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CREATE CHANGE

NWMP Target Compilation

Aims

- Provide awareness of previously developed targets
  - What was their basis?
  - More broadly applicable?
- Consider limits to applicability
- What else could be done
- Potential to rank or consider your own areas
- To what extent do they agree or disagree?
- Target Types
  - Empirical
  - Conceptual
  - Prospectivity

Geochemical Anomalies

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95_percentile_Cu

Shapefile

Description | Spatial | Attributes

Keywords

Theme: exploration geochemistry, rockchip analyses, soil analyses, stream sediment analyses, statistical appraisal, regional geochemical synthesis

Place: North-west Queensland, Australia

Description

Abstract

This theme depicts the 95 percentile copper assay values for all surfac

This theme depicts the 95 percentile copper assay values for all surface sample types within the study area that included soil, stream sediment and rock chip analyses. The geochemical data used in the statistical analysis were compiled from open-filed exploration company reports submitted to the Geological Survey of Queensland. The data are heterogeneous with over 2000 analytical variables and data quality are highly variable.

Purpose

To display the location of copper aureole at the 95 percentile value wh

To display the location of copper aureole at the 95 percentile value which has been defined statistically within the study area for all surface sample types

Supplementary Information

The data set is sourced from the Department's Exploration Geochemistry

The data set is sourced from the Department's Exploration Geochemistry and Drill Hole Database, which was compiled from Queensland open-filed exploration company reports submitted to the Department.

99_Percentile_Cu

Shapefile

Description | Spatial | Attributes

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Cu_Anomaly

Shapefile

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Description

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This theme depicts the distribution of copper anomalies defined statis

This theme depicts the distribution of copper anomalies defined statistically as "Mean + 2 standard deviations greater than the 99 percentile" for all surface sample types within the study area that included soil, stream sediment and rock chip analyses. The geochemical data used in the statistical analysis were compiled from open-filed exploration company reports submitted to the Geological Survey of Queensland. The data are heterogeneous with over 2000 analytical variables and data quality are highly variable.

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Geophysical Anomalies

- Geophysical Anomalies
  - radmap_v3_2015_filtered_ppmu_gt10_esri_polygons
  - onshore_geodetic_Complete_Bouguer_2016_QLDABC_5kRES_99pt5_pctile_esri_polygons
  - Mag_Anom_2000nT_threshold_polygons

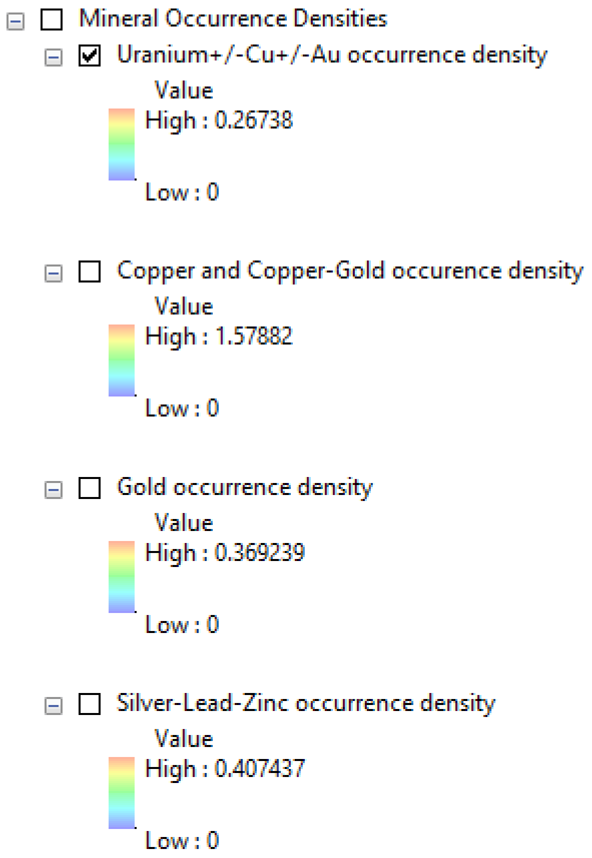
>10ppm U from Radiometrics

99.5th percentile bouguer gravity high

Magnetics RTP greater than 2000nT

Lots more could be done with this!!

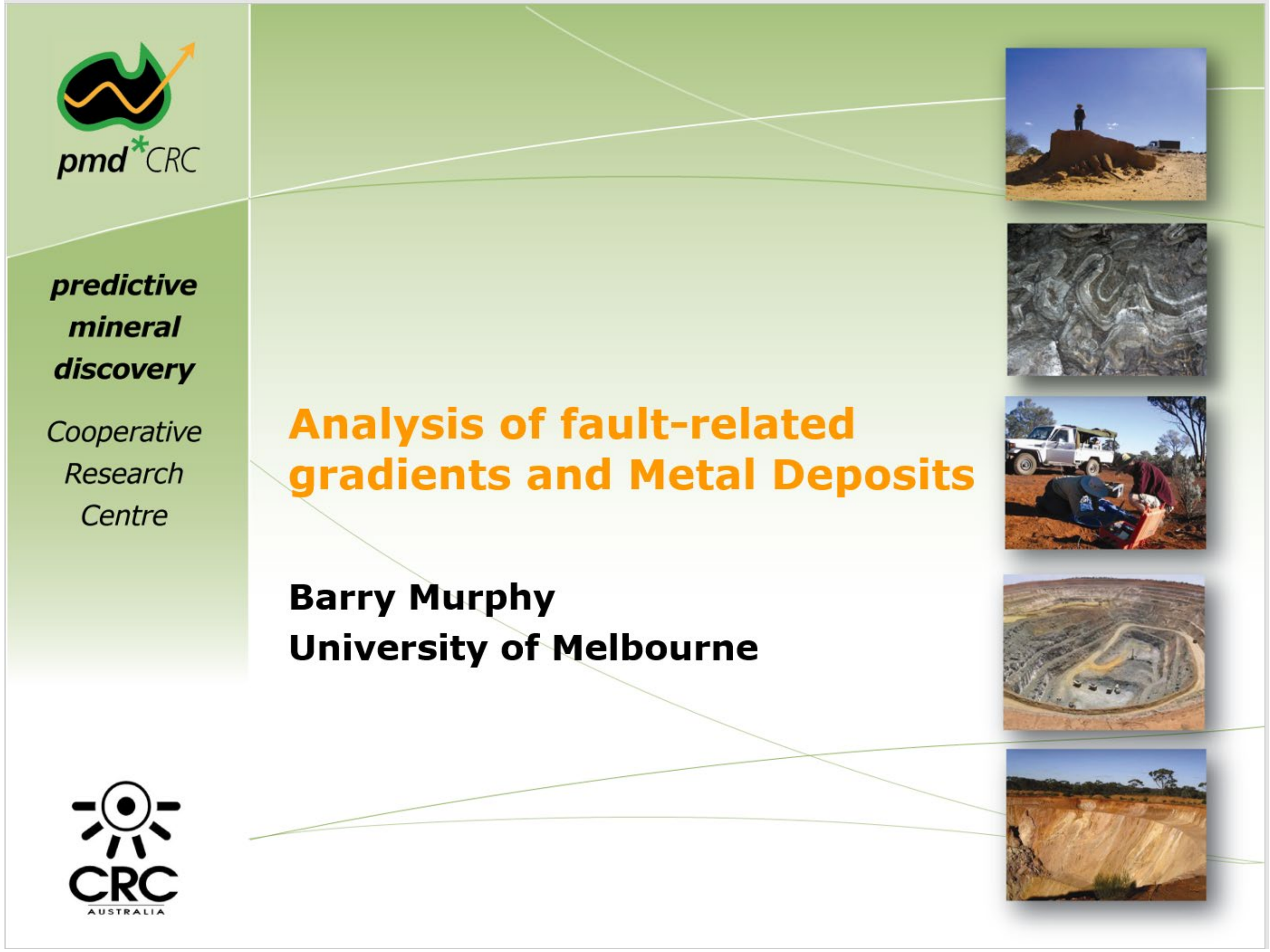
Mineral Occurrence Densities



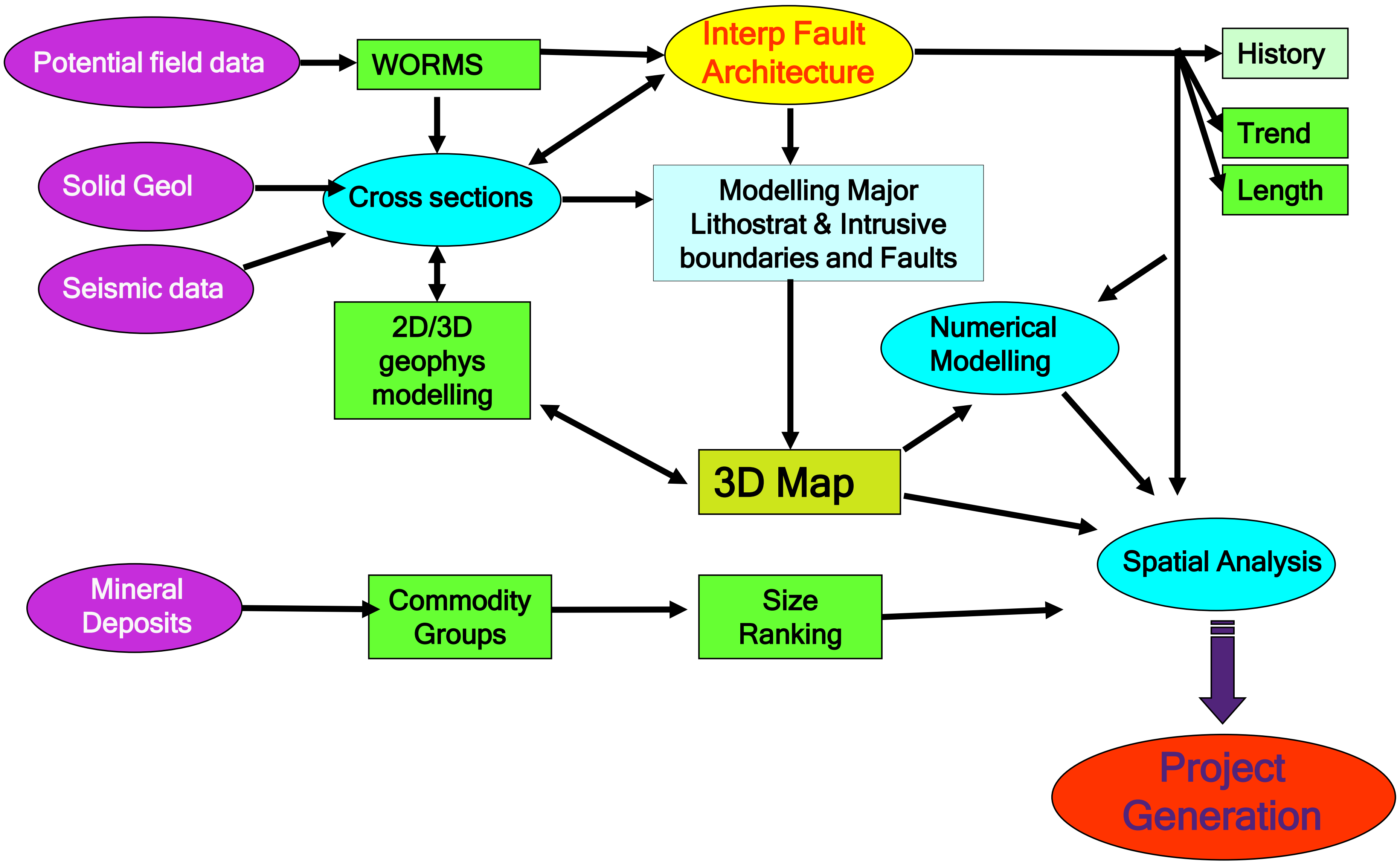
Mineral Occurrence density

- From GSQ Mineral Occurrence database
- Classified according to the terms in that database
- 1km grid over entire inlier
- Counting number of deposits within a 5km radius of each point

Pmd*CRC Conceptual – Lawn Hill



Pmd*CRC Conceptual – Lawn Hill



Pmd*CRC Conceptual – Lawn Hill

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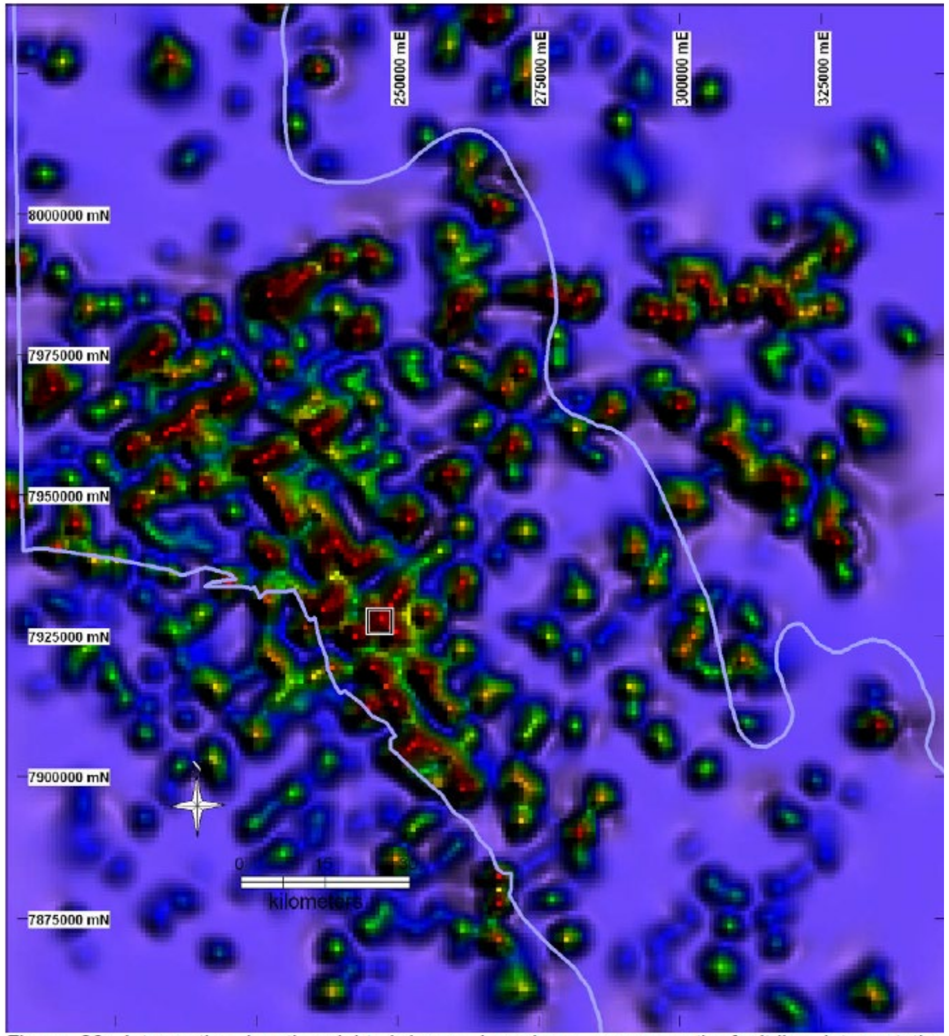
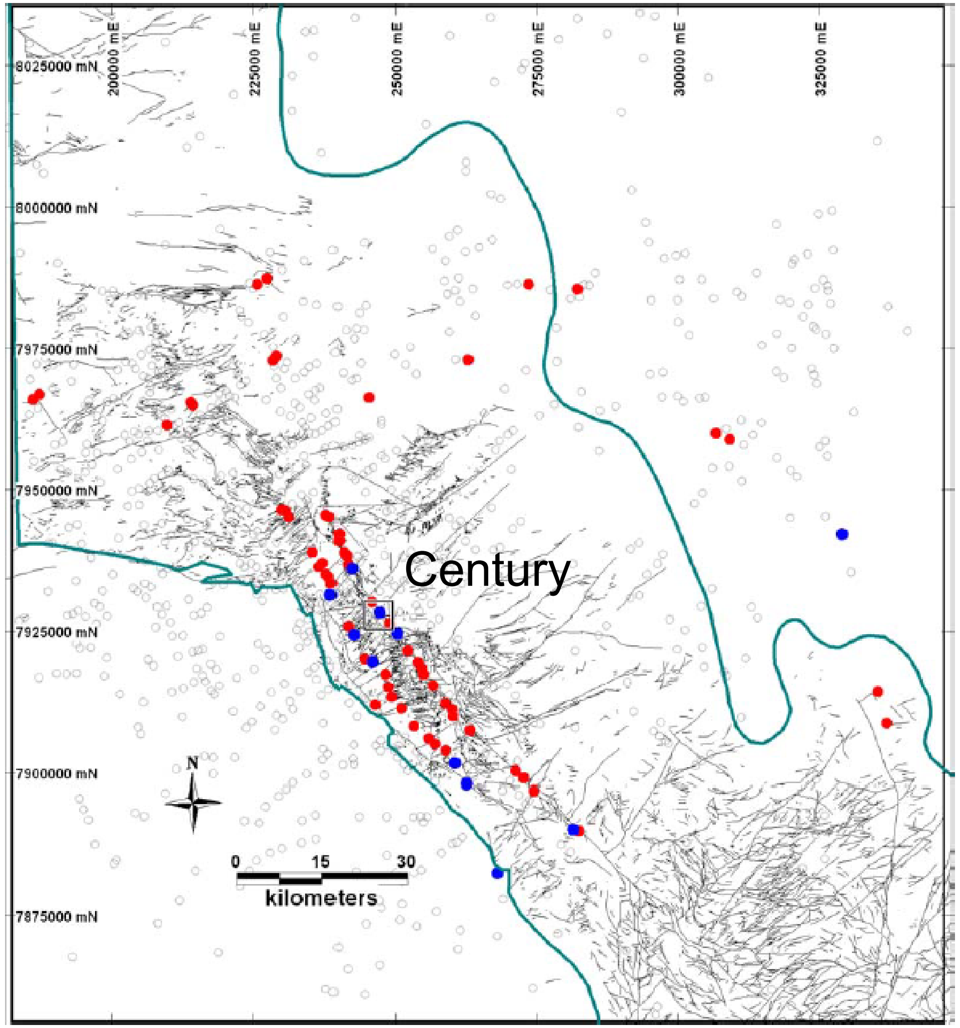


Figure 28: Intersection length-weighted image based on aeromagnetic fault-line interpretation. Warmer colours represent longer line intersections. Includes Proterozoic outcrop boundary and Century mine.



(c)

Figure 29: Aeromagnetic fault-line intersections as scatterplots of (a) Minimum and Maximum Length, (b) Minimum and Maximum Trend, and (c) spatial distribution of the population. See text for discussion of colour coding. Century deposit highlighted as boxed symbol in each plot.

Intersections
Red or Blue
Min > 50km
Max > 80km

Blue – NW trends
Red – ENE trends

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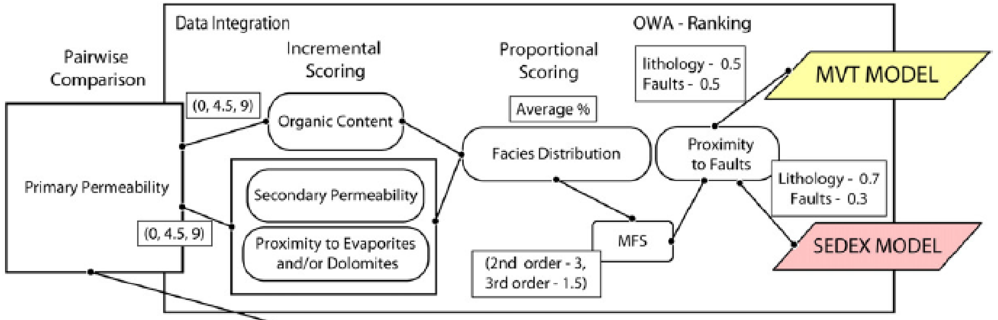
Predictive modelling of prospectivity for Pb–Zn deposits in the Lawn Hill Region, Queensland, Australia

Leonardo Feltrin *

Predictive Mineral Discovery Cooperative Research Centre, School of Earth and Environmental Sciences, James Cook University, Queensland, 4811, Australia

Knowledge-driven model



	Primary Permeab. Score (SEDEX)	Primary Permeab. Score (MVT)	Total Score (SEDEX)	Total Score (MVT)
Bre	0.5	17.5	5	26.5
C-Sh	15	3	24	7.5
Che	17.5	0.5	22	18.5
Cg	0.5	17.5	0.5	22
Cr-dol	17	1	21.5	14.5
D-mud-sts	11.5	6.5	16	20
D-mud-gra-str	9	9	13.5	27
San-Sts_str	5.5	12.5	10	30.5
Dololut	10.5	7.5	15	12
L-San	2.5	15.5	7	15.5
Carb-Qtz-San	8	10	12.5	28
Qtz-San	2.5	15.5	2.5	15.5
Qtz-San-Dolst	5	13	9.5	26.5
Dolosts-sh	12	6	21	15
Sh	15	3	24	7.5
Sts	7	11	11.5	11
Sts-San	5	13	9.5	13
Sts-Sh	12	6	21	6
T	14.5	3.5	14.5	3.5

Fig. 8. Schematic diagram portraying different phases of expert-driven weighting. Initial phases involved development of numerical scores based on pairwise comparison of primary permeability of different lithotypes. Incremental scoring is used in a second phase to account for the organic content, secondary permeability variation, and relative content of evaporites and dolomites. Proportional scoring uses a qualitative estimate (average %) of the spatial distribution of lithofacies within each considered stratigraphic interval. The final models (SEDEX, VS) consider also additional scores for occurrence of maximum flooding surfaces and proximity to faults (see text).

SEDEX VEIN-STYLE

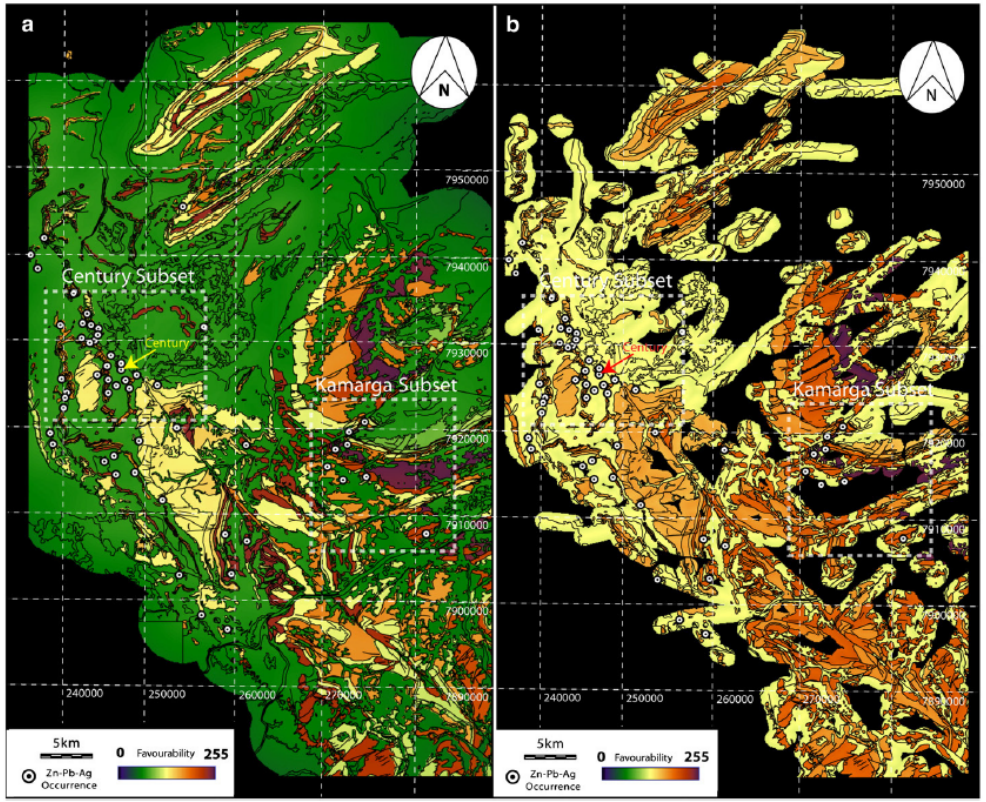


Fig. 10. Maps of mineral potential derived from knowledge-driven modelling compared against known distribution of mineral occurrences. (a) SEDEX model shows that known deposits are localised within areas where less-permeable units are present. Favourability is dominated by lithological variation rather than fault control (note large 5 km fault buffering). The model is not restrictive therefore wide areas may have potential for SEDEX-type mineralisation in the region. However, if we consider the relationship to clusters of small tonnage deposits and Century, the prospectivity may be constrained to areas where a similar spatial association occurs (e.g. the Kamarga Dome Area). This area records also elevated lithostratigraphic potential. (b) VS model with equal weighting for faults and lithological control (1 km buffer chosen for faults). Most of the prospect/deposits occur in the northwestern part of the Lawn Hill Region. In contrast, the knowledge-driven model output for VS ore predicts the occurrence of mineralisation in the southeastern part of the Lawn Hill Region. This may be explained either as due to relative undiscovered sites in the favourable intervals or to local redistribution of syngenetic mineralisation that would justify the linkage of VS deposits to Century-style mineralisation in less favourable areas.

Data-driven model

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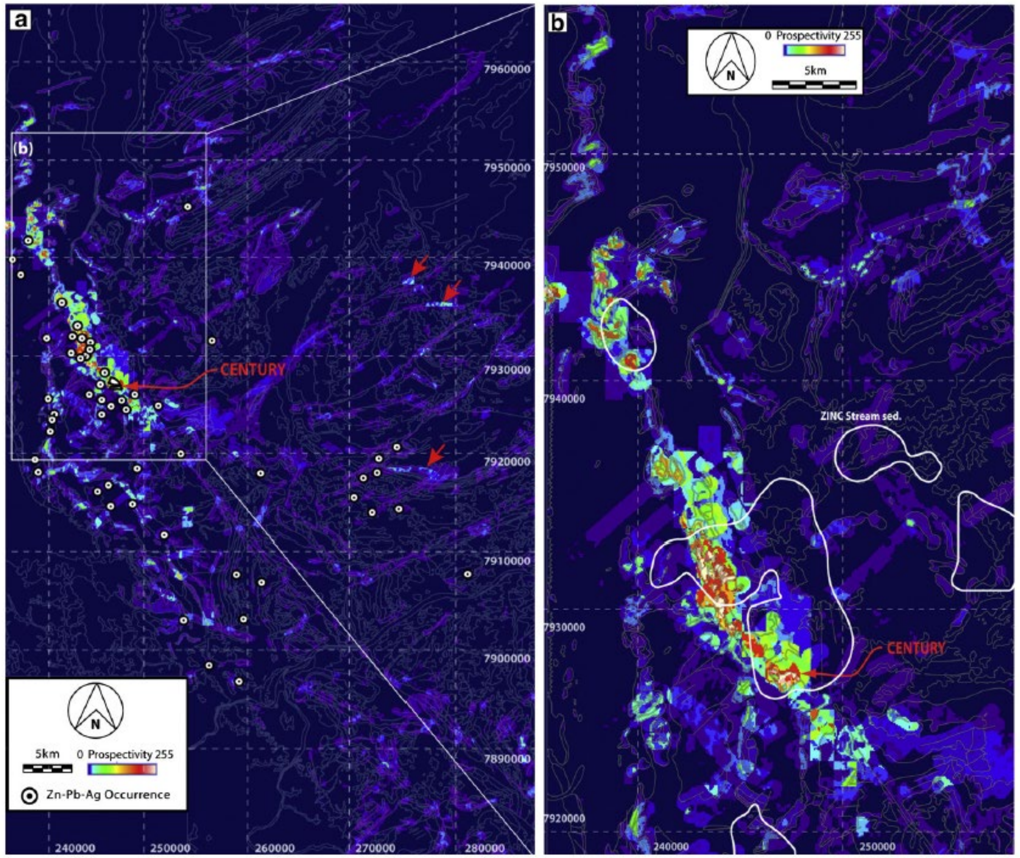

Fig. 16. Output of data-driven modelling considering 11 layers (3 rejections) and missing information related to cover sediments (QTJ – see Fig. 1a). (a) Data-driven model compared against known mineral deposits/prospects. Note the high potential along the Termite Range Fault, which was expected considering that clusters of known deposits are located in this area. However, local highs (although with lower values) are found in the Kamarga Dome area (see arrows). (b) Enlargement of Century area showing comparison of high-probability sites with geochemical stream sediment data (anomalies above 100 ppm of Zn content are indicated as closed polylines).

11 layers – not clearly specified

SEDEX VS DIFFERENCE

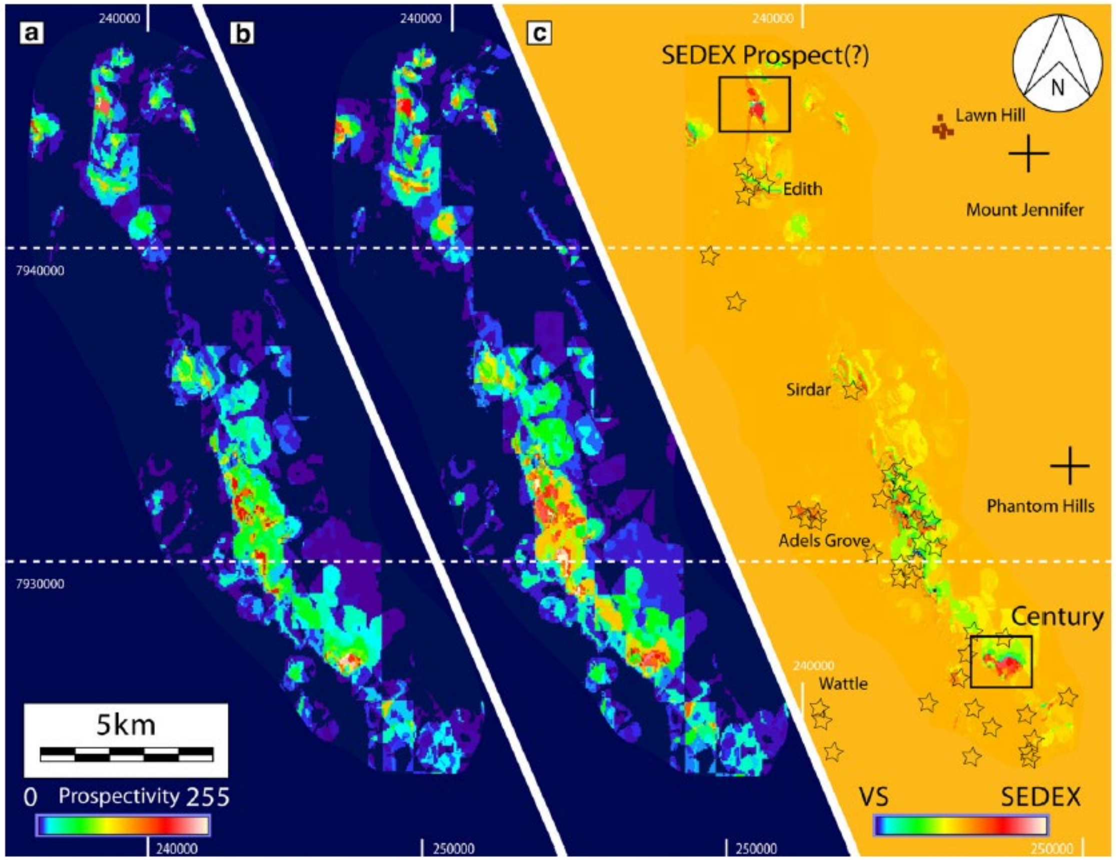

Fig. 17. Comparison of integrated knowledge- and data-driven models. (a) SEDEX model. (b) VS model. Difference between the two total models is outlined in (c). The first two models offer similar results although local differences (km-scale) can be used to discriminate on a probabilistic ground between areas of elevated mineral potential for SEDEX or VS mineralisation. A potential SEDEX target is outlined because of its similar favourability values to the Century deposit.

DMQ Targets – 3 styles

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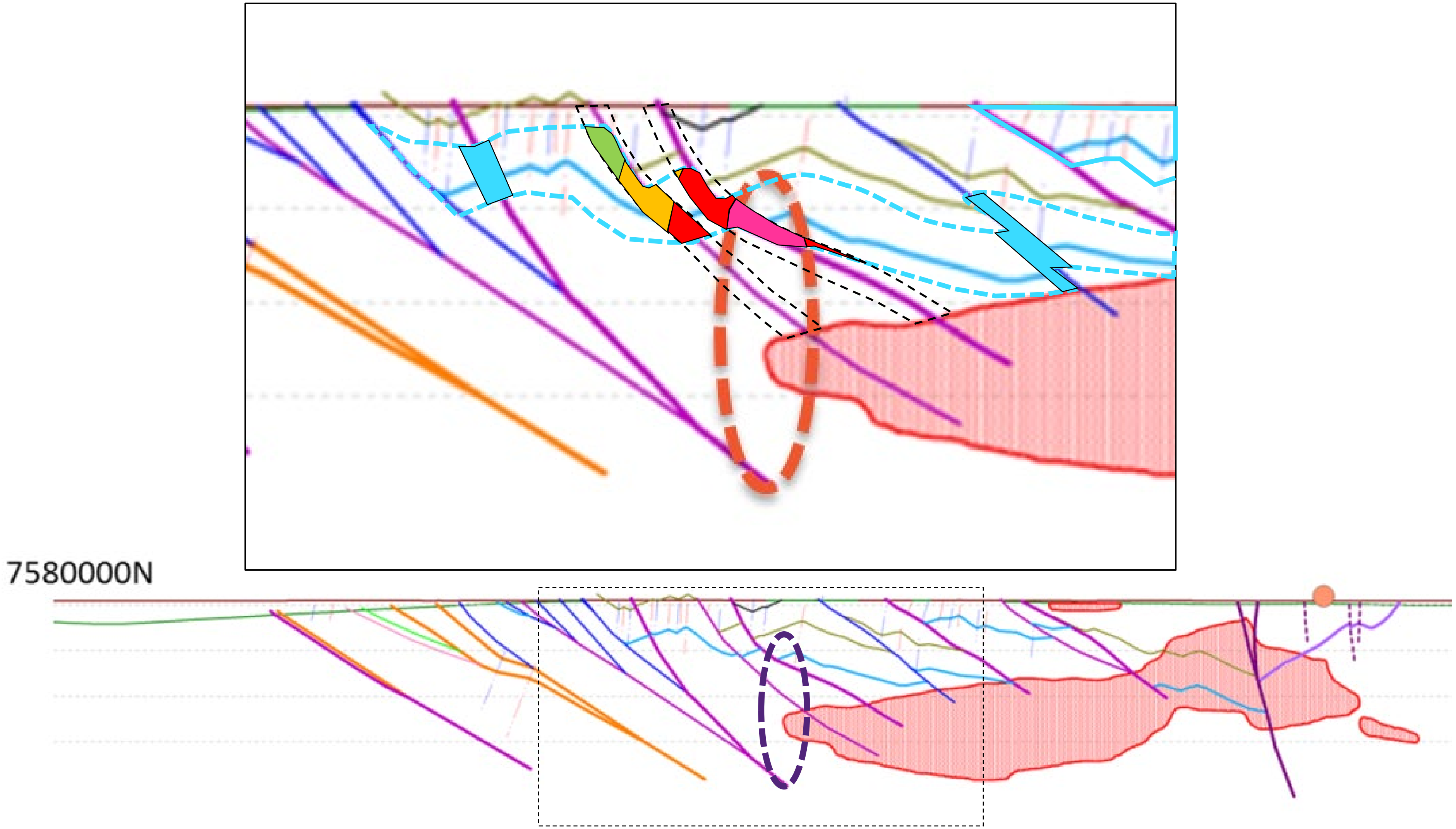
1. Deposits Hosted Within the Upper Staveley/Lower Kuridala Stratigraphy.
   - Rheological contrast between Calc-silicates, Roxmere Quartzite, and Kuridala schists seen as a focus for deformation and exploited during mineralization in late D3.
   - ‘Other’ rigid bodies at this stratigraphic position, e.g. SWAN Diorite, offer further rheological contrast and focusses brecciation/secondary permeability and potential to host mineralization if within a fluid cell.
   - Redox potential of Staveley in contact with overlying reduced rocks (Figure 5.2) inferred as an important ingredient.
   - Presence of ironstones yields discrete targets within this broader stratigraphic package.
   - E.g. Osborne-Kulthor, Mt Elliott-SWAN, and Merlin-Mt Dore deposits.

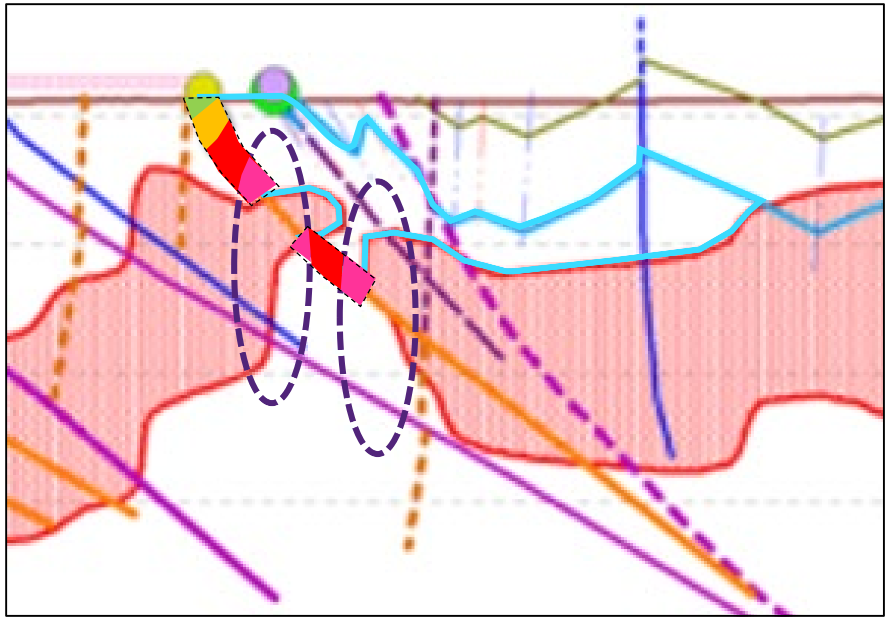
2. *Structural juxtaposition of Staveley with Other (Reduced) Packages.*
   - Likely to be evidently structurally-controlled/hosted
   - Greater potential expected where Staveley is in structural contact with reduced packages such as Answer Slate/ Toole Creek Formation.
   - Focussing relationship of early structural features, likely reactivated basement structures.
   - E.g. Starra line of deposits.

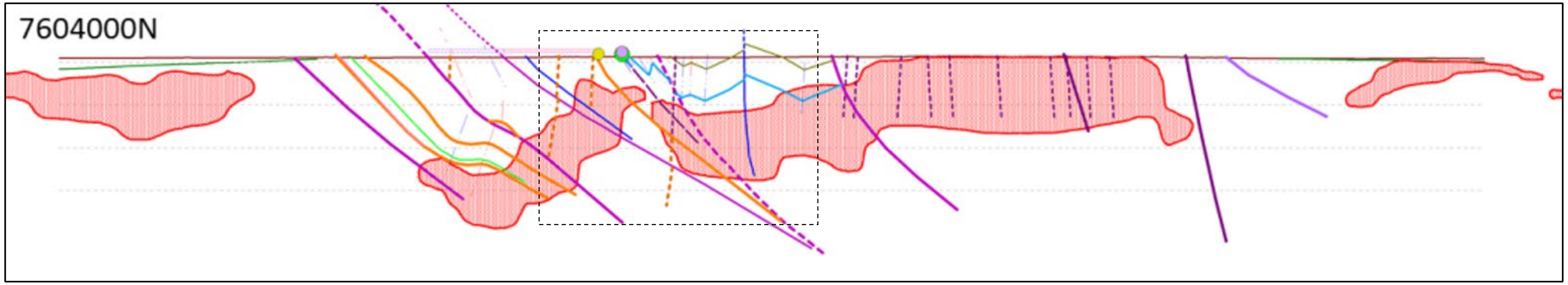
3. *Deposits hosted in Overlying Sequences, but Related to Staveley:Granite:Fault Association at Depth.*
   - Highly variable deposit-style possible.
   - Deposits may be structurally-focussed or within broader breccia bodies.
   - Intrusion of granite into the Staveley calcareous sequence inferred as driver for brecciation (CO_2 release).
   - E.g. EH, Eloise

Swan-style

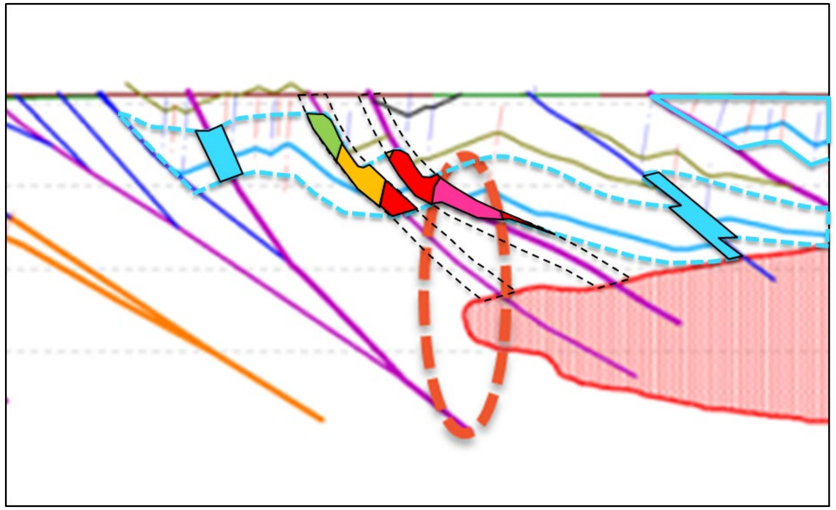


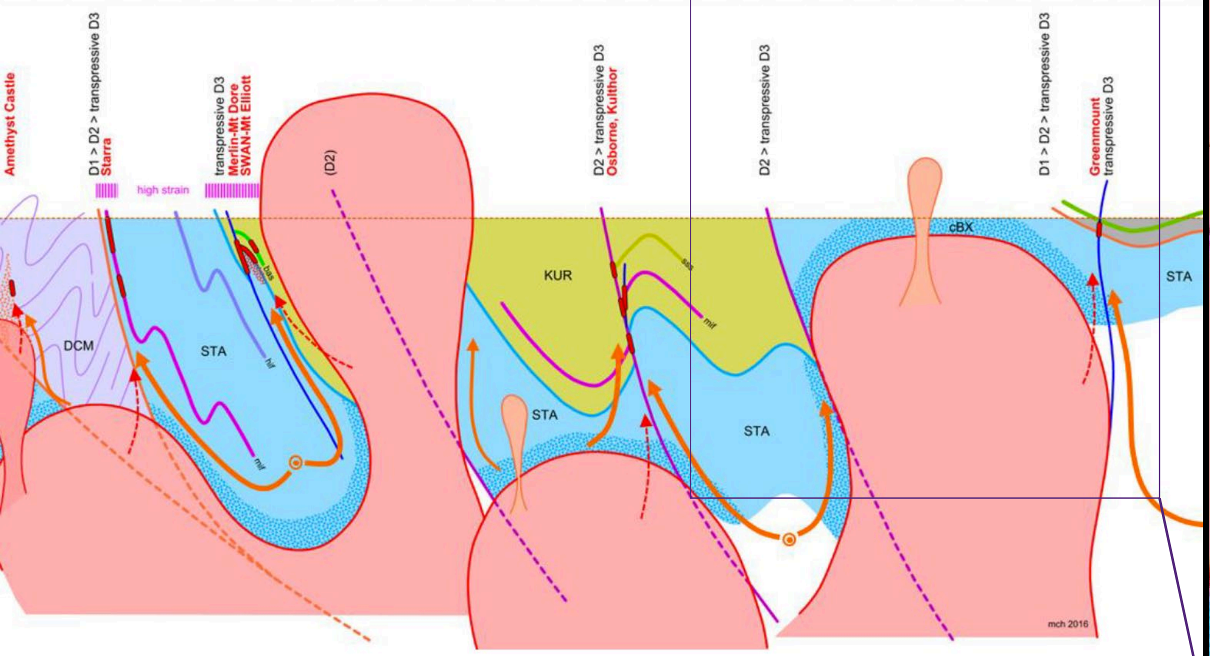
Starra-style

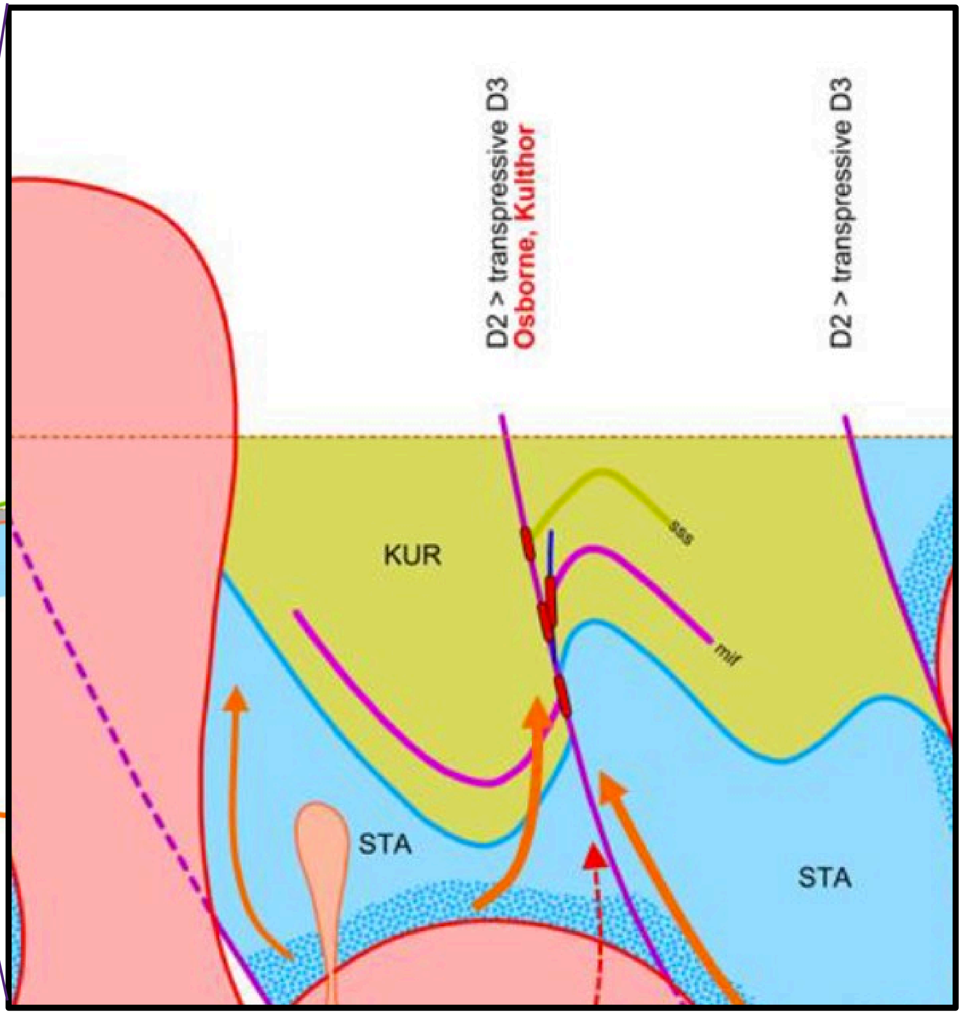




Osborne/Kulthor - style







NWQMP Targets

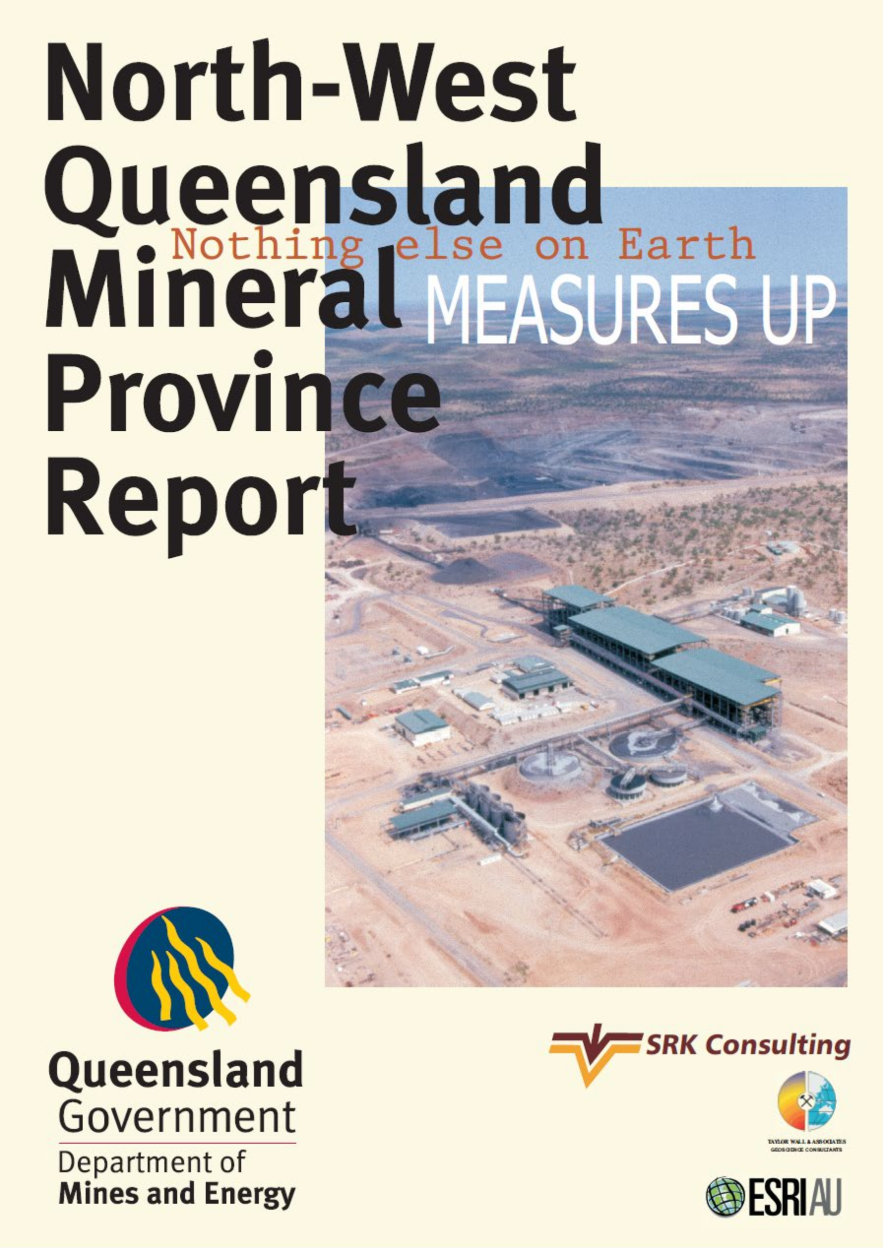


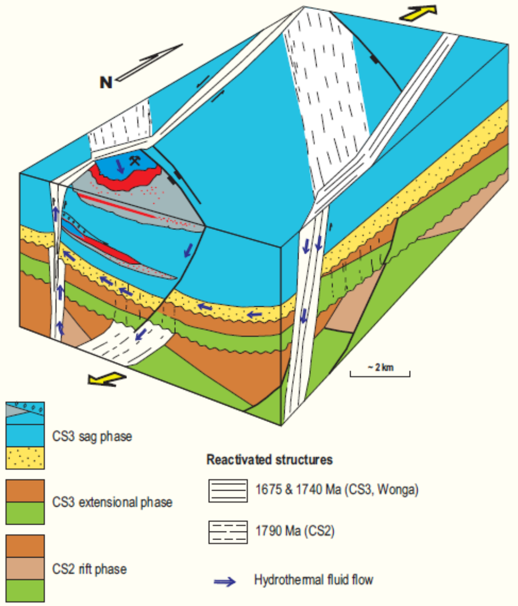
TABLE 11.1: ISA-CENTURY STYLE ZN-PB-AG TARGETS

Identifier	Location (AMG)	Styles	Regional structural setting	Local structural setting	Lithostratigraphic setting	Alteration/Mineralisation indicators	Cover thickness	Overall rating	Comments
	E N	Target Style and Mineralising Events	Key structural elements, geometries and kinematic histories relevant to target style, ie target zone in regional structural context.	Key structural elements, geometries and kinematic histories relevant to target style – at scale of target zone or prospect	Unit(s), lithologies, ages Any key features with respect to target styles)	Mineral occurrences of styles related to target Geochemical anomalism Any significant local lithological and alteration features)	Depth to Proterozoic basement Estimate of target depths, if possible		Any relevant comments, opinions, qualifiers from target generator Historical exploration data, if available
ZIC1	E: 343610 N: 7585510	Zinc-lead-silver: Sediment-hosted, Isa-Century style Mineralising Event(s): 1640, 1650Ma	Cover Sequence 2 accommodation (transfer) zone, NE-trending. Transtensional segment of 1640Ma accommodation structure Rating: A	Possible basin related to transtensional jog Rating: A	Gun Supersequence, Moondarra Siltstone Rating: B	Not known Rating: B	<50m Rating: A	2	
ZIC2	E: 331370 N: 75 77350	Zinc-lead-silver: Sediment-hosted, Isa-Century style Mineralising Event(s): 1640, 1650Ma	Cover Sequence 2 accommodation (transfer zone), NE-trending. Weak transtensional segment of 1640Ma accommodation structure Rating: B	Not known Rating: B	Isa Superbasin possible Gun Supersequence and above Rating: B	Not known Rating: B	<100m Rating: B	2	
ZIC3	E: 342450 N: 7552000	Zinc-lead-silver: Sediment-hosted, Isa-Century style Mineralising Event(s): 1640, 1650Ma	ENE-Wonga-age normal faults at intersection with 1640Ma accommodation structure Rating: B	Not known Rating: B	Isa Superbasin possibly Gun Supersequence Rating: B	Not known Rating: B	100-300m Rating: B	2	
ZIC4	E: 303990 N: 7540060	Zinc-lead-silver: Sediment-hosted, Isa-Century style Mineralising Event(s): 1640, 1650Ma	Cover Sequence 2 transfer fault and Wonga normal faults at intersection with 1640Ma accommodation zone Rating: B	Not known Rating: B	Isa Superbasin, possibly Gun Supersequence Rating: B	Not known Rating: B	200-500m Rating: C	2	
ZIC5	E: 329630 N: 7630960	Zinc-lead-silver: Sediment-hosted, Isa-Century style Mineralising Event(s): 1640, 1650Ma	Cover Sequence 2 transfer fault and Barramundi structure plus 1640Ma transtensional accommodation zone Rating: A	Not known Rating: B	Isa Superbasin Gun Supersequence Rating: B	Not known Rating: C	<50m Rating: A	2	Largely outcropping area
ZIC6	E: 338950 N: 7675830	Zinc-lead-silver: Sediment-hosted, Isa-Century style Mineralising Event(s): 1640, 1650Ma	Cover Sequence 2 transfer zone at intersection with 1640Ma transtensional accommodation zone Rating: A	Steeply dipping metasediments Rating: B	Gun Supersequence Rating: B	Stratabound pyrite and copper occurrences Rating: A	<50m Rating: A	2	Largely outcropping area, south of Mount Isa
ZIC7	E: 290880 N: 7696220	Zinc-lead-silver: Sediment-hosted, Isa-Century style Mineralising Event(s): 1640, 1650Ma	Wonga normal fault at intersection with ?1640Ma accommodation zone Rating: C	Shallow dipping and plunging folded succession Rating: B	Gun Supersequence Rating: B	Not known Rating: B	50-100m Rating: A	3	
ZIC8	E: 316510 N: 7694770	Zinc-lead-silver: Sediment-hosted, Isa-Century style Mineralising Event(s): 1640, 1650Ma	Cover Sequence 2 transfer fault and Wonga normal faults plus 1640Ma accommodation zone Rating: A	Steeply dipping, strong D2 deformation Rating: B	Gun Supersequence Rating: B	Minor copper and uranium mineralisation Rating: B	<50m Rating: A	2	
ZIC9	E: 340110 N: 7724480	Zinc-lead-silver: Sediment-hosted, Isa-Century style Mineralising Event(s): 1650Ma	Folded Wonga normal faults and Cover Sequence 2 normal fault intersecting 1640Ma transtensional zone Rating: A	Moderately to steeply dipping, faulted succession Rating: B	Thick Gun Supersequence, Urquhart Shale. Carbonaceous and pyritic lutites Rating: A	Hilton and George Fisher Zn-Pb-Ag deposits. Highly pyritic, dolomitic carbonaceous stratigraphy Rating: A	<50m. Deeper targets? Rating: A	2	Current Mount Isa Zn-Pb-Ag mining; heavily explored to substantial depths

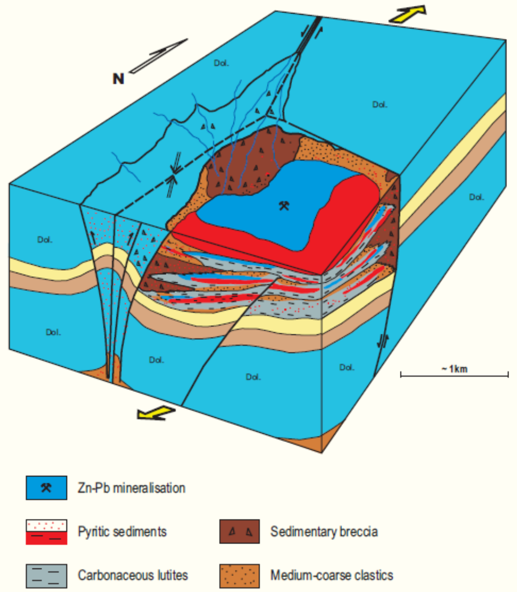
TARGET MODELS

STRATABOUND Zn-Pb-Ag: ISA-CENTURY-STYLES

REGIONAL TECTONOSTRATIGRAPHIC MODEL



STRUCTURAL AND LITHOSTRATIGRAPHIC LOCALISATION



ESSENTIAL ELEMENTS

- Brine, high SO_4^{2-}/H_2S, 100-200°C
  - evaporite source
  - acid fluid (? clay-carbonate buffer)
- Fault system – related fluid circulation system connecting
  - fluid recharge zone
  - faulted basement and basal sandstone aquifer
  - fluid discharge fault zone
- Fault system active/reactivated episodically during one or more mineralizing events and sedimentation
- Related foundering sedimentation compartments (sub-basins)
  - accumulating organic-rich sediments and coarser clastics
  - related to accommodation zones of fault systems
- Fluid infiltration zones
  - fed by discordant fault systems
  - in organic-rich sedimentary packages
- Ore deposition in infiltration zones
  - interaction with kerogen, and/or mixing with reduced fluids effecting thermochemical sulphate reduction
  - host rock carbonate dissolution and acid neutralisation
  - fluid cooling

TARGET CRITERIA

Mineralisation: Supersequences and event(s)	▪ Gun, Loretta, River, Wide; - suprabasinal events 1660-1590Ma - Isan D_1
Tectonostratigraphic domains	▪ South Murphy, Lawn Hill, Mount Oxide-Gunpowder, Mount Isa, Wonga Belt
Regional structural settings	▪ NNW trending zones active during above events - reactivated Cover Sequence 3 (and ?Wonga) accommodation systems: sidewalls/transfer systems ▪ at intersections with NW-, EW-, NE-, trending basement fault systems - reactivated earlier rift structures of Cover Sequence 2, Wonga ages
Local structural settings	▪ Associated with syn-sedimentation fault systems - NS to EW orientations ▪ Fault bound compartments exhibiting block tilting and anomalous sedimentation
Host lithostratigraphic settings	▪ Sag phase sedimentary successions - Cover Sequence 3, as above ▪ Carbonate- and siliceous clastic packages containing - carbonaceous lutites - interbedded with coarser clastics ▪ Anomalous thickness distributions of these sedimentary facies in fault-related sub-basins
Mineralisation indicators	▪ Abundant stratabound fine-grained (diagenetic) pyrite ▪ Ferroan carbonate alteration envelope and stylo-laminated lutites ▪ Zn and Pb anomalism – stratabound and in early and late vein systems ▪ EM conductors reflecting abundant sulphides as well as carbonaceous metasediments

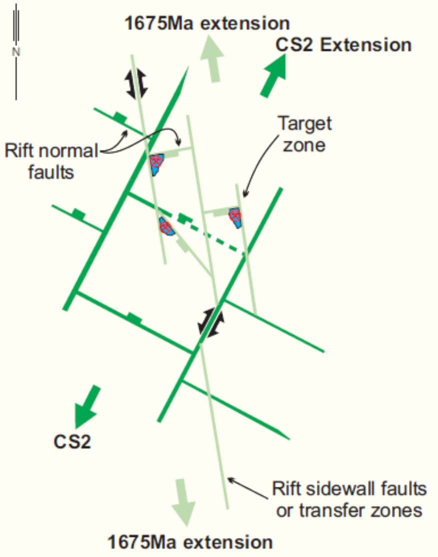
PLATE 16

PLATE 17

TARGET MODELS

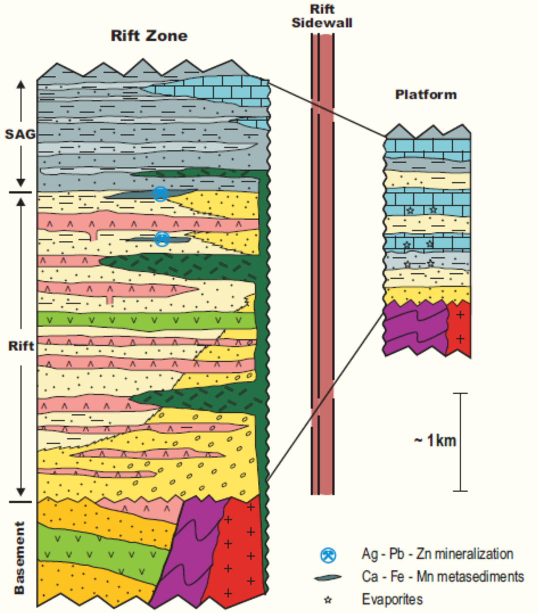
STRATABOUND Ag-Pb-Zn: CANNINGTON-BROKEN HILL STYLES

TECTONIC SETTING: 1680Ma RIFT ZONE



Stratabound Ag - Pb - Zn mineralization is interpreted to be localised by sedimentary packages and hydrothermal systems controlled by 1675Ma rift structures, and also reactivated fault systems

LITHOSTRATIGRAPHIC MODEL



This model emphasises the importance of near rift top host stratigraphic packages, contiguous platform evaporate-bearing successions and footwall sills.

ESSENTIAL ELEMENTS

- Analogies with both VHMS and clastic sediment-hosted Zn-Pb-Ag systems
- Late rift phase clastic sedimentation
  - near cessation of bimodal igneous activity
  - immediately prior to commencement of sag phase sedimentation
- Contiguous evaporitic shelf succession, source of brines
- Fault-related fluid circulation system, active during
  - host succession sedimentation
  - igneous intrusion into rift succession
- Mineralisation: exhalative and/or subseafloor replacement of calcareous lithologies

TARGET CRITERIA

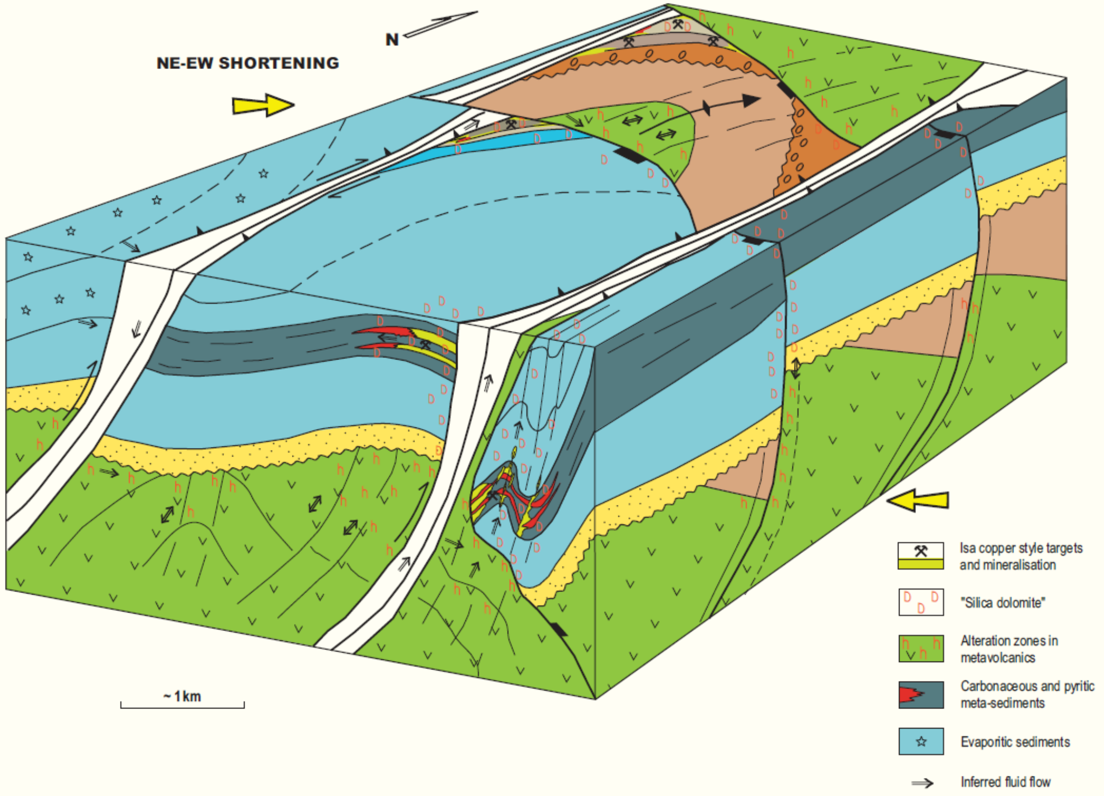
Mineralising event(s)	▪ Soldiers Cap rift (1690-1670Ma)
Tectonostratigraphic domains	▪ Eastern Fold Belt ▪ Wonga Belt
Regional structural settings	▪ Rift sidewall faults or transfer zones - NNW-trending ▪ at intersections with rift normal faults and/or reactivated basement structures - EW- to NW-trending
Local structural settings	▪ Mafic and/or felsic sills structurally/stratigraphically underlying target region
Host lithostratigraphic settings	▪ Top-of-rift stratigraphy - upper Soldiers Cap unit SC2 - lower Sc3 (subdued magnetics, psammite-dominated metasedimentary succession) ▪ stratigraphically below more mature siliciclastics: sag phase sediments, (Soldiers Cap unit SC3)
Mineralisation indicators	▪ Ca-Mn-Fe rich metasediments - may include BIF's ▪ Siliceous metasedimentary package - stratabound footwall alteration zone ▪ associated, stratabound Pb-Zn anomalism - eg gahnite-bearing metasediments

TARGET MODELS

PLATE 19

METASEDIMENT-HOSTED COPPER: ISA-STYLE

TECTONOSTRATIGRAPHIC MODEL



ESSENTIAL ELEMENTS

- Saline, H_2S-poor, high SO_4^{2-} / H_2S fluids 200-400°C
  - path history involving evaporite environments and oxidised rock masses
- Syn-metamorphic, fault-related fluid circulation system
  - connecting fluid source, oxidised rocks and host metasediments
- Strongly reducing and reactive, low grade metamorphosed sedimentary host succession
- Dilational zones in these metasediments

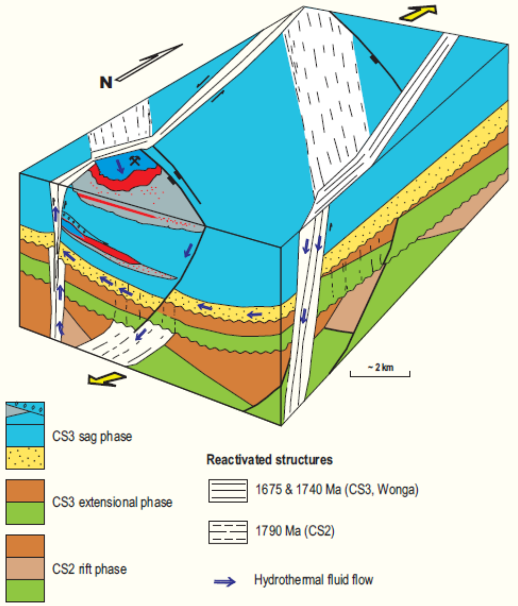
TARGET CRITERIA

Mineralising event(s)	▪ Isan D_3 deformation
Tectonostratigraphic domains	▪ Mount Isa, Mount Oxide-Gunpowder, Lawn Hill, South Murphy, North Murphy, Wonga Belt
Regional structural settings	▪ Along broadly N-trending fault systems, active during D_3 - reactivated segments of earlier fault systems ▪ at intersections of these with E-W, WNW trending reactivated fault systems ▪ Fault juxtaposition of basement metavolcanics and host metasediments
Local structural settings	▪ Shallow plunging host metasediment – (metavolcanic) basement (fault) contact ▪ D_3 fold-fault system - subvertical extension - faults subparallel to metasediment stratigraphy
Host lithostratigraphic settings	▪ Cover Sequence 3 metasediments - carbonaceous and preferably dolomitic siltstones - pyritic diagenetic facies or pyritic alteration ▪ Mechanical contrasts in metasediment package ▪ Greenschist facies metamorphic grade
Mineralisation indicators	▪ 'Silica dolomite': quartz-carbonate-sulphide veining and alteration, D_3 age - related ^{18}O depletion zone ▪ Pyritic and Zn-Pb-Ag mineralization ▪ Altered, demagnetized basement metavolcanics ▪ Cu ± Co, As anomalism

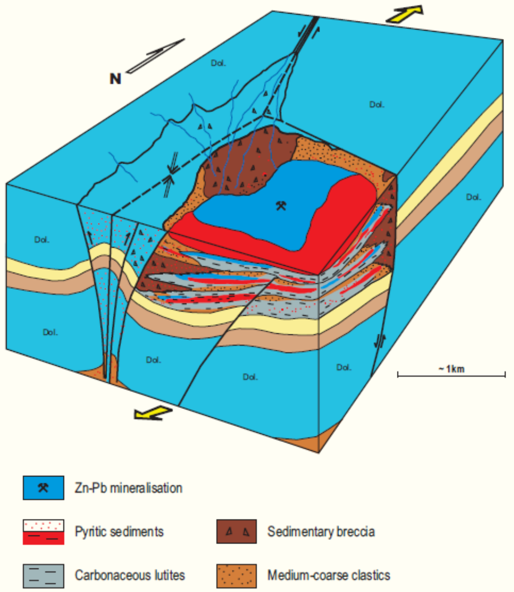
TARGET MODELS

STRATABOUND Zn-Pb-Ag: ISA-CENTURY-STYLES

REGIONAL TECTONOSTRATIGRAPHIC MODEL



STRUCTURAL AND LITHOSTRATIGRAPHIC LOCALISATION



ESSENTIAL ELEMENTS

- Brine, high SO_4^{2-} / H_2S, 100-200°C
  - evaporite source
  - acid fluid (? clay-carbonate buffer)
- Fault system – related fluid circulation system connecting
  - fluid recharge zone
  - faulted basement and basal sandstone aquifer
  - fluid discharge fault zone
- Fault system active/reactivated episodically during one or more mineralizing events and sedimentation
- Related foundering sedimentation compartments (sub-basins)
  - accumulating organic-rich sediments and coarser clastics
  - related to accommodation zones of fault systems
- Fluid infiltration zones
  - fed by discordant fault systems
  - in organic-rich sedimentary packages
- Ore deposition in infiltration zones
  - interaction with kerogen, and/or mixing with reduced fluids effecting thermochemical sulphate reduction
  - host rock carbonate dissolution and acid neutralisation
  - fluid cooling

TARGET CRITERIA

Mineralisation: Supersequences and event(s)	▪ Gun, Loretta, River, Wide; - suprabasinal events 1660-1590Ma - Isan D_1
Tectonostratigraphic domains	▪ South Murphy, Lawn Hill, Mount Oxide-Gunpowder, Mount Isa, Wonga Belt
Regional structural settings	▪ NNW trending zones active during above events - reactivated Cover Sequence 3 (and ?Wonga) accommodation systems: sidewalls/transfer systems ▪ at intersections with NW-, EW-, NE-, trending basement fault systems - reactivated earlier rift structures of Cover Sequence 2, Wonga ages
Local structural settings	▪ Associated with syn-sedimentation fault systems - NS to EW orientations ▪ Fault bound compartments exhibiting block tilting and anomalous sedimentation
Host lithostratigraphic settings	▪ Sag phase sedimentary successions - Cover Sequence 3, as above ▪ Carbonate- and siliceous clastic packages containing - carbonaceous lutites - interbedded with coarser clastics ▪ Anomalous thickness distributions of these sedimentary facies in fault-related sub-basins
Mineralisation indicators	▪ Abundant stratabound fine-grained (diagenetic) pyrite ▪ Ferroan carbonate alteration envelope and stylo-laminated lutites ▪ Zn and Pb anomalism – stratabound and in early and late vein systems ▪ EM conductors reflecting abundant sulphides as well as carbonaceous metasediments

PLATE 16

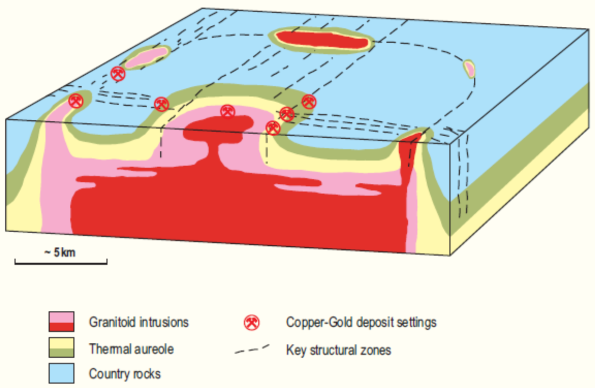
TARGET MODELS

PLATE 21

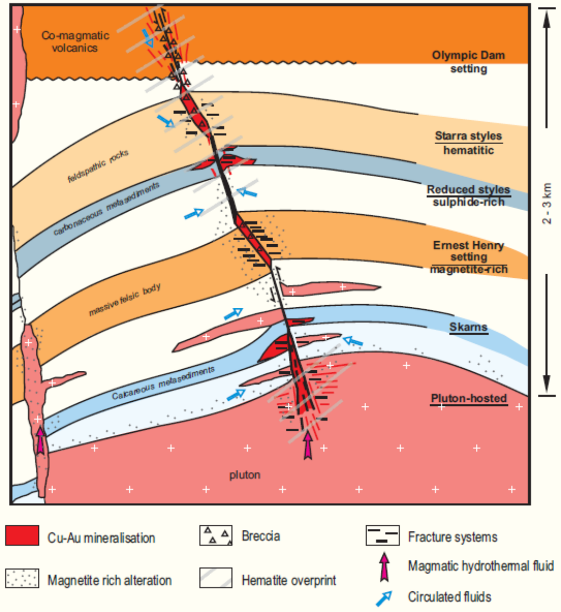
IRON OXIDE-COPPER-GOLD SYSTEMS

- magnetite-rich (eg Ernest Henry)
- hematitic (eg Selwyn; Olympic Dam)
- reduced styles (eg Eloise, Mount Roseby)

Iron oxide Cu-Au systems: pluton roof zones



The structural and lithological settings of Cu-Au targets



ESSENTIAL ELEMENTS

- High temperature, relatively oxidised felsic magmatism
- Pluton roof zones, above pluton margins and cupolas
- Structures active during pluton emplacement and cooling
  - pluton accommodation and reactivated fault-fold systems
- Spatially and temporally related, medium-to-high temperature metasomatic zones, commonly magnetite-rich
- Dilatant zones related to
  - fault/fold systems
  - major lithological/mechanical contrasts
- Intruded successions:
  - preferably with evaporitic components (input to hematitic mineralisation styles)
  - carbonaceous metasediments for more reduced styles

TARGET CRITERIA

Mineralising event(s)	▪ Williams-Naraku magmatism (1500-1520Ma) ▪ Wonga magmatism (~1740Ma)
Tectonostratigraphic domains	▪ Eastern Fold Belt ▪ Wonga Belt
Regional structural settings	▪ Roof zones of Williams and Wonga-age plutons ▪ Fault-fold systems reactivated during and after pluton emplacement
Local structural settings	▪ Wonga age: - fault jogs, intersections in upper plate fault systems - dilatant irregularities in extensional detachment ▪ Williams age: - reverse thrust-faulted, antiformal zones ▪ Magnetite alteration related to these structures
Host lithostratigraphic settings	▪ Feldspathic potential hosts (volcanics, sills, pluton tops) in more ductile metasediment envelope ▪ Carbonaceous metasedimentary packages (reduced styles) ▪ Pre-existing magnetite-rich zones (hematitic styles)
Mineralisation indicators	▪ Magnetite-bearing alteration systems and their less magnetic extensions ▪ Potassic (biotite-K-feldspar) wall rock alteration contemporaneous with hydrothermal carbonate + magnetite-rich infill ▪ Hematitic overprint on hydrothermal magnetite ▪ Copper-gold (± U, As)

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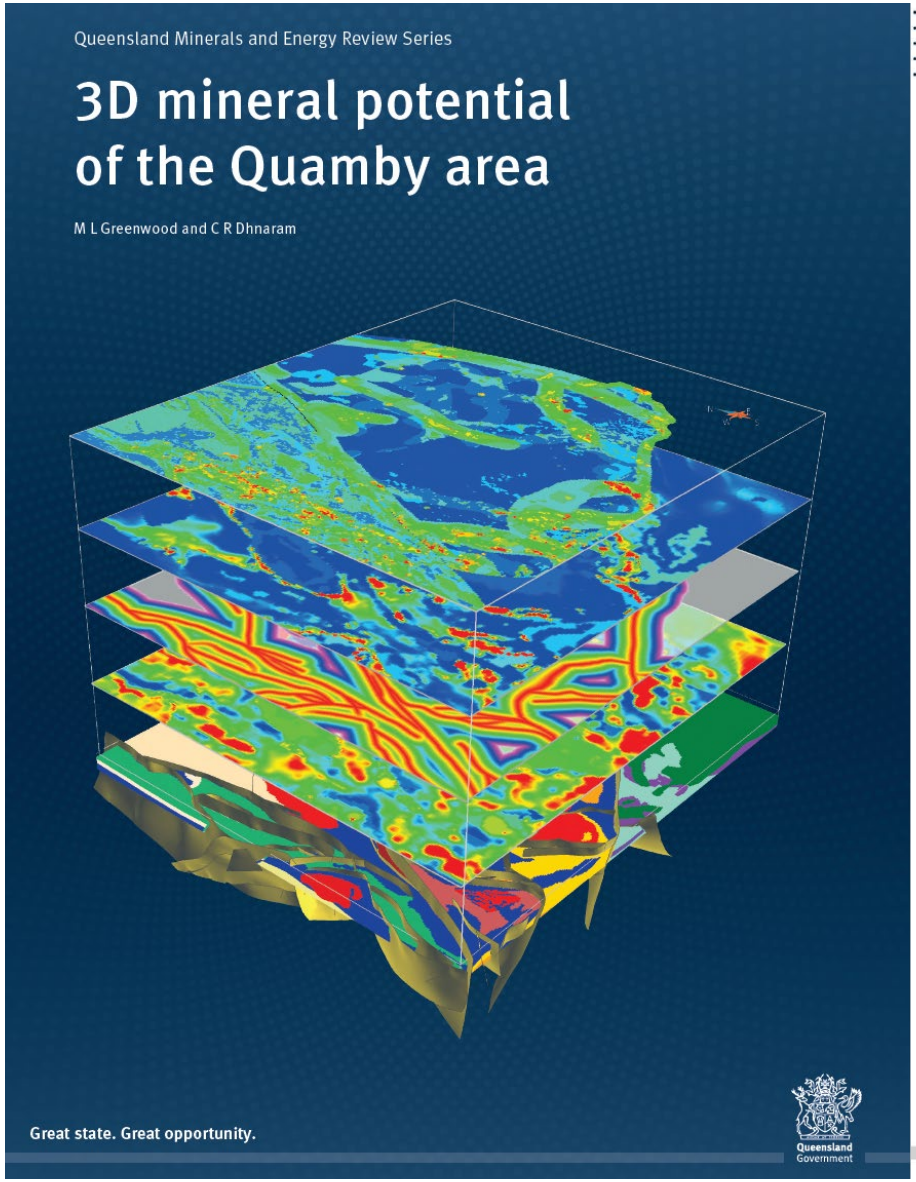
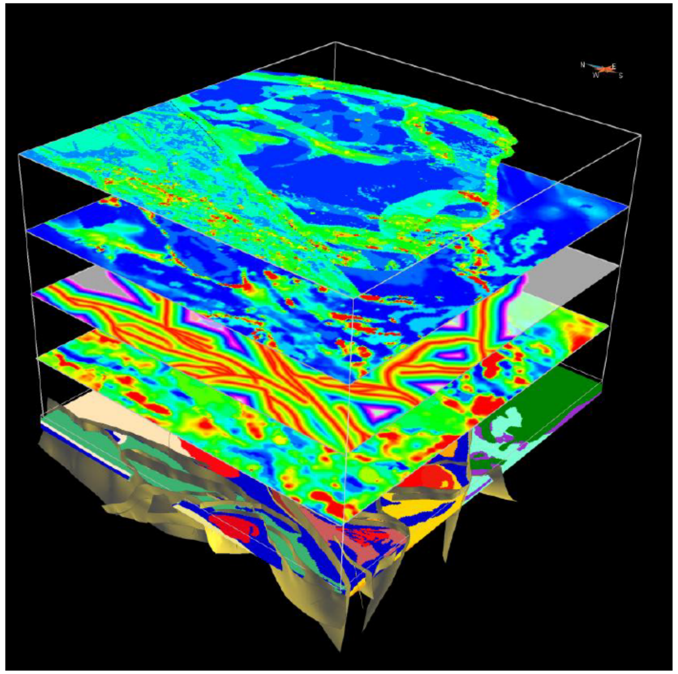


Regional 3D Mineral Potential Modelling using Geology and Geophysics



Matthew Greenwood

Courteney Dhnaram

Greenfields Prospectivity Unit

Geological Survey of Queensland

Department of Natural Resources and Mines

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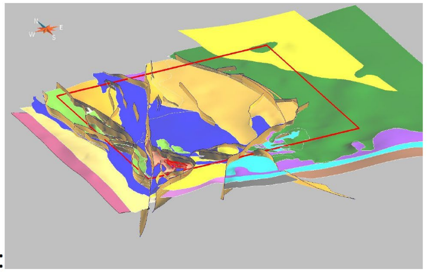
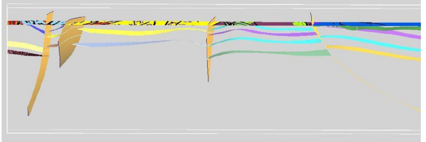
- 3D Lithology Surface modelling
- Surfaces representing base of lithological packages built in GOCAD/SKUA from:
  - Seismic
  - Cross-sections
  - Mapping
  - Potential Fields





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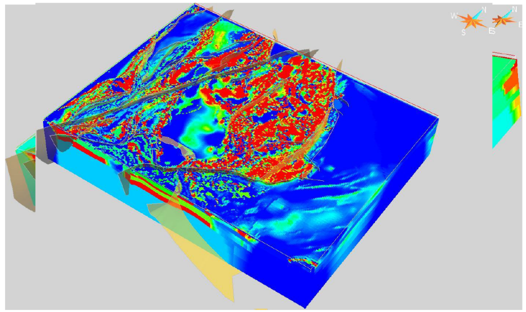
3D Magnetic Susceptibility Model

- Final 3D magnetic susceptibility model result of several generations of iterative inversion. Constrained by geological model and the set magnetic susceptibility range of the units



Standard deviations from mean unit magnetic susceptibility / Final 3D Magnetic Susceptibility model

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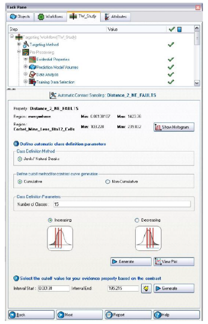
3D Weights of Evidence (WoE) Targeting

- Statistical evaluation of spatial relationships between known mineral occurrences and other spatial datasets (evidential properties/exploration criteria such as rock type, structure, geochemistry) → used to define ***mineral potential probabilities***
- Mineral systems analysis and literature review undertaken as part of NWQMEP study identified exploration criteria believed to be associated with Copper and/or Gold mineralisation in area.
- Exploration criteria represented in the Common Earth model in GoCAD as continuous or discrete variables (evidential properties)
- GoCAD Targeting workflow used to assess the correlation of these evidential properties with known mineralisation (training data).



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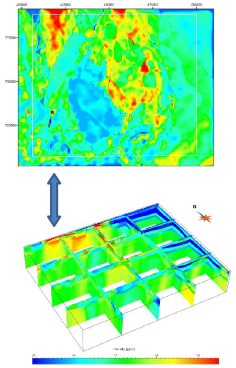
Potential Field Inversions

- Discretised voxet populated with available physical properties (density and magnetic susceptibility) collected in field, calculated in laboratory or from literature.
- Homogenous Property Inversion of magnetic and gravity data to optimise values of properties
- Resultant optimised magnetic and gravity distributions subjected to Heterogeneous Property Inversion.
- Local anomalies, where model can't account for observed response, may represent alteration along fluid pathways, concentrations of dense and/or magnetic rock (Ore?) etc…



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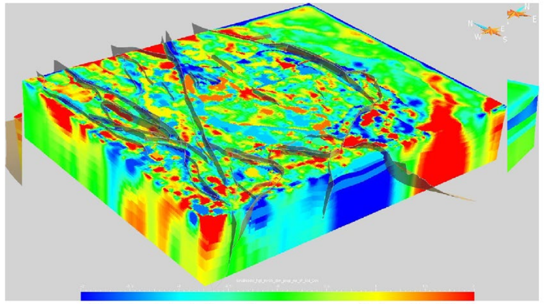
3D Density model

- Final 3D density model result of several generations of iterative inversion Constrained by geological model and the set density range of the units



Standard deviations from mean unit density (Red – Higher than expected, Blue – Lower than expected.) / Final 3D density model (Red – High Density, Blue – Low Density.)

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3D Weights of Evidence

- WoE modelling completed on top 2.5 km of model
- Different exploration criteria, contrast and cut-off values across the geological domains due to different mineralisation styles, expected targets and depth of cover.

Evidential Property	W+	W-	Contrast	Stud. Contrast
Geochemisty Au	3.73	-0.75	4.48	8.65
Geochemisty Cu	3.78	-0.62	4.40	8.51
Fault Curvature	1.38	-0.32	1.70	3.10
Density Deviation	1.52	-0.52	2.05	3.95
Distance to Williams Granite	0.47	-0.56	1.03	1.87
Distance to Faults	0.89	-2.22	3.11	3.01
Magnetic Susceptibility Deviation	1.65	-0.43	2.08	3.95
Structural Complexity	0.54	-0.39	0.94	1.81
Uranium / Thorium	1.74	-0.35	2.09	3.81

- WoE models completed for two main domains, Canobie in centre of model and Mary Kathleen in west of model to find favourable mineral potential locations in each.
- Tested 23 evidential properties (including some combinations/variations:
  Inverted density/Mag Susc, variation from mean/ median of unit, number of standard deviations from unit mean.
  U/Th, U^2/Th

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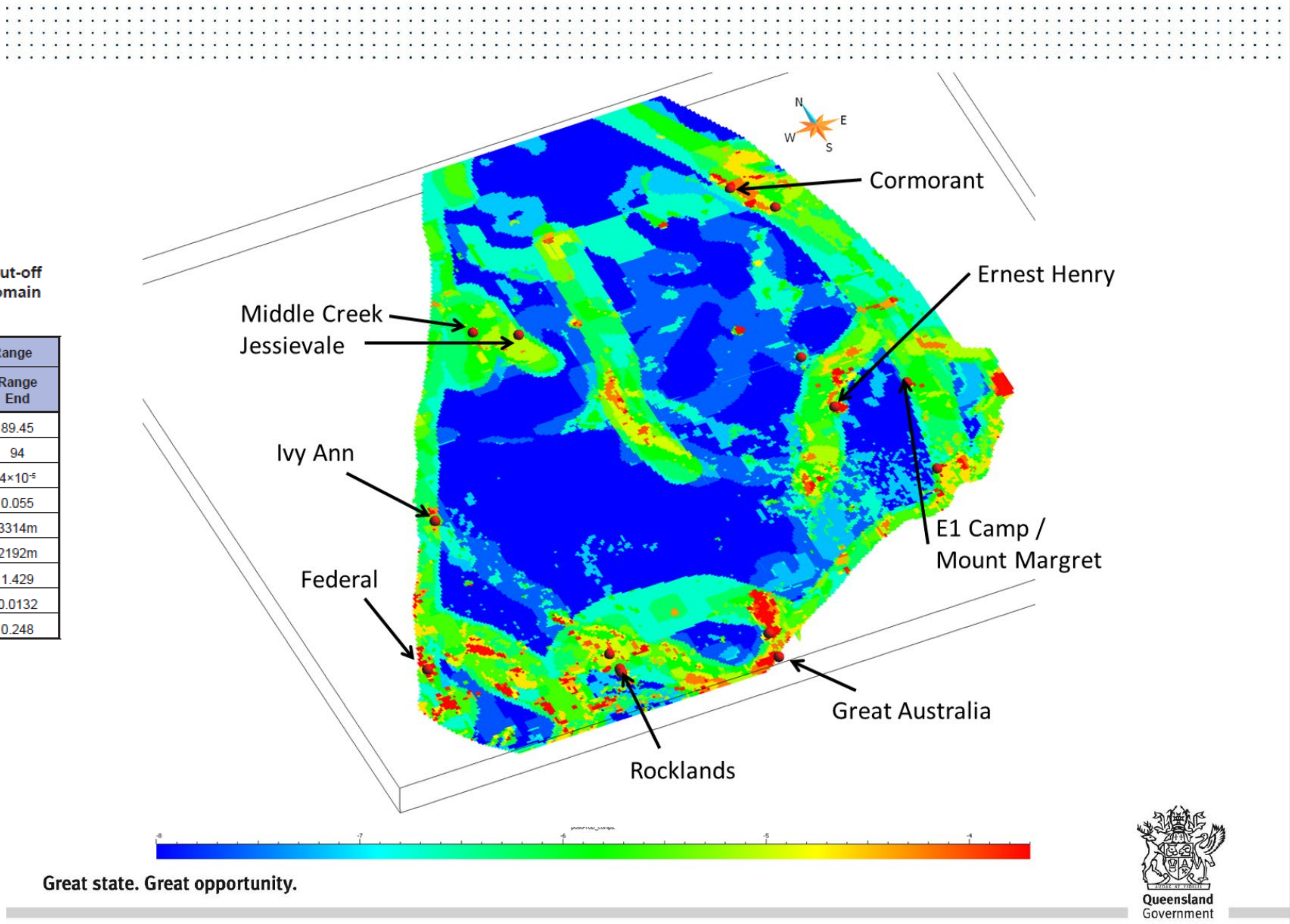
Full Model

Subset Model

Table 7: Statistically significant exploration criteria, associated weights and cut-off values used for the Weights-of-Evidence modelling within the Constantine Domain

	Weights				Favourable Range	
Exploration Criteria	W^+	W^-	Contrast	Stud. Contrast	Range Start	Range End
Au_Geochem	3.726	-0.749	4.475	8.647	100	89.45
Cu_Geochem	3.785	-0.618	4.403	8.507	100	94
Curvature	1.382	-0.318	1.701	3.105	5×10^{-3}	4×10^{-5}
Density_dev	1.525	-0.522	2.046	3.954	0.247	0.055
Dist_Will_Gran	0.467	-0.558	1.025	1.872	0m	3314m
Fault_Distance	0.889	-2.224	3.113	3.008	0m	2192m
MS_no_of_std_dev_ABS	1.652	-0.431	2.083	3.953	27	1.429
Geol_Complex_552	0.544	-0.392	0.935	1.807	1.218	0.0132
Rad_UdivTh	1.742	-0.345	2.087	3.810	1.380	0.248



Mira Geoscience Mt Dore

Table 9: Weights, contrast values and favourable ranges for each of the evidential properties used to compute the complete mineral potential model. S.Contrast = studentised contrast = C/stdC). Top three properties ranked by studentised contrast are in bold.

Exploration Criteria	W+	W-	Con trast	Stud. Contrast	Favourable range - start	Favourable range - end
Coincident_GravityHigh_MagneticHigh	2.29	-0.20	2.49	5.90	0.810	0.246
Distance_CSharp_ISO_Gt35	**2.88**	**-0.91**	**3.79**	**11.09**	**0m**	**300m**
Distance_CrustalFaults	0.74	-0.32	1.06	3.12	0m	964m
Distance_MtDore_FaultModel_Surface_intersectingMafics	1.12	-0.29	1.42	4.00	0m	921m
Fault_Roughness	2.79	-0.17	2.97	6.63	0	0.00015
GeolComplex_552_moving_average_filter	1.80	-0.35	2.15	6.09	0.107	0.0198
Normalised_Susceptibility	3.25	-0.14	3.39	7.03	0.372	0.0885
Regional_density_model_upscaled_TopoMask	3.00	-0.08	3.08	5.11	0.426	0.32
Uranium_divided_Thorium	2.12	-0.58	2.70	8.10	1.289	0.274
dist_Geochem_merged_AuGt150	**5.16**	**-0.29**	**5.45**	**14.15**	**0m**	**304m**
dist_Geochem_merged_CuGt2000	**5.72**	**-0.75**	**6.47**	**19.35**	**0m**	**250.7m**

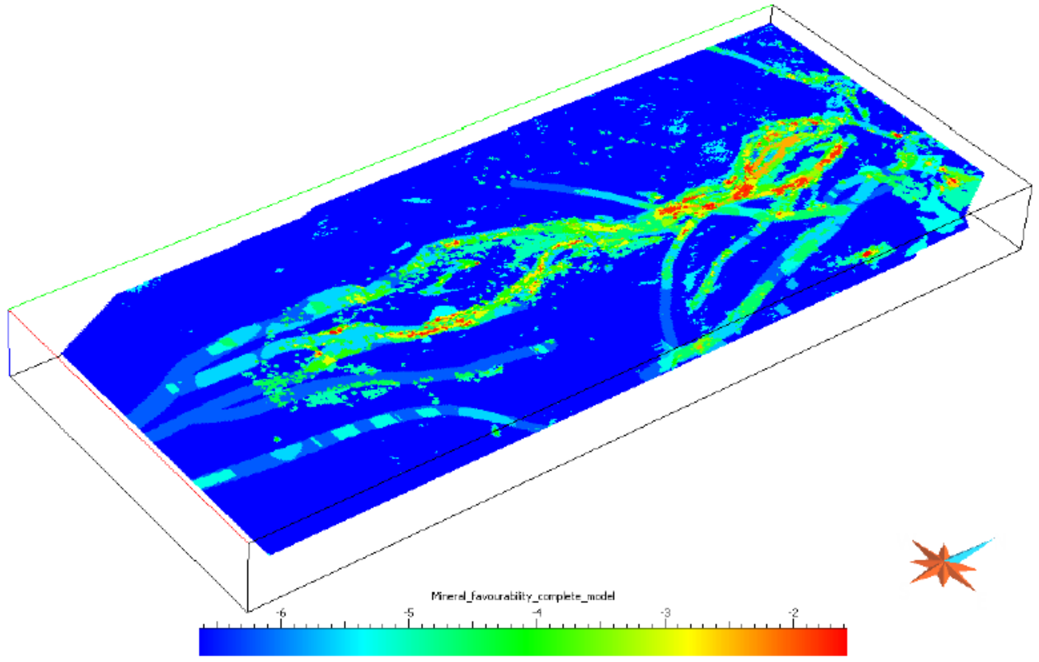


Figure 62. Mineral potential index for the complete model, displayed in log-scale on depth orientation plane through the 3D grid. 5x vertical exaggeration applied.

Mira Geoscience Mt Dore

Table 10: Weights and contrast values for each of the evidential properties used to compute the undercover mineral potential model. S.Contrast = studentised contrast = C/stdC).

Exploration Criteria	W+	W-	Contrast	S. Contrast
Coincident_GravityHigh_MagneticHigh	2.29	-0.20	2.49	5.90
Distance_CrustalFaults	0.74	-0.32	1.06	3.12
Distance_MtDore_FaultModel_Surface_intersectingMafics	1.12	-0.29	1.42	4.00
Fault_Roughness	2.79	-0.17	2.97	6.63
Normalised_Susceptibility	3.25	-0.14	3.39	7.03
Regional_density_model_upscaled_TopoMask	3.00	-0.08	3.08	5.11
Uranium_divided_Thorium	2.12	-0.58	2.70	8.10

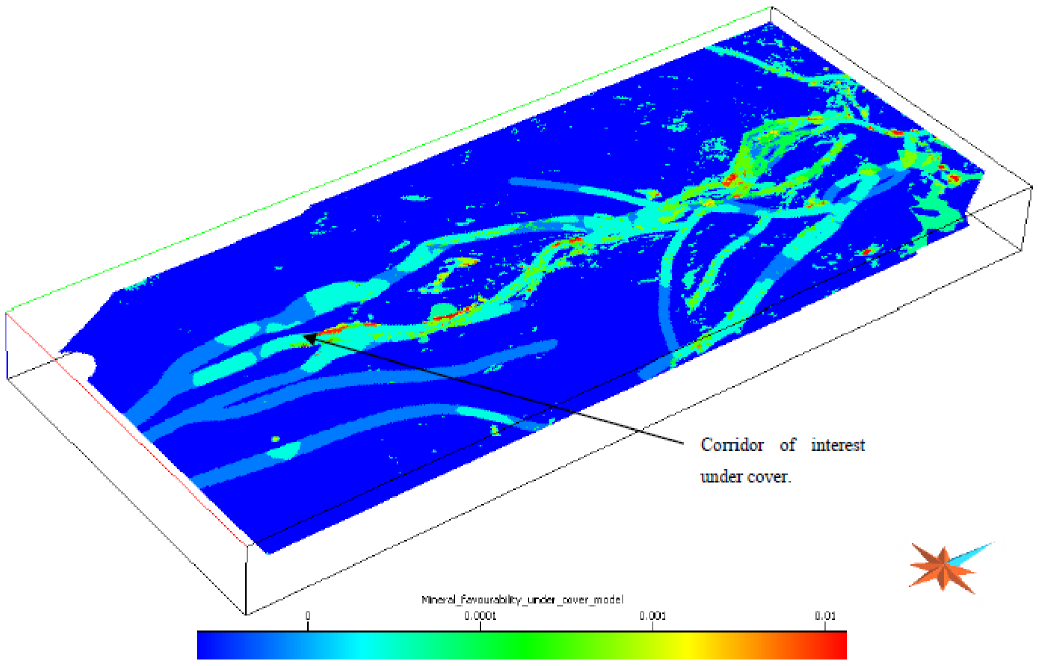


Figure 64. Mineral potential result for the undercover model, displayed in log-scale on depth orientation plane through the 3D grid. 5x vertical exaggeration applied.

Pmd*CRC i2 Prospectivity

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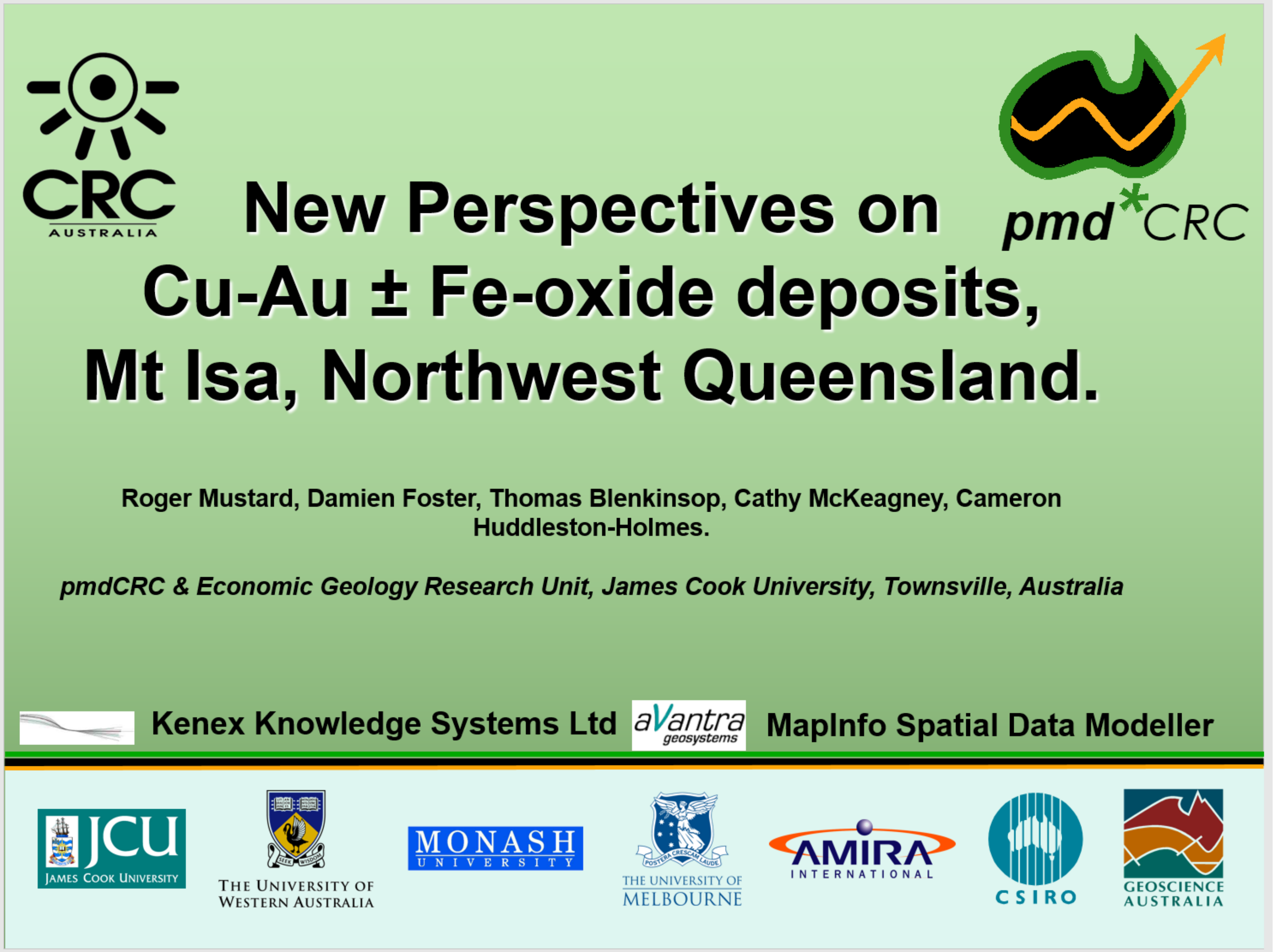

Pmd*CRC i2 Prospectivity – 12 layer

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Predictive Mineral Discovery

Ranking of Ingredients

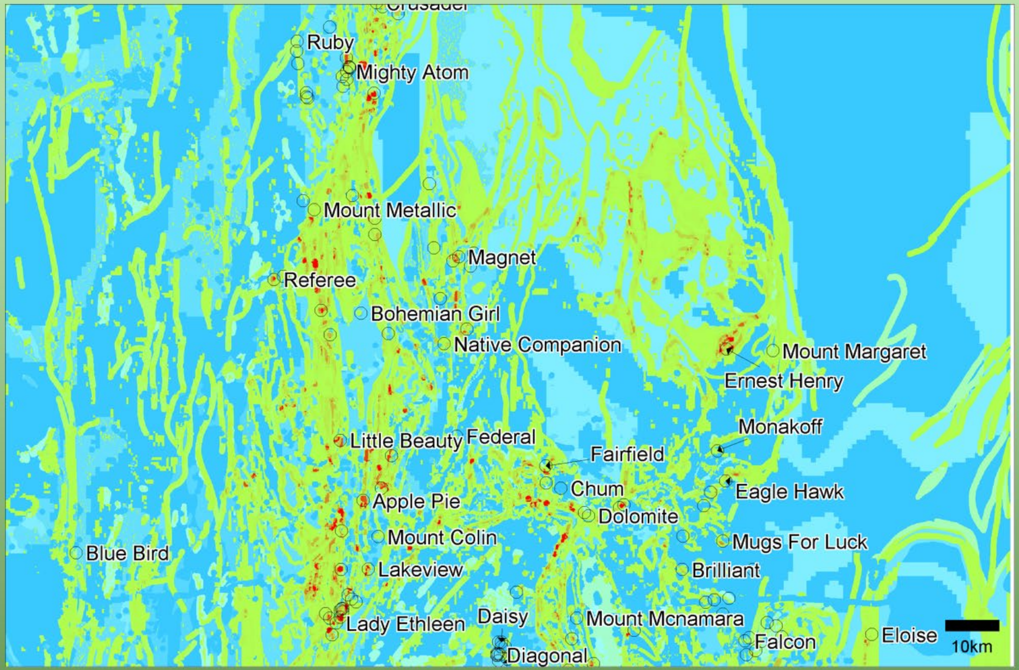
pmd*CRC

Ranking	Key Ingredient	Contrast	Confidence
1	Copper in rockchips (>249 ppm Cu)	2.50	36.31
2	Gold in rockchips (>0.11ppm Au)	2.38	26.45
3	Corella-Soldiers Cap Contact (750m buffer)	1.87	13.98
4	Aeromagnetics (magnetic highs)	1.82	14.36
5	N-S and ENE faults (650m buffer)	1.45	17.20
6	Mafic Intrusives (750m buffer)	1.25	7.47
7	Lithologies (dominantly Cover Sequence 3)	1.21	5.09
8	Gravity (Gradients)	1.03	15.91
9	Bends on N-S and ENE faults	1.03	2.33
10	Metamorphic Grade (Amphibolite Facies)	0.98	7.85
11	Radiometrics (U/Th)	0.83	4.46
12	Williams and Naruku batholiths (4km buffer)	0.64	3.36

Predictive Mineral Discovery

Ernest Henry – Cloncurry Region 12 Layer Model

pmd*CRC



Pmd*CRC i2 Prospectivity – 9 layer

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Predictive Mineral Discovery

Ranking of Ingredients

pmd*CRC

Ranking	Key Ingredient	Contrast	Confidence
~~1~~ X	Copper in rockchips (>249 ppm Cu)	2.50	36.31
~~2~~ X	Gold in rockchips (>0.11ppm Au)	2.38	26.45
3	Corella-Soldiers Cap Contact (750m buffer)	1.87	13.98
4	Aeromagnetics (magnetic highs)	1.82	14.36
5	N-S and ENE faults (650m buffer)	1.45	17.20
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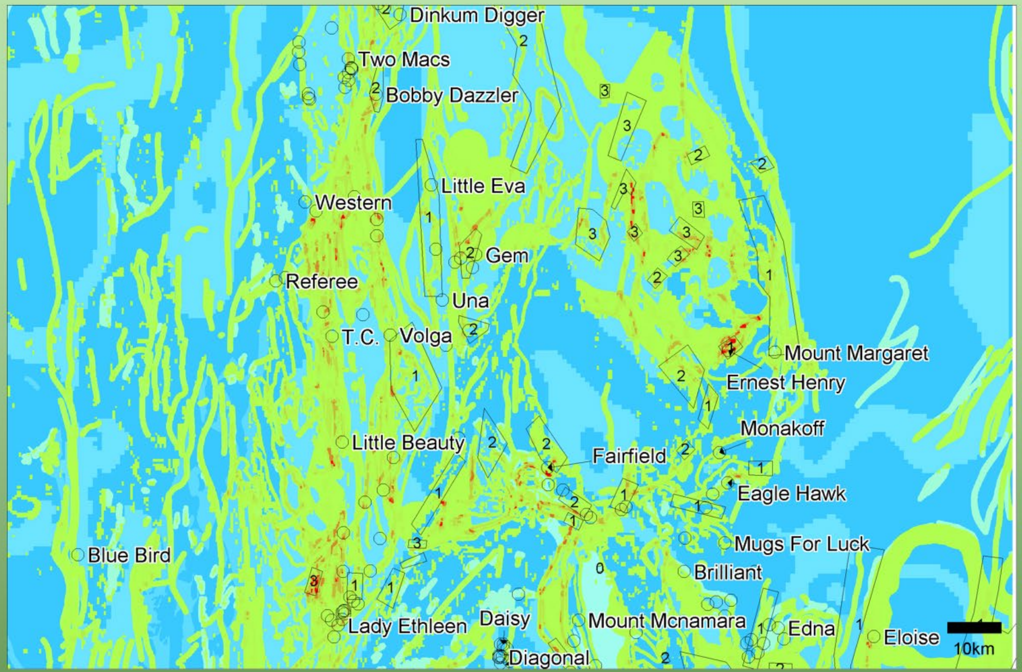
~~11~~ X	Radiometrics (U/Th)	0.83	4.46
12	Williams and Naruku batholiths (4km buffer)	0.64	3.36

Predictive Mineral Discovery

Expert versus Data Driven

9 Layer Model, Ernest Henry – Cloncurry Region

pmd*CRC



GMEX Geomechanical models

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Advanced Understanding of Structural and Geochemical Controls on Mineralisation in the Eastern Mt Isa Inlier Using Innovative Techniques for Exploration

A GSQ funded Industry Priorities Initiative

Geological Survey of Queensland

Audax at Fidelis
Queensland Government

queensland exploration council

A New Approach to Understanding Deformation and Mineralisation
'A Critical Tool in the Exploration Process'

John McLellan

Think on

GMEX GEOLOGICAL MODELLING FOR EXPLORATION

MBC

HCOV

1

GMEX GEOLOGICAL MODELLING FOR EXPLORATION

MBC

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Dr John McLellan
Managing Director & Principal Geoscientist
GMEX (Geological Modelling for Exploration)
john@gmex.com.au

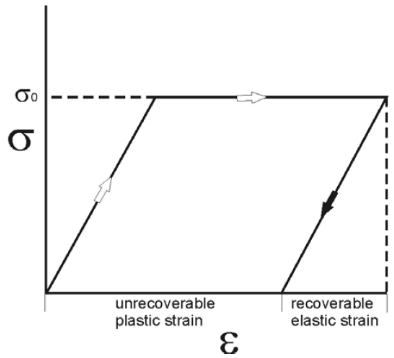
Mr Mat Brown
Principal Geoscience Consultant
MBC (Mat Brown Consulting)
geology@matbrownconsulting.com.au

Dr Nick Oliver
Principal & Director
HCOV Global
nickoliver@hcovglobal.com

GSQ Industry Priorities Initiative
Final Report July 2016

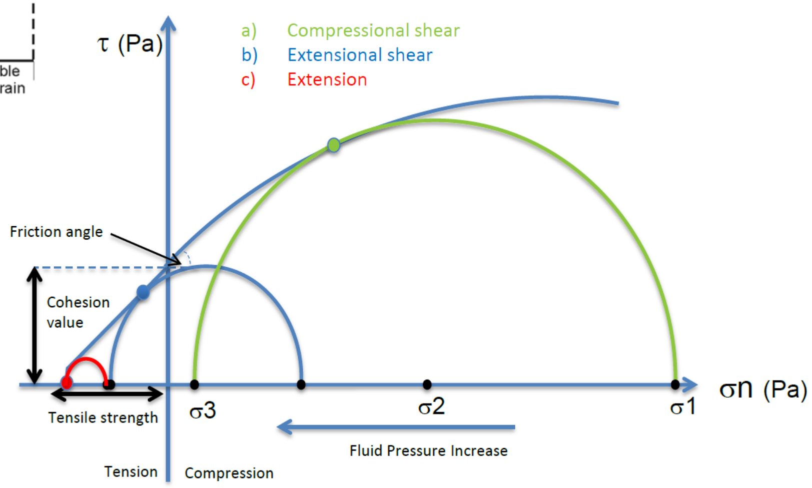
Advanced Understanding of Structural and Geochemical Controls on Mineralisation in the Eastern Mt Isa Inlier Using Innovative Techniques for Exploration

GMEX Geomechanical models



Given specific criteria e.g. rock properties, failure criteria, fluid pressures, we can deduce when a rock will fail in either

a) Compressional shear
b) Extensional shear
c) Extension



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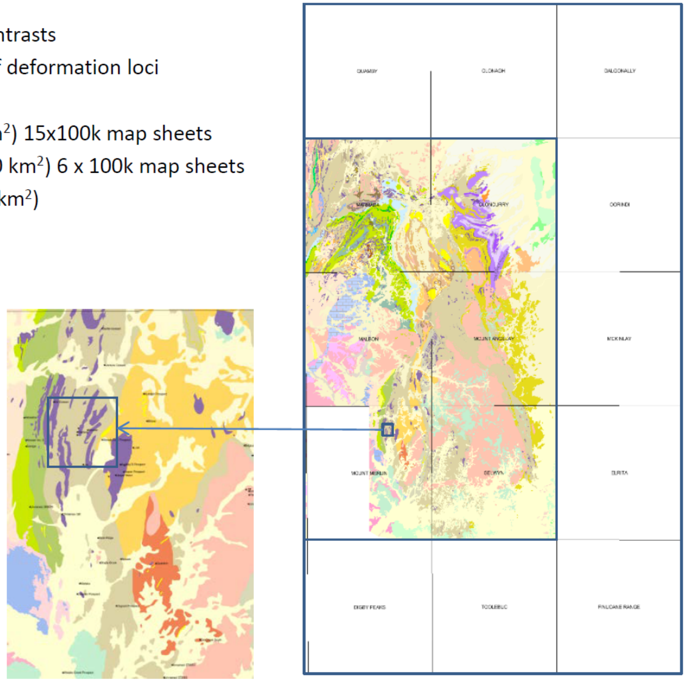
10

Eastern Mt Isa Block–Modelling Scales

- Structurally controlled mineralisation
- Fault controlled system with competency contrasts
- Aim: to identify the most favourable areas of deformation loci

Three scales of interest:

1. Large Scale Regional Modelling (~43,000 km^2) 15x100k map sheets
2. Medium Scale Regional Modelling (~ 17,000 km^2) 6 x 100k map sheets
3. Small Scale Local Modelling (between 0-25 km^2)



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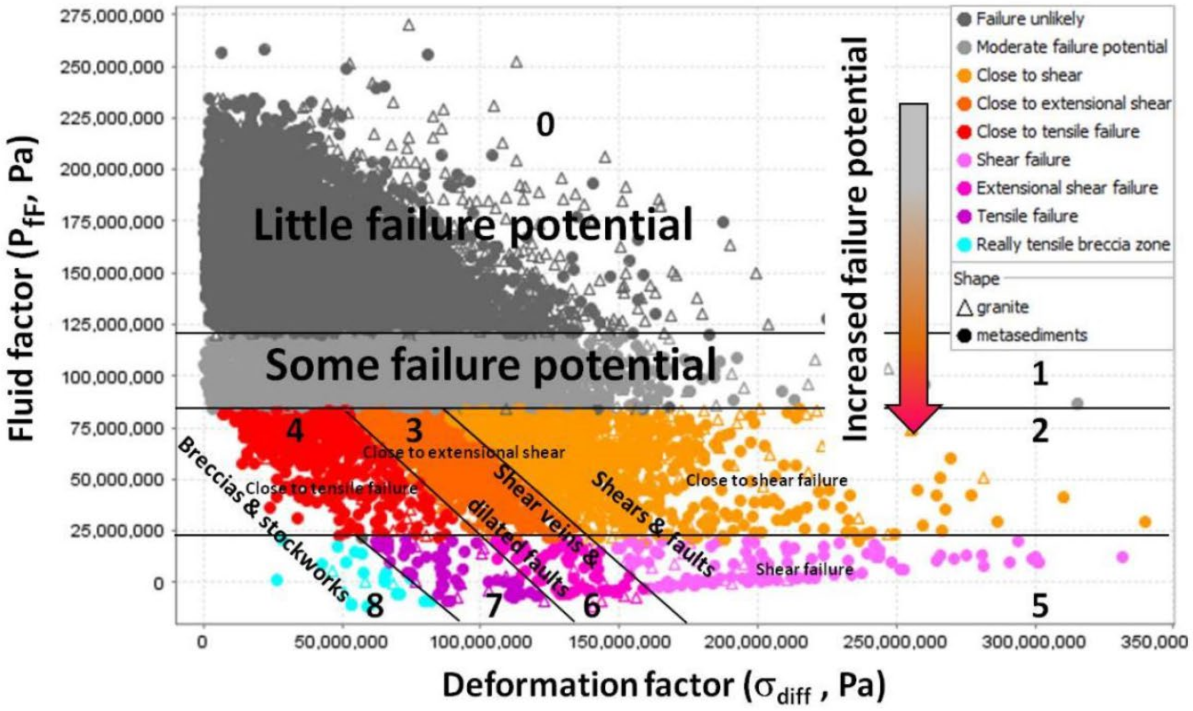
15

Modelling outputs as Predictor Maps

Predictor Maps have been generated using IOGAS. These are based on the geomechanics and highlight areas most likely to fail based on material parameters and fluid pressures



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28

Eastern Succession exercise

Available target layers

- Empirical
  - Geochem/Geophys/Occurrence anomalies
- Conceptual
  - NWQMP, DMQ Conceptual
- Prospectivity/modelling
  - Pmd*CRC, Quamby, Mt Dore, Geomechanical

Find 3 prospect-scale areas that have some support from each of the above categories

Why did you pick them and what would you do next?

G14 Lawn Hill model

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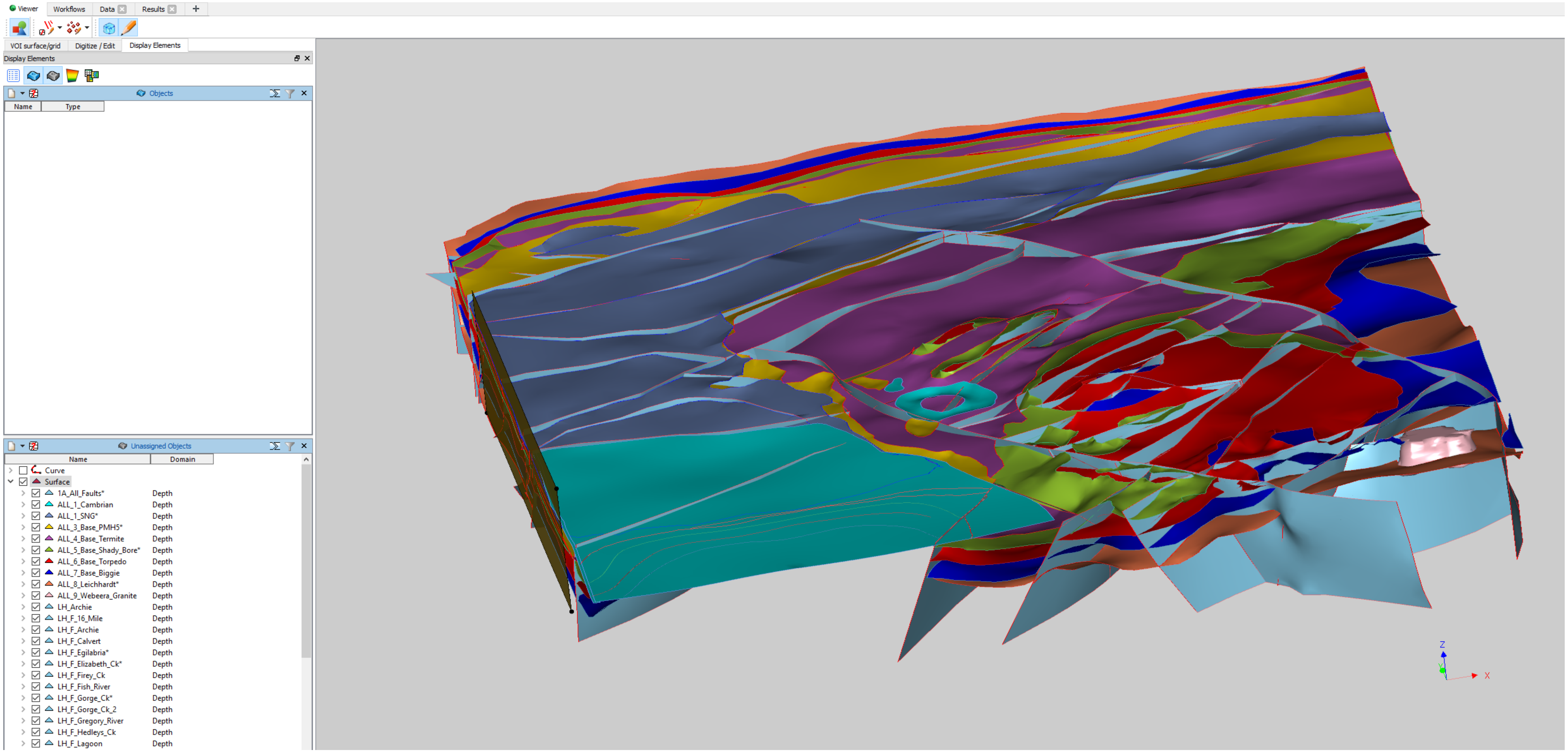
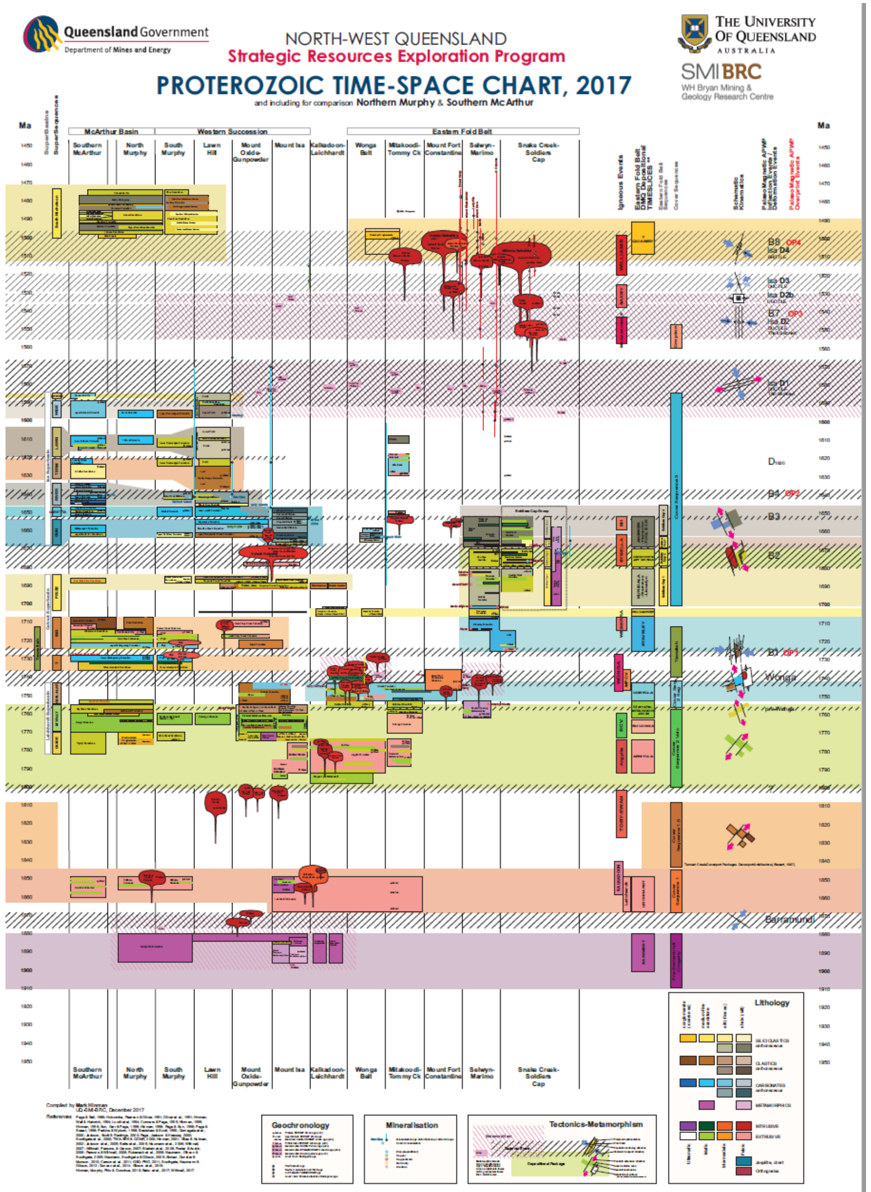
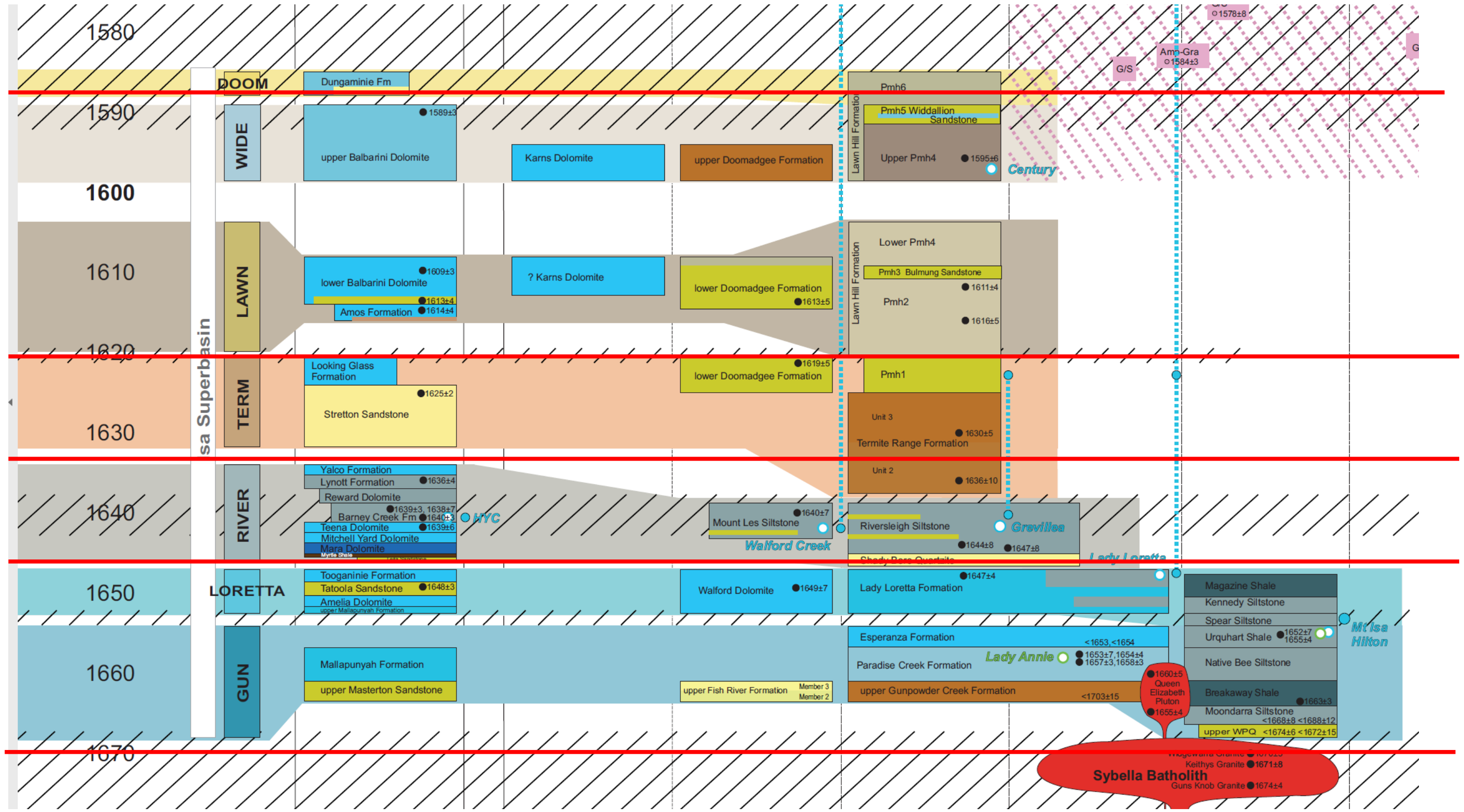


G14 surfaces modelled





https://nwmp-data.s3-ap-southeast-2.amazonaws.com/NWMP+Timeslices.zip

https://nwmp-data.s3-ap-southeast-2.amazonaws.com/NWMP_Timeslices_MI.zip

Lawn Hill area exercise

Pick three areas which meet the following criteria

- Isa/Century host rocks with 1000m of surface
- One other characteristic which provides support, eg
  - Previously targeted
  - Structural Justification
  - Stratigraphic justification (eg thickness change)
  - Empirical support

Why did you pick them and what would you do next?

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Thank you

Prof Rick Valenta | Director
WH Bryan Mining and Geology Research Centre
Sustainable Minerals Institute
r.valenta@uq.edu.au

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