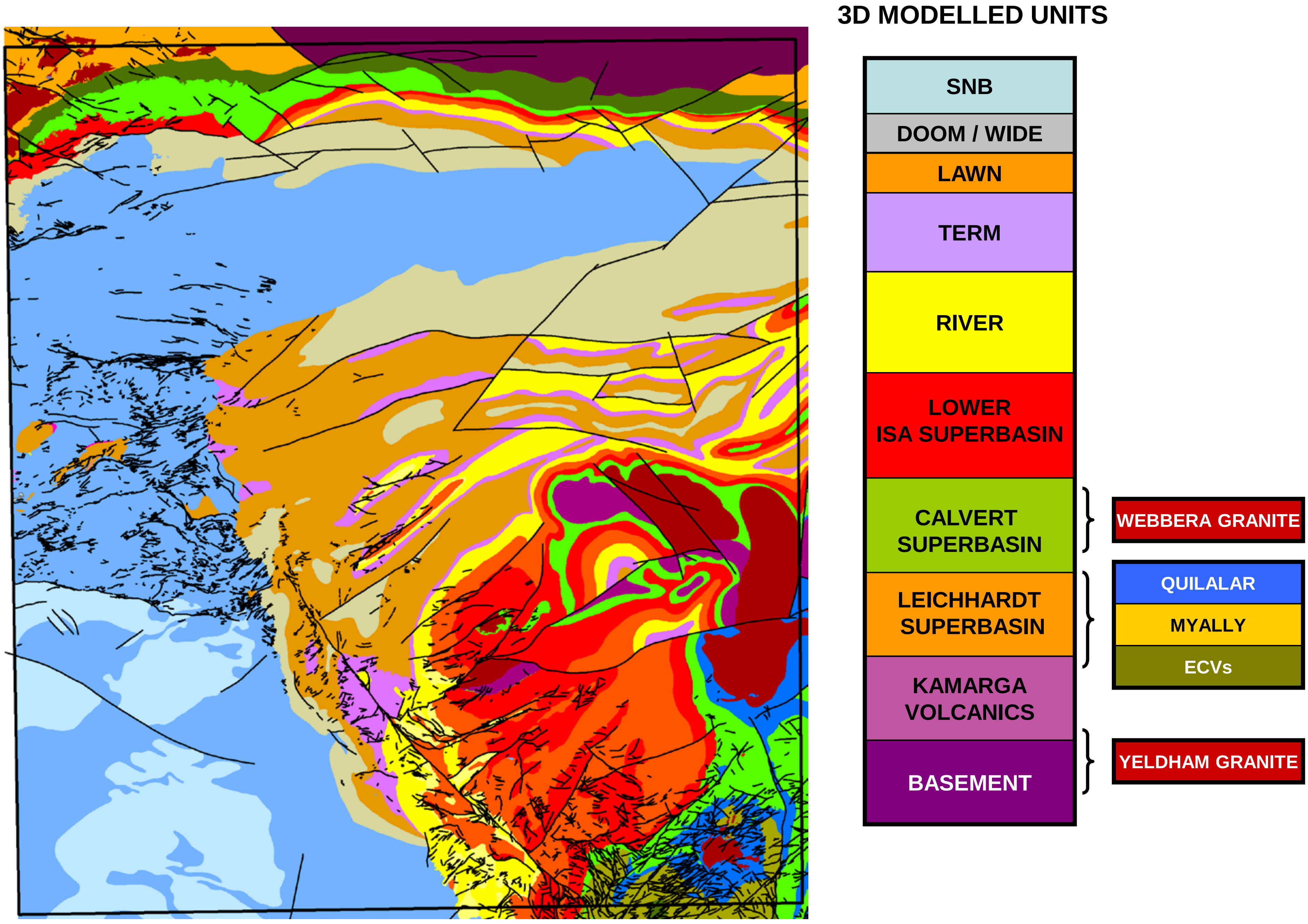
Geological Model



Raster Model

GRAV + MAG Inversions

Mineral Potential Maps



3D MODELLED UNITS
SNB
DOOM / WIDE
LAWN
TERM
RIVER
LOWER ISA SUPERBASIN
CALVERT SUPERBASIN
LEICHHARDT SUPERBASIN
KAMARGA VOLCANICS
BASEMENT
WEBBERA GRANITE
QUILALAR
MYALLY
ECVs
YELDHAM GRANITE

FIELD WORK

• Carried out in May 2011

• Better define unit relationships and fault orientations in key localities

• Collect representative rock property samples

The team braves the wilds of the Kamarga Dome

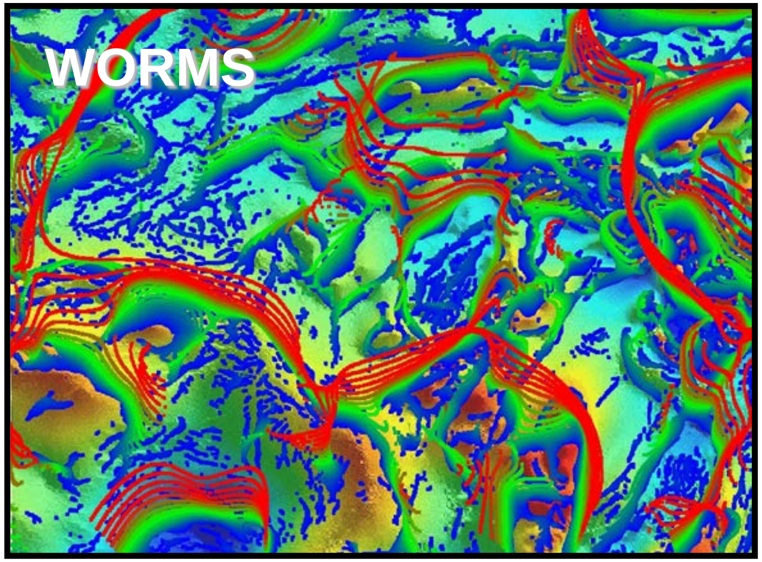
Peters Creek Volcanics

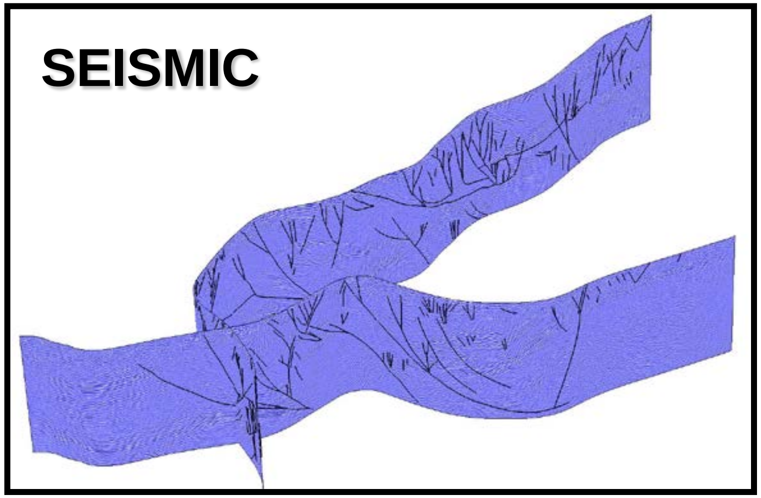
Stromatolites; Paradise Ck Formation

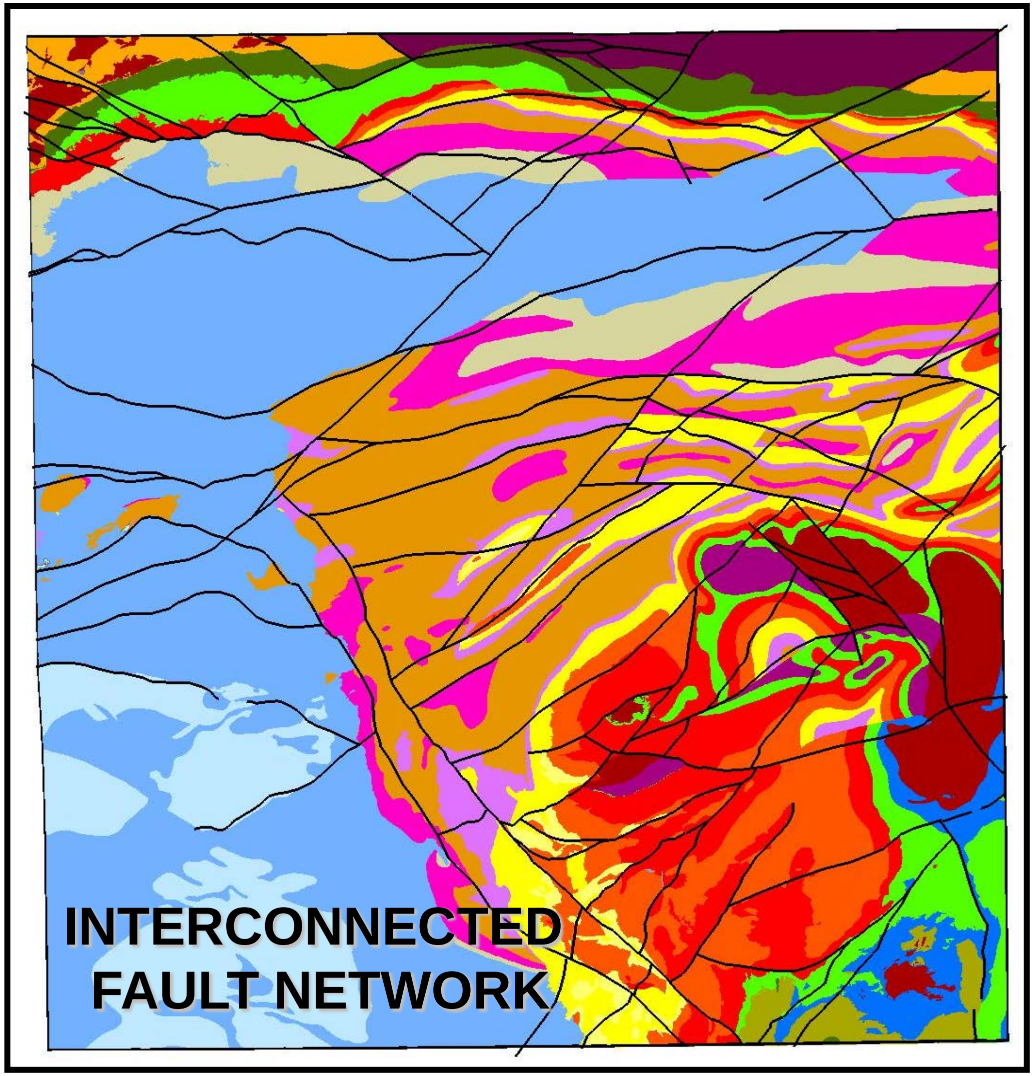
Torpedo Creek Formation

Lawn Hill Formation (Pmh2)

FAULT ARCHITECTURE



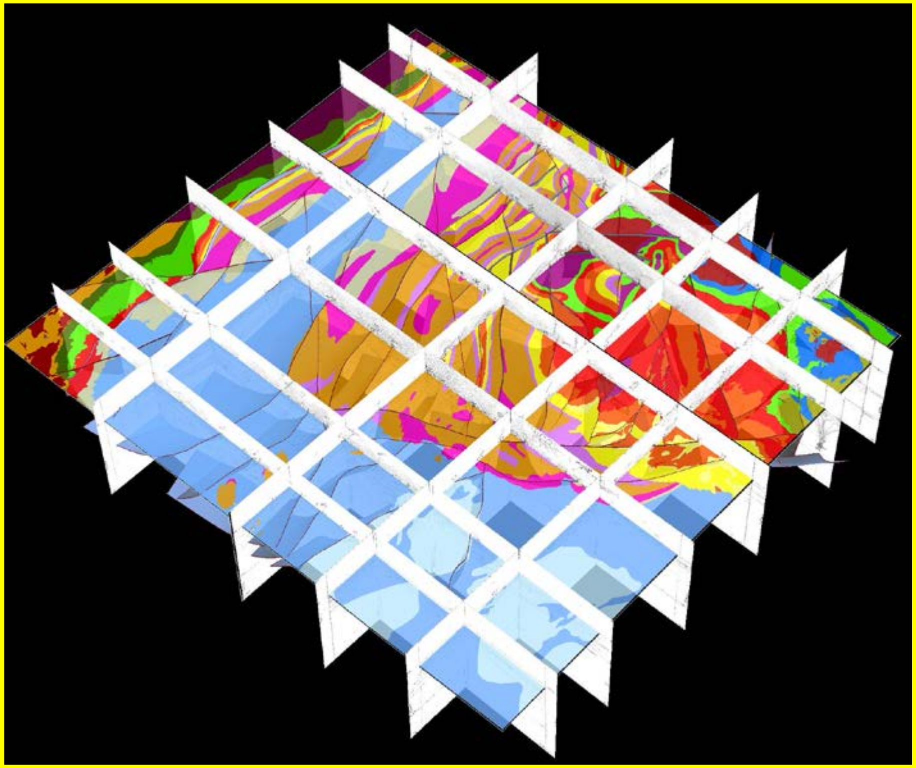


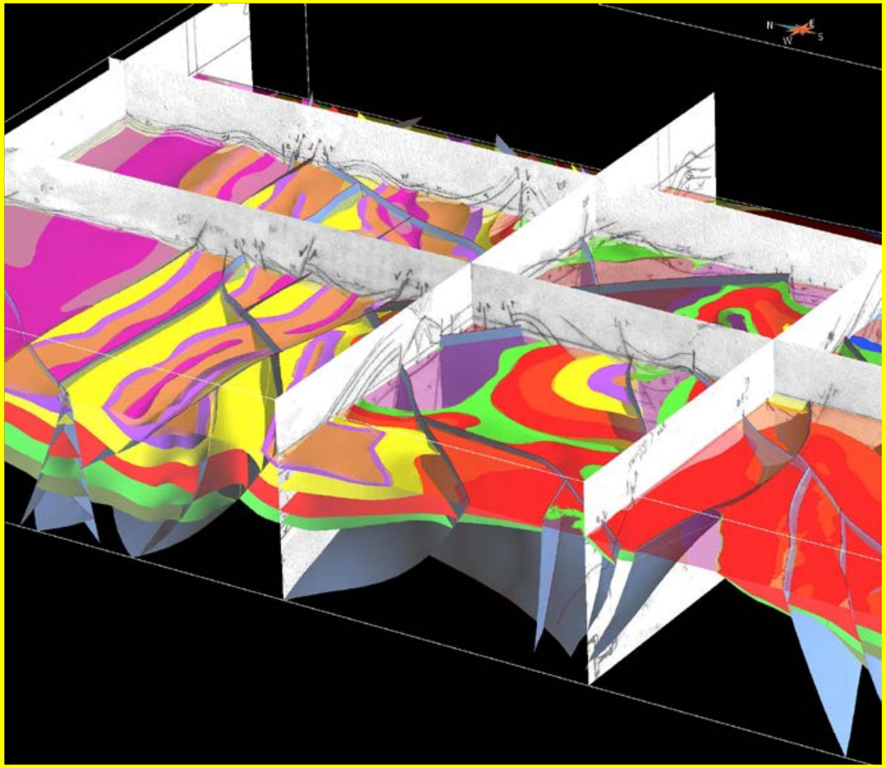


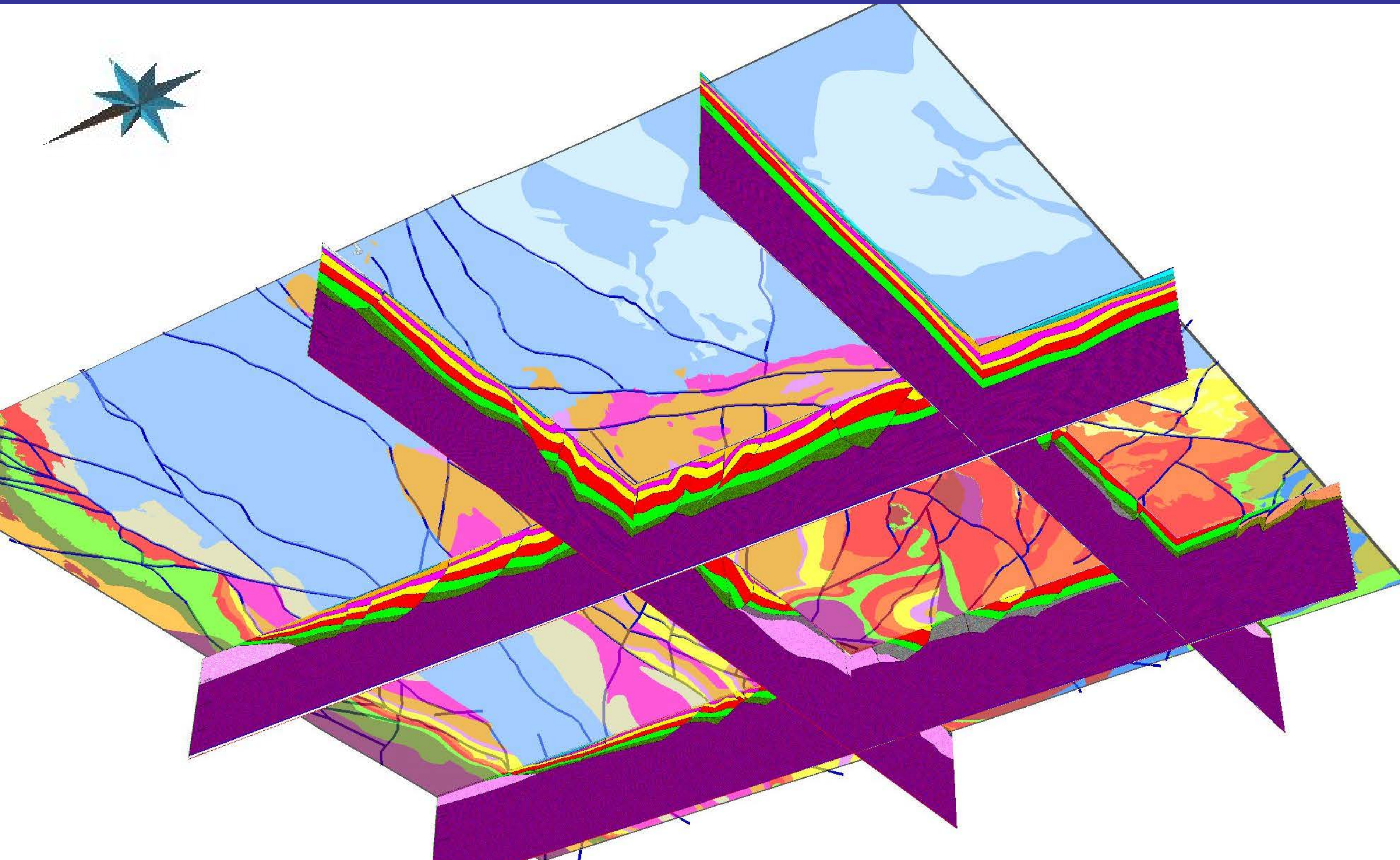
CROSS SECTIONS

- Ten cross sections drawn to define the subsurface geometries and lithological distributions

- Drawn at 1:250000 scale along a semi-regular N-S / E-W grid (~20km spacing)

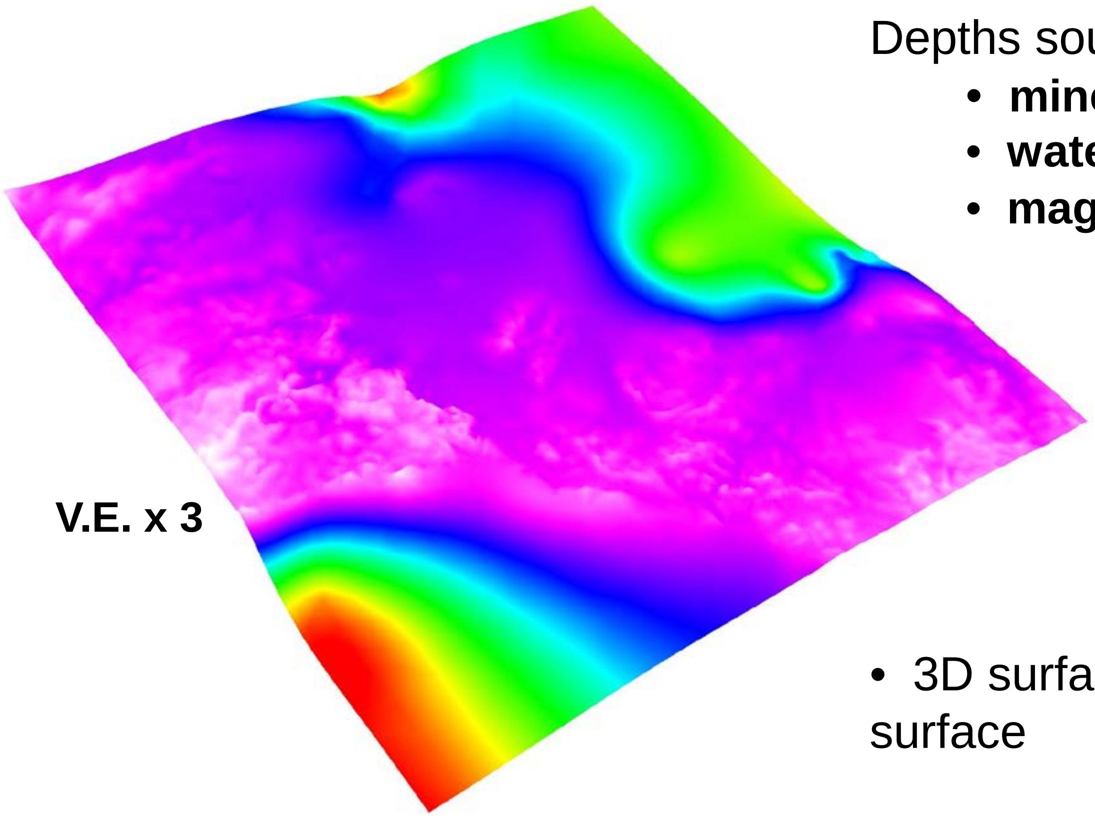






View from subsurface looking upward

DEPTH TO BASEMENT



Depths sources have been constrained from:

- **mineral exploration holes**
- **water bores**
- **magnetic depth to source modelling**

(NWQMEP Study)

- 3D surfaces have been constrained to this surface
- Cover depths range from >1000m to 0m

3D FAULT NETWORK

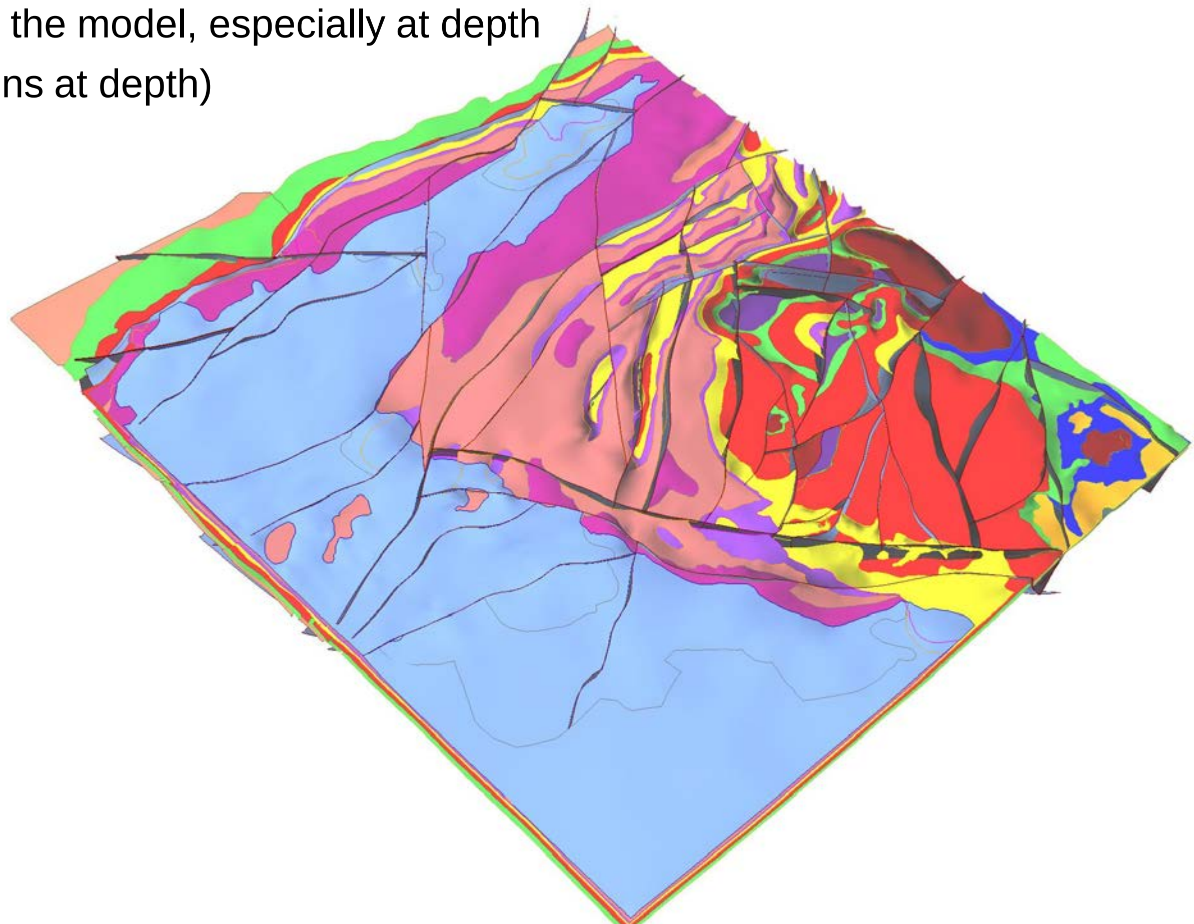
- Constructed in 3D using GOCAD-SKUA
- Over fifty faults
- Due to geological complexity of the region, an overall simplification was required
- Faults >10km strike length were constructed and where major breaks were identified

3D LITHOLOGIES

- Twelve units and two intrusive suites have been constructed using GOCAD
- Due to the complexity and size of the region simplification was required
- An overall layer cake type distribution has been assumed
- Significant uncertainties remain within the model, especially at depth

(i.e. fault orientations and unit distributions at depth)

SNB
DOOM / WIDE
LAWN
TERM
RIVER
LOWER ISA SUPERBASIN
CALVERT SUPERBASIN
LEICHHARDT SUPERBASIN
KAMARGA VOLCANICS
BASEMENT

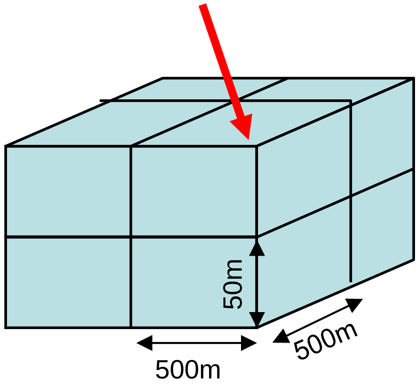


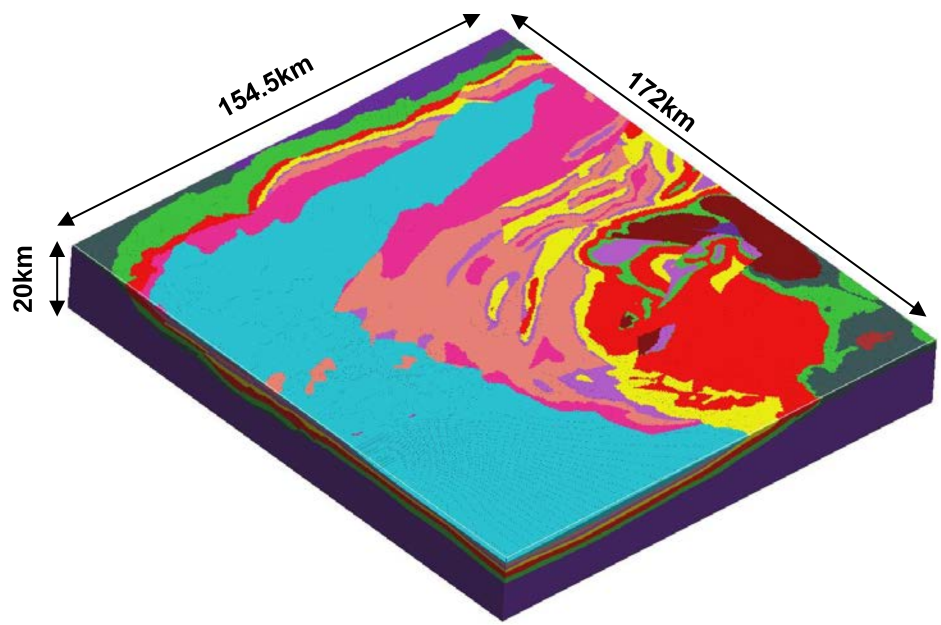
VOXET MODEL

- From the surface model a 3D grid model was created
- A grid resolution of 500m x 500m x 50m was chosen (total 43,956,450 cells)
- Each cell is assigned to a geological formation and populated with their physical rock properties
- The voxet model forms the input model for the inversion process

Each cell is assigned a lithological domain and populated with:

- *Density*
- *Magnetic Susceptibility*





Volumetric Model

GEOPHYSICAL INVERSIONS

- Several phases of geophysical inversion are currently underway

- The ultimate goal is to create an updateable model which is consistent with all potential field and geological inputs using rock properties as the link between geology and geophysics

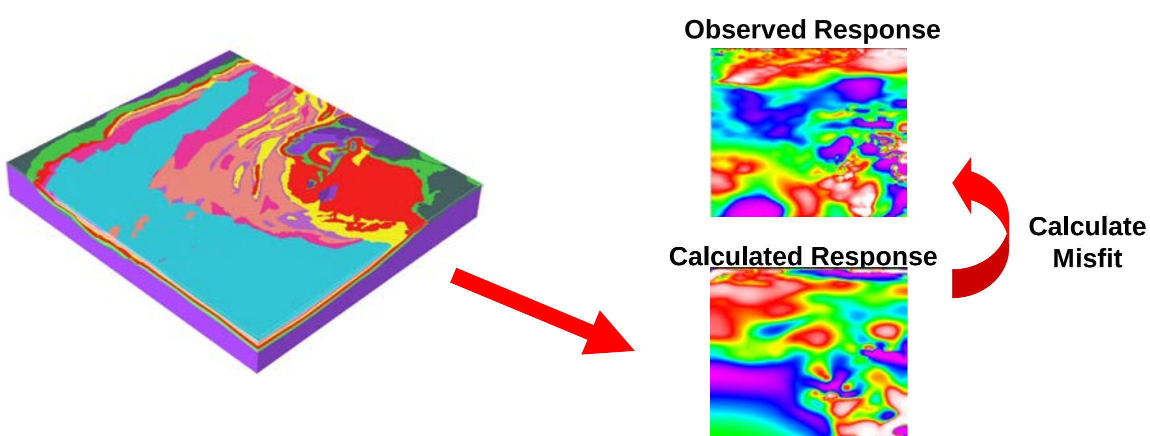
- Multiple steps using both VPmg and UBC-GIF will be undertaken to create a model which best fits magnetics, gravity and geology

VPmg

- initial full model scale inversions to 20km for Magnetics and Gravity
- homogenous inversions intended for property optimization
- heterogenous property inversion may be required to further reduce misfit

UBC-GIF

- high resolution tiled inversions for magnetics will be carried out for the upper 2.5km to target shorter wavelength features (shallower in origin)



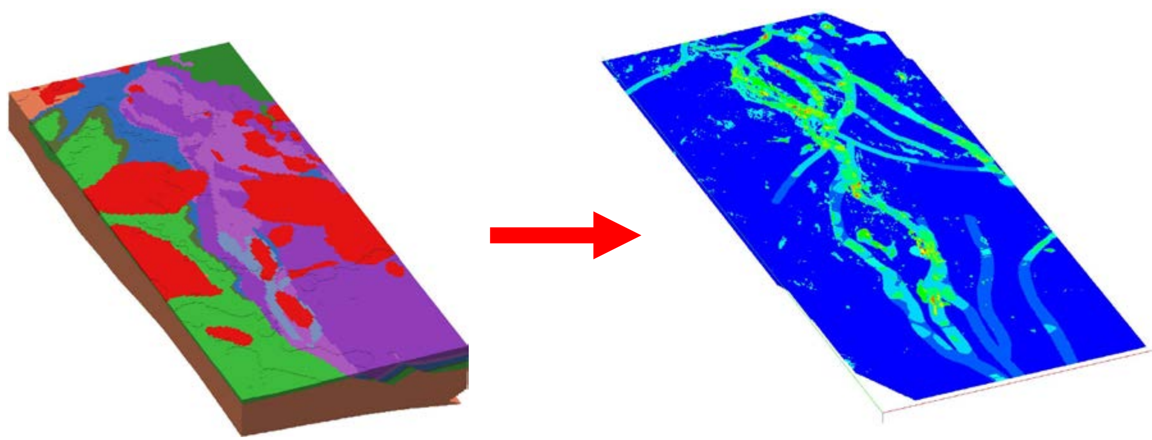
3D EXPLORATION TARGETING

Purpose is to evaluate the spatial distribution of known targeting criteria against the known distribution of deposits and prospects within the Lawn Hill region

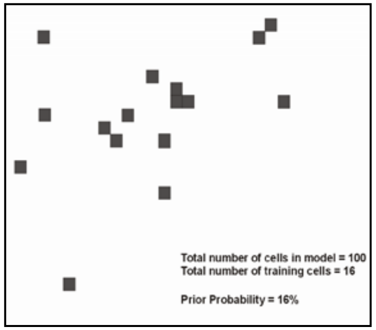
Correlation will be assessed by a data driven **Weights of Evidence** process applied to the 3D grid model

Applied through the GOCAD® **'Targeting Workflow'**

Aim to identify discrete groupings of cells within the model which have high exploration potential



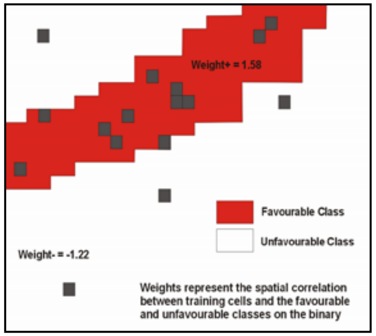
Mineral Potential Study: Example from Mount Dore Study

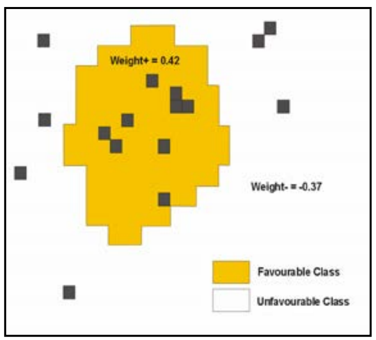


Prior Probability

Is computed from the ratio of training cells to the model volume

Calculates the probability of mineralization at any random cell in the model given no additional information except known deposits (training data)





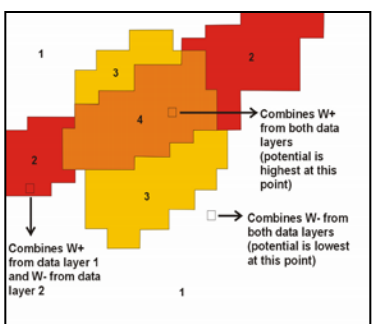
Exploration Criteria

For each exploration criteria a positive (**W+**) and a negative weight (**W-**) are computed within favourable and unfavourable regions respectively

W+ and **W-** are applied based on spatial correlations between the training cells and the favourable & unfavourable evidential properties (converted to binary properties)

$$W+ = \left[\frac{\left(\frac{\text{\# training cells in favourable region}}{\text{total \# training cells}} \right)}{\left(\frac{\text{\# cells in favourable region with no training data}}{\text{total \# cells in model with no training data}} \right)} \right]$$

$$W- = \left[\frac{\left(\frac{\text{\# training cells in unfavourable region}}{\text{total \# training cells}} \right)}{\left(\frac{\text{\# cells in unfavourable region with no training data}}{\text{total \# cells in model with no training data}} \right)} \right]$$

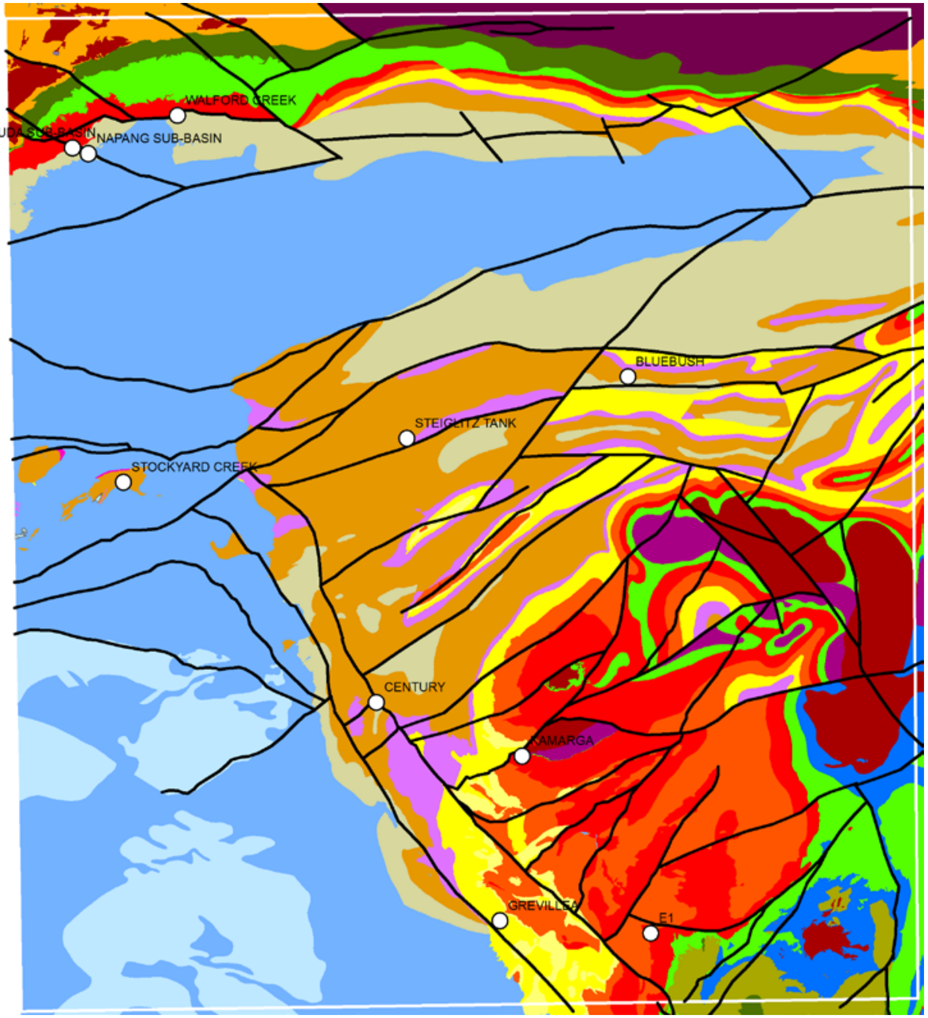


Ranked Mineral Potential

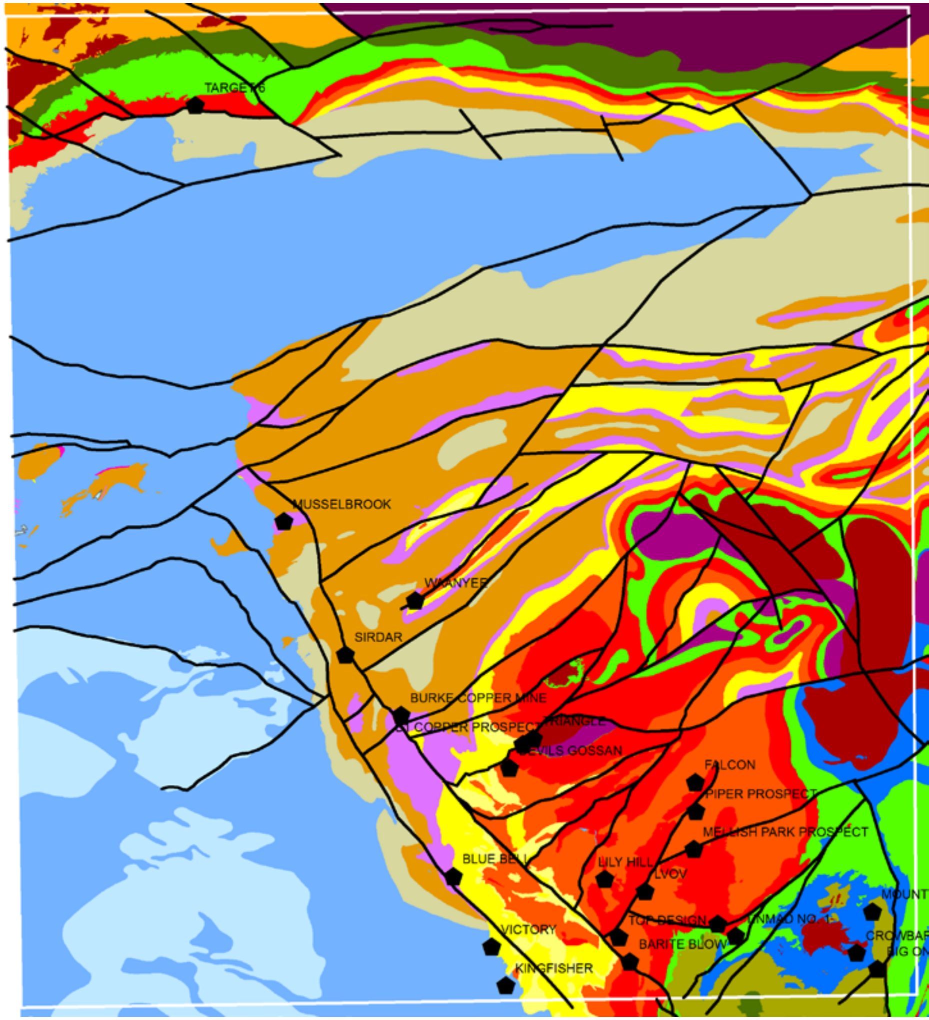
Once weights are assigned the mineral potential is calculated using the spatial overlap of the binary criteria

Class	Criterion 1	Criterion 2
1	absent	absent
2	present	absent
3	absent	present
4	present	present

LAWN HILL TRAINING DATA



Zn-Pb-Ag



Cu-Au

EXPLORATION CRITERIA

- **A review of targeting criteria has been carried out based on company reports and published literature**

- **These criteria form the basis for the Weights of Evidence study (examples below)**

Examples:

Sediment hosted Zn-Pb-Ag

- Presence of Isa Superbasin sediments
- Proximity to crustal scale, syn-sedimentation fault systems
- Presence of long strike length NNW trending fault zones (100's kms) with intersecting NW, EW faults and NE trending faults (these zones were reactivated during 1670-1590Ma mineralizing events)

Structurally controlled epigenetic Cu-Au

- Proximity to crustal scale faults active during compression
- Cu & Au geochemical anomalism (± strong links with Co, Mo, Ba, U, Ag, Ob, Zn, Bi, As, Ni, Se, Hg, Te, Sn, W, Ca, Mn, Y and F)
- Presence of source rocks (i.e. mafic volcanics) and diagenetic aquifers in lower parts of the stratigraphic pile (i.e. LSB sediments and volcanics)
- Zones of geological complexity where multiple potential fault dilations and rheological contrast can occur

UNCERTAINTIES

A number of uncertainties have come to light during the investigation of the Lawn Hill Platform

Dips and depth extent of faults
Seismic and potential field datasets are helping constrain some of these geometries at depth

Lithological distribution at depth and undercover. Lawn Hill has proven to not really be a well layered cake. What is the true distribution of LSB? How extensive are the Kamarga Volcanics?
Seismic, forward models and geophysical inversions are helping resolve some of these issues

Depth to Basement Modelling
Control points rely heavily on magnetic depth source modelling and sparse drill holes

Petrophysical rock property ranges are broad, largely due to the lumping of lithologies within the 3D modelled units.
Statistical analyses of these properties coupled with property optimisation during the inversion process will help reduce these issues

CONCLUSION

The Lawn Hill Project remains work in progress but final results will be released within 2012

Through the geological modelling process coupled with inversion techniques a robust integrated 3D model can be derived.

This process will provide a greater overall understanding of the geology of Lawn Hill region both in outcrop and in undercover areas

Using the quantitative Weights of Evidence studies using the Lawn Hill model will ultimately lead to an increased understanding of the mineralizing systems within Lawn Hill which in turn will help narrow the search window for discovery


76


THANK YOU!!


CAT
THIS IS A TRUCK