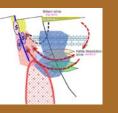
NWMP Discovery Program Components

Comprehensive compilation

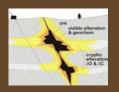
updating the existing open file data compilations (to extent possible)

- distilling the results of geoscientific studies
- ensuring that this information is comprehensive, spatially consistent, wellexplained
- delivered in a form which can be easily used by explorers and other projects



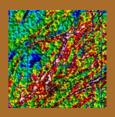
Mineral systems insight

- Regional structural/stratigraphic targeting frameworks
- Mineral systems and footprints
- Studies of Igneous fertility
- New insights from data analytics



Exploration toolkits

- Atlas of Northwest Mineral Province mineral deposits
- Geochemistry over post-mineralisation cover sequences
- Halo models for recognition of blind or covered systems



Transformative new data and interpretations

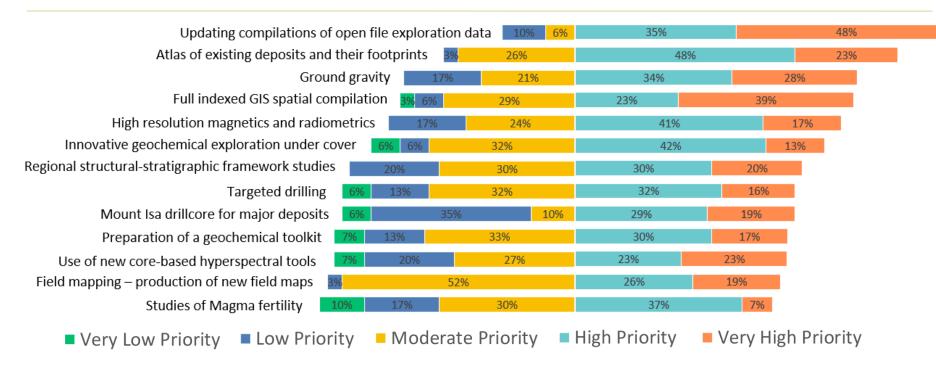
- New regional airborne gravity gradiometry
- Cover geochemical surveys
- Targeted drilling
- New interpretations of existing precompetitive datasets







Survey of Industry – top half priorities



- Open file exploration data (1/26)
- Atlas of existing deposits and footprints (2/26)
- Full indexed GIS spatial compilation (4/26)
- Mount Isa drillcore repository (9/26)



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Full indexed spatial data compilation

Updating compilations of open file explo	ration data 10% 6%	35%	48%
Atlas of existing deposits and their footprints	S <mark>3%</mark> 26%	48%	23%
Ground gravity	17% 21%	34%	28%
Full indexed GIS spatial compilation 3%	5% 29%	23%	39%
High resolution magnetics and radiometrics	7% 24%	41%	17%
Innovative geochemical exploration under cover 6% 6%	32%	42%	13%
Regional structural-stratigraphic framework studies 20%	30%	30%	20%
Targeted drilling 6% 13%	32%	32%	16%
Mount Isa drillcore for major deposits 6%	35% 10%	29%	19%
Preparation of a geochemical toolkit 7% 13%	33%	30%	17%
Use of new core-based hyperspectral tools 7% 20%	27%	23%	23%
Field mapping – production of new field maps 3%	52%	26%	19%
Studies of Magma fertility 10% 17%	30%	37%	7%
Very Low Priority Low Priority Mod	derate Priority	High Priority 📕 🛛	/ery High Priority







Full indexed GIS spatial compilation

- Faceted spatial data index
- Updated time-space chart
- GIS time-sliced stratigraphy, structure, igneous events
- 2D isopachs/depths from existing 3D models
- Exploration target compilation
- Compilation of miscellaneous legacy datasets
 - Metamorphic map
 - NABRE sections
 - CRC LEME regolith maps
 - Others as available
- Update of solid geology interpretation where justified







SMIBRC WH Bryan Mining & Geology Research Centre

September 2018



SOLID GEOLOGICAL INTERPRETATION of the southern EASTERN FOLD BELT, Mt Isa, Northwest Queensland'

Queensland Government

Geological Survey of Queensland

Mark Hinman, Danny Huisman, Glen Little & Matt Porter





INDUSTRY-UNIVERSITY-GOVERNMENT COLLABORATION

AN INDUSTRY-UNIVERSITY-GOVERNMENT COLLABORATION

SOLID GEOLOGY INTERPRETATION of the southern EASTERN FOLD BELT, Mt Isa, Northwest Queensland.

Mark HINMAN, Danny HUISMAN, Glen LITTLE & Matt PORTER June, 2018

1|BRC

WH Bryan Mining & Geology Research Centre

> Data contributed by: South32, Minotaur Exploration, Sandfire Resources

Interpretation funded by: Qld Government's New Discovery Program in Northwest Queensland

Interpretation carried out by: UQ-SMI-BRC (Mark Hinman)

FINAL REPORT & Data on QDEX ...

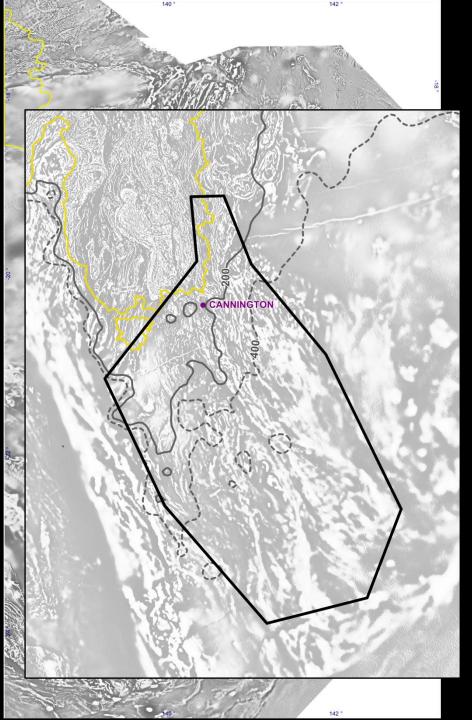
<u>http://qdexdata.dnrm.qld.gov.au/QDEXDataDownloa</u> <u>dManager/Results?type=Report&id=108143</u>

T-x Chart, GIS Solid Geology, process-oriented BHT model discussion, Prospectivity



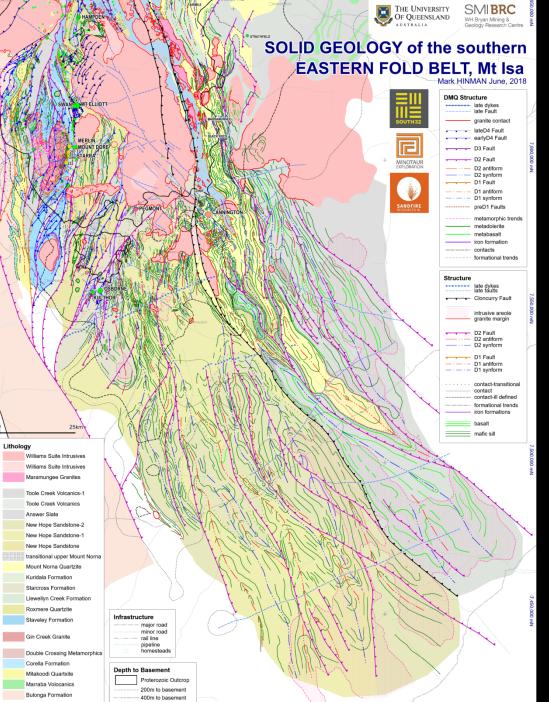






Southern extension of EASTERN FOLD BELT ...

... under <u>significant</u> Mesozoic cover

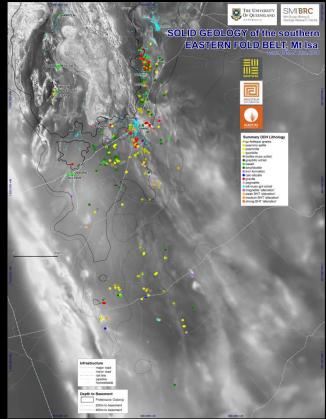


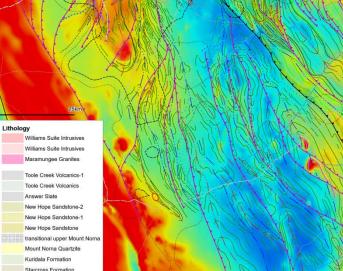
500 000 mE

450 000 mE

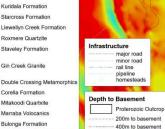
550 000 mE

Lithology & Stratigraphic Interpretation leveraged South32's & Minotaur's regional exploration drilling





500,000 mE



Roxmere Quartzite

Staveley Formation

Gin Creek Granite

Corella Formation

Mitakoodi Quartxite

Bulonga Formation

-SOLID GEOLOGY of the southern EASTERN FOLD BELT, Mt Isa

THE UNIVERSIT



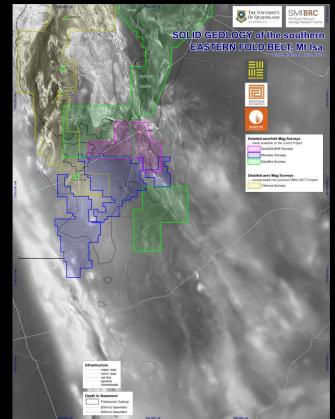
SMI BRC WH Bryan Mining &

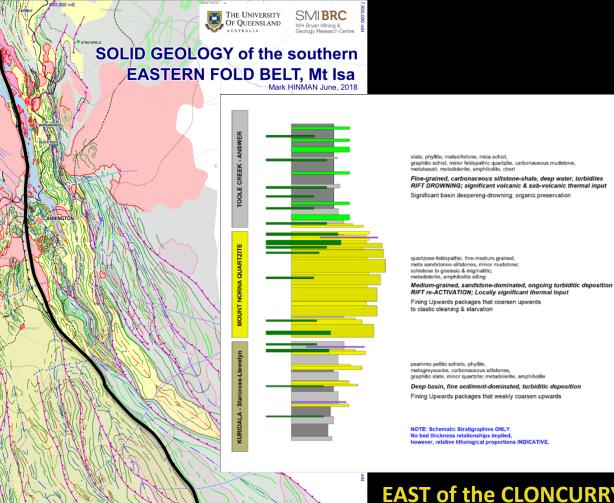






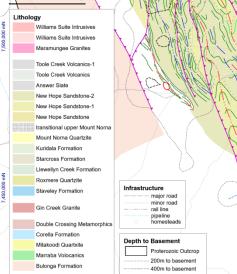
Form Surface & Structural Interpretation leveraged South32's, Minotaur's & Sandfire's detailed Magnetic Surveys





LONCURRY

550 000 mE



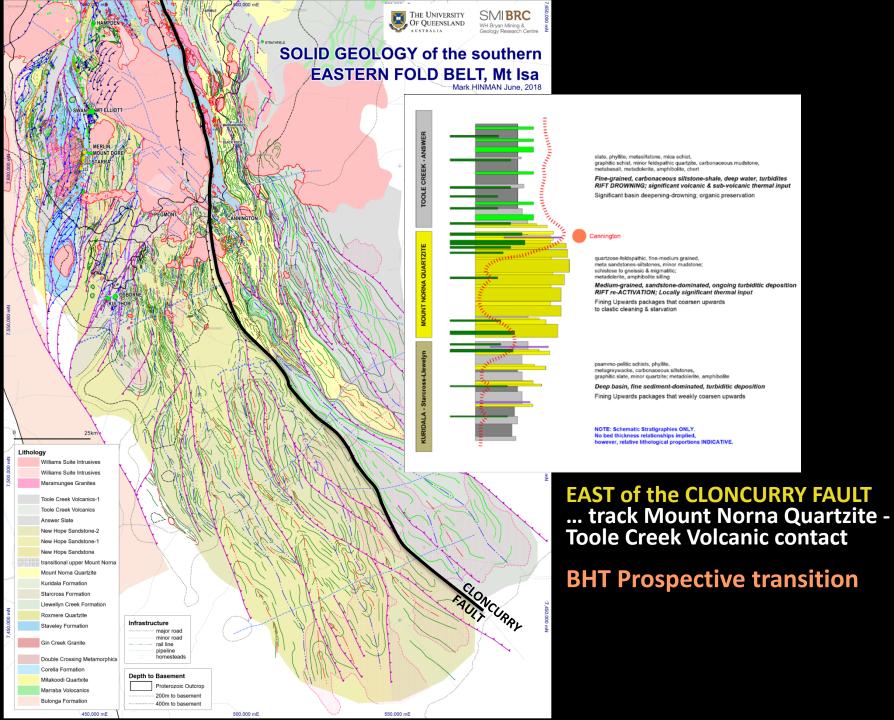
450 000 mE

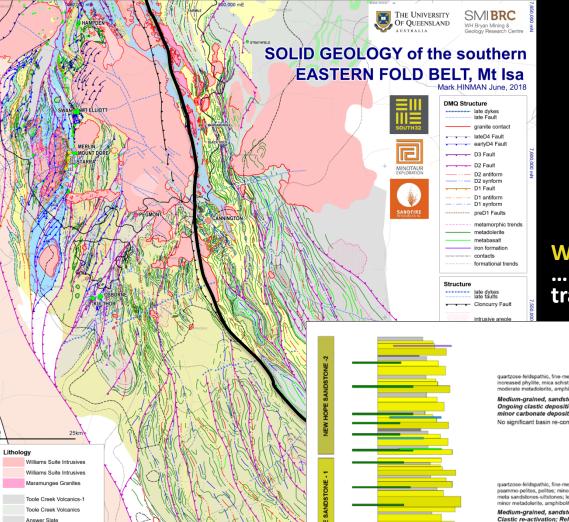
500 000 mE

25km

HOT

EAST of the CLONCURRY FAULT ... track Mount Norna Quartzite -Toole Creek Volcanic contact





WEST of the CLONCURRY FAULT ... less distinct lithological package transition

quartzose-feldspathic, fine-medium grained psammites, psammo-pelites; increased phylite, mica schist component; minor graphitic schist; minor calc-silicate; moderate metadolerite, amphibolite siling; very minor metabasalt

Medium-grained, sandstone, siltstone & mudstone turbidites Ongoing clastic deposition with increased fine component; minor carbonate deposition; Moderate sub-volcanic thermal input No significant basin re-configuration; Moderately increased thermal input

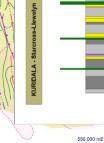
quartzose-feldspathic, fine-medium grained psammites, psammo-pelites, pelites; minor mudstone; meta sandstones-siltstones; lesser schistose to gneissic varients; minor metadolerite, amphibolite silling

Medium-grained, sandstone-dominated, ongoing turbiditic deposition Clastic re-activation; Relatively weak thermal input Fining Upwards clastic packages without discernable trends

psammo-pelitic schists, phyllite, metagreywacke, carbonaceous siltstones, graphitic slate, minor quartzite; iron formations; metadolerite, amphibolite

Deep basin, fine sediment-dominated, turbiditic deposition Fining Upwards packages that weakly coarsen upwards

NOTE: Schematic Stratigraphies ONLY. No bed thickness relationships implied, however, relative lithological proportions INDICATIVE.



NEW HOPE

New Hope Sandstone-2 New Hope Sandstone-1 New Hope Sandstone transitional upper Mount Norna Mount Norna Quartzite Kuridala Formation

Starcross Formation

Roxmere Quartzite

Staveley Formation

Gin Creek Granite

Mitakoodi Quartxite

Marraba Volocanics

Bulonga Formation

Llewellyn Creek Formation

Double Crossing Metamorphics Corella Formation

450 000 mE

Infrastructure

major road minor road

homesteads

Proterozoic Outcrop

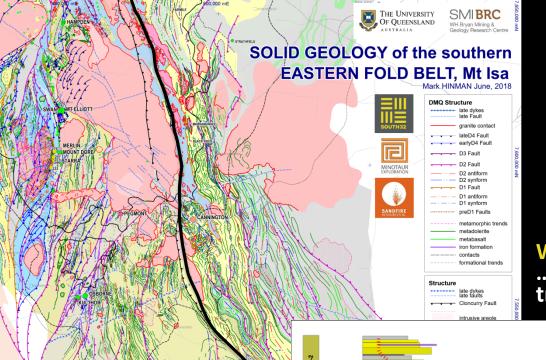
200m to basement

400m to basement

500 000 mE

rail line pipeline

Depth to Basement



SANDSTOP

NEW HOPE

SANDSTONE - 1

NEW HOPE

550 000 mE

WEST of the CLONCURRY FAULT ... less distinct lithological package transition

quartzose-feldspathic, fine-medium grained psammites, psammo-pelites increased phyllite, mica schist component; minor graphitic schist: minor calc-silicate moderate metadolerite, amphibolite siling; very minor metabasa

Medium-grained, sandstone, siltstone & mudstone turbidites Ongoing clastic deposition with increased fine component; minor carbonate deposition; Moderate sub-volcanic thermal input No significant basin re-configuration; Moderately increased thermal input

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Medium-grained, sandstone-dominated, ongoing turbiditic deposition Clastic re-activation; Relatively weak thermal input Fining Upwards clastic packages without discernable trends

Pegmont

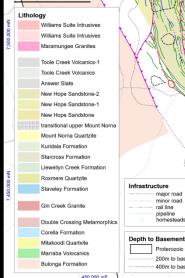
psammo-pelitic schists, phyllite, metagreywacke, carbonaceous siltstones, graphitic slate, minor quartzite; iron formations; metadolerite, amphibolite

Deep basin, fine sediment-dominated, turbiditic deposition Fining Upwards packages that weakly coarsen upwards

NOTE: Schematic Stratigraphies ONLY. No bed thickness relationships implied, however, relative lithological proportions INDICATIVE.

less clear **BHT Prospectivity**

but other **BHT Prospective** transitions



major road minor road

Proterozoic Outcrop

200m to basement

400m to basement

500 000 mF

rail line pipeline homesteads

25km



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Mark HINMAN, Danny HUISMAN, Glen LITTLE & Matt PORTER June, 2018





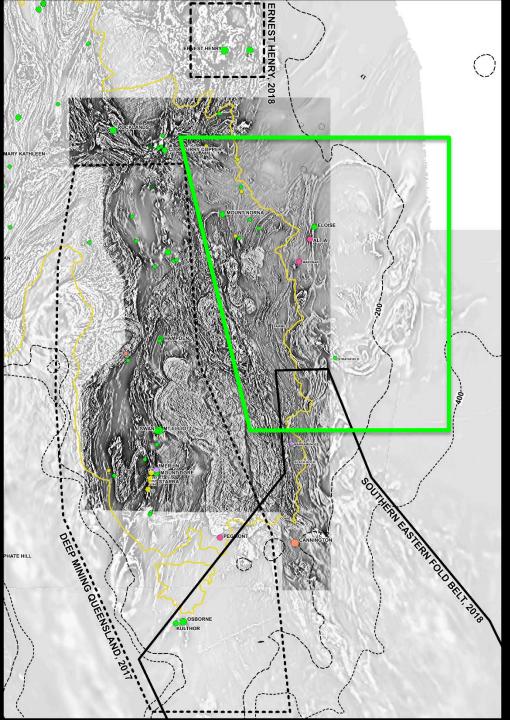
FINAL REPORT & Data on QDEX ...

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T-x Chart, GIS Solid Geology, process-oriented BHT model discussion, Prospectivity



14



Looking to extend the same approach to the new Cloncurry surveys

Previous BRC Solid Geology Interpretations DEEP MINING QUEENSLAND, 2017 Southern EASTERN FOLD BELT, 2018 ERNEST HENRY, 2018

Proterozoic Outcrop Extent

Recently-released CLONCURRY 1370 tmi-1vd over Mt Isa regional tmi-1vd.

Current Status and Next Steps

Current Status

- Time-space compilation complete
- Atlas Prototype complete
- Target compilation complete
- Spatial data index well progressed
- Core collection under way
- Legacy datasets near completion
- Solid geology updates under way
- Next Steps
 - Expand Atlas Prototype (Mt Isa/EH) to full atlas of all deposits
 - Full core collection
 - Additional studies based on gap analysis







Gap Analysis

Area	Current State	Target State	Difference	Action Plan	Priority
Consistency of mineral deposit sample data Industry priority rank: 2/26	No consistent set of mineralogical, geochemical and petrophysical data for NW/MP mineral deposits	A consistent set of sample data exists for all major deposits in the region	Greater ability to carry out consistent analysis and comparison of individual deposits using new data-driven exploration tools which require standardised data	Cloncurry Metal Project Provide an up-to-date consistent understanding of the Cloncurry mineral system, which will be expressed as an Alttas of alteration types and petrophysical responses. Develop a toolkit consisting of techniques developed in order to identify critical mineral system indicators using relatively inexpensive tools, i.e., tools that can be made available in the core shed	High
Hydrogeochemistry Industry priority rank: 6/26	Despite clear evidence of the effectiveness of groundwater chemistry in mapping ithology, alteration and prospectivity in the NWMP, there are significant gaps in coverage and many unsampled bores	All available sources of hydrogeochemical data have been rigorously sampled and incorporated into an improved hydrogeochemical database for the region	New insights into spatial variations in prospectivity in covered areas in the NWMP – potential for identification of new targets for under cover exploration	Hydrogeochemistry Project Sampling and analysis of unsampled water bores in the region, followed interpretation and data integration in order to interpret patterns of lithology, alteration and prospectivity under cover	High
	o		0111	!	
Area	Current State	Target State	Difference	Action Plan	Priority
NW/MP Mineral deposit information <i>Industry priority</i> rank: 2/26	There is currently no systematic atlas of NWMP Mineral deposit characteristics which combines systematic data relating to geology, geochemistry, geophysics and publicly available information relating to mineralisation and its footprints	A single atlas with consistent public information on all the major deposits in the region, as well as a publicly- accessible collection of drillcore for these deposits	Enhanced ability for established and new explorers in the region to gain an overview of deposits in the region, and an improved ability to recognise mineralisation styles in exploration data	NW Mineral Province Deposit Atlas, Phase 2 Continue compilation of the NW Mineral Deposit atlas, extending the Atlas to all major deposits in the region	High
Innovative geochemical exploration under cover	A geochemical toolkit has been produced which summarises potential approaches to exploration in various coverade regimes. However, there is no systematic coverage of geochemical data in settings amenable to such covered exploration	Fit-for-purpose geochemical datasets covering the areas where potential exists for the application of geochemical exploration under cover	Better detection and prioritisation of covered targets on the basis of their geochemical signature.	DNRME should prioritise the provision of Collaborative Exploration Initiative funds to companies who undertake to carry out appropriate geochemical surveys in covered areas on the basis of recommendations and orientation information in the GTK	High
Drillcore collection Industry priority rank: 9/26	Additional drillcore has been sourced for the Mount Isa Core Storage Facility, but many of the region's deposits are not yet represented in the facility	Representative drillcore and associated geoscientific information exist for all the major deposits in the region	Enhanced ability for established and new explorers in the region to gain an overview of deposits in the region, and an improved	GSQ and NW Mineral Province Deposit Atlas, Phase 2 Continue to source representative drillcore and associated data	High
	represented in the racility		ability to recognise mineralisation styles in exploration data	through the GSQ and the MNW Mineral Province deposit Atlas project	

Area	Current State	Target State	Difference	Action Plan	Priority
Open File Compilations Industry priority rank: 1/26	Open file data for the NWMP have been compiled up to October 2016. Explorers have noted a need to carry out additional quality control on the data, and have placed a high priority on the availability of this information	Open file data is fit-for- purpose and up-to-date	Explorers able to formulate their exploration programs based on all available data, and unlikely to encounter evidence of undocumented exploration in their tenements	Updated compilation is beyond the scope of the NWMP Discovery program, but is being addressed in other DNRME programs from the point of view of both compilation and updates to reporting standards	High
Regional Structural- Stratigraphic Framework studies Industry priority rank: 7/26	Many areas of the NWMP do not have studies of this type at a scale relevant to exploration.	Prospective areas of the NW Mineral Province covered by Structural-stratigraphic framework studies which make use of all available high resolution geophysical datasets and current understanding of mineral system criteria, and include mineral system-based target regions	Increased ability to identify covered or blind areas of high prospectivity based on rigorous mineral system criteria	Not funded as part of this program. This activity is traditionally carried out by companies "in-house", and opportunities for improvement may exist in the form of targeted workshops and/or other learning opportunities	High
Studies of Magma Fertility Industry priority rank: 13/26	No clear understanding of the links between mineralisation and magma fertility in the region. Disagreement exists as to the strength of the link, and the tools which could arise which may be of relevance to exploration	Magma fertility links clearly demonstrated for applicable mineral systems and a toolkit developed for recognition of fertile regions in exploration datasets	Enhanced ability to prioritise regional target areas on the basis of Magma Fertility indicators	EGRU Magma Fertility Project Research aimed at studying key areas such as the Mary Kathleen belt where the greatest potential seems to exist for clear demonstration of magmatic links	High
			8111	•	
Area Target Prediction using machine learning Industry priority rank: 26/26	Current State The potential advantages and applications of machine- learning to exploration in the NWMP are not well- understood, and industry perceptions of its applicability and usefulness in exploration are poor	Target State Geoscientists and explorers have a better understanding of the best applications of machine learning to the exploration process	Difference Clearer understanding and acceptance of appropriate uses of the technology, resulting in greater application of associated techniques and potentially more effective exploration	Action Plan North West Mineral Province data-driven mineral exploration Review results of data- driven exploration preliminary study and identify the most productive future avenues	Priority High
Spatial Data index Industry priority rank: 4/26	A prototype Spatial Data index has been prepared based on an established ESRI platform. It allows searching on some keywords under different categories, but is not intuitive and does not allow faceted searching	A clear and intuitive tool which allows faceted spatial searching of geoscientific data and publications for the region	More efficient and comprehensive searching and sourcing of existing geoscientific data	Comprehensive review of prototype and recommendations for further improvement	Moderate
NWMP 3D models	NWMP 3D models exist at various scales, formats and	Easily accessible 3D geological models at a scale	Explorers making better use of 3D	Review and benchmarking of web-based delivery	Moderate

(and two more...)

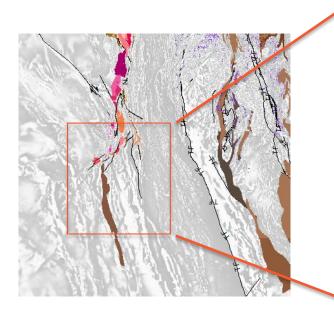


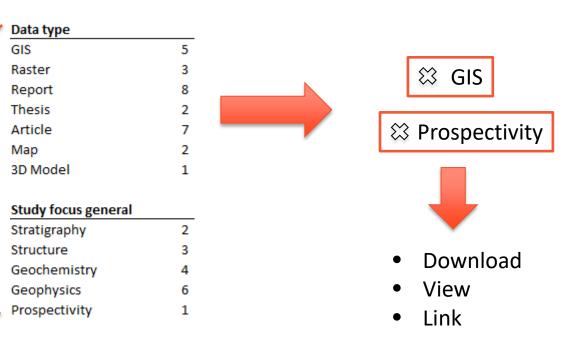




Faceted spatial data index

- Full compilation of reports, theses, publications, etc
- Categorised by study focus, data type, mineralisation style,...
- Spatially indexed
- Faceted search by theme



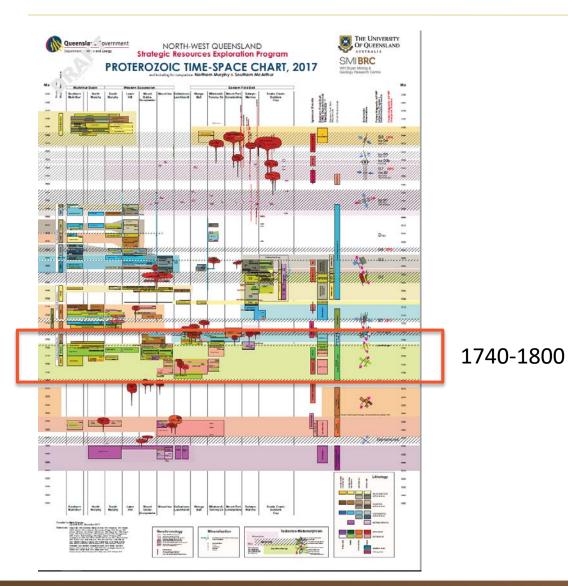








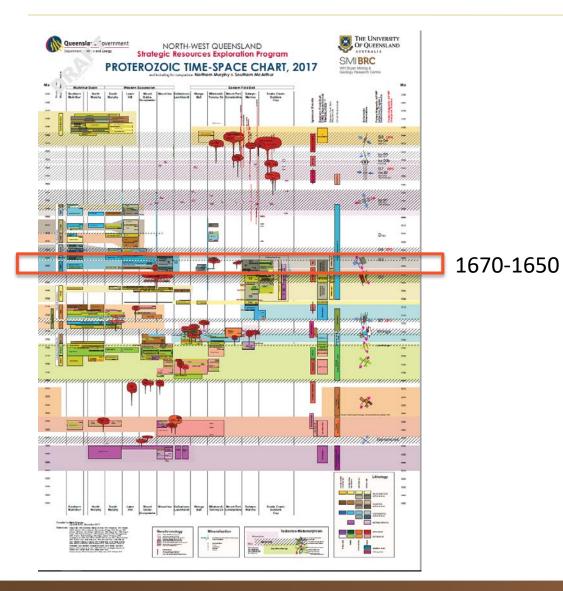
Updated time-space chart



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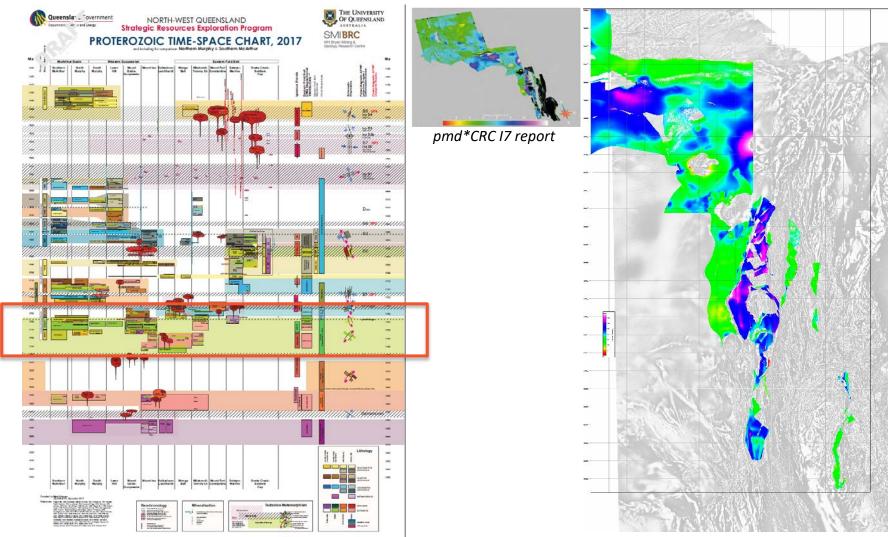
Updated time-space chart







2D isopachs/depths from existing 3D models



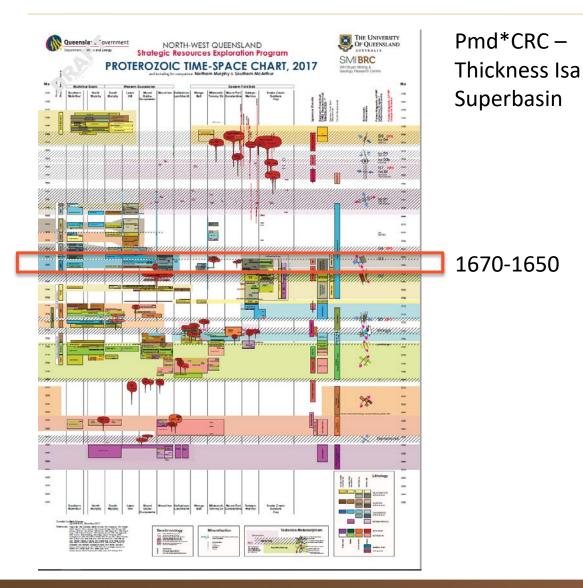
Pmd*CRC – Thickness Leichhardt Superbasin







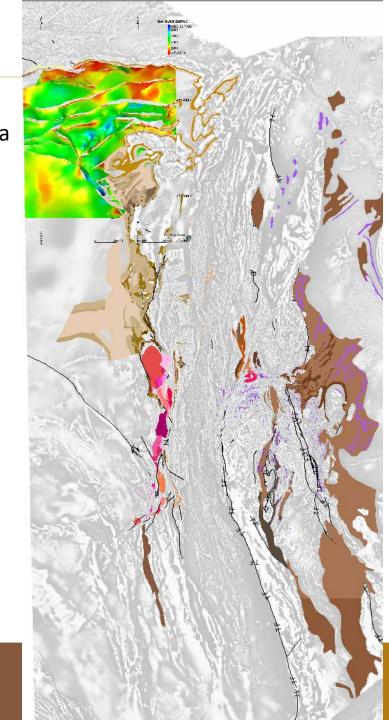
Isopachs from 3D models



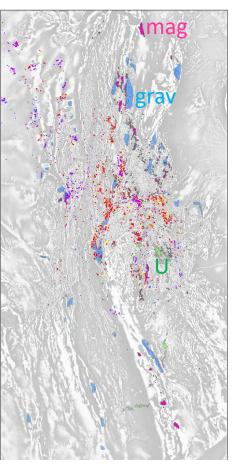
SMIBRC

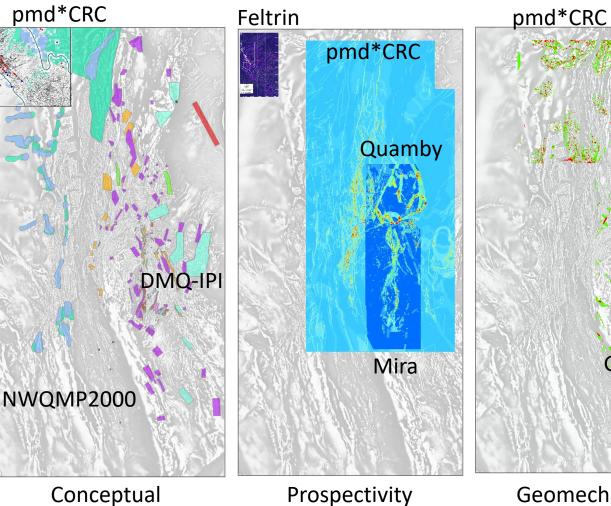
WH Bryan Mining & Geology Research Centre





Exploration target compilation





Geophysical/ Geochemical

Conceptual

Geomechanical

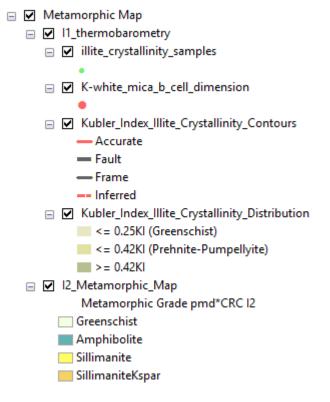


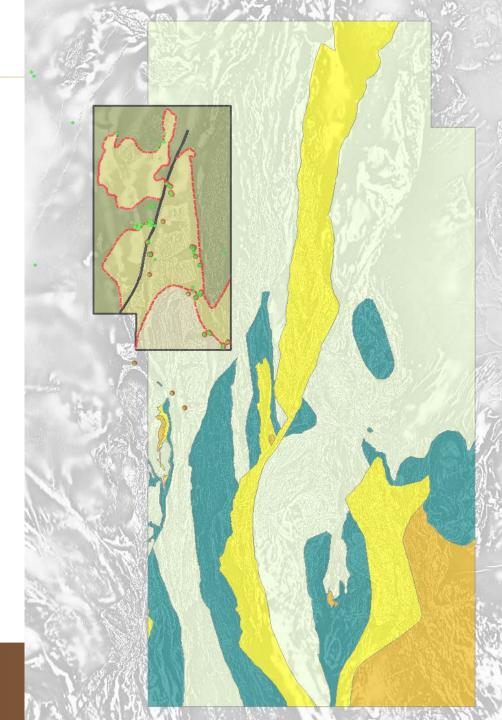




GMEX-IPI

Metamorphic Grade





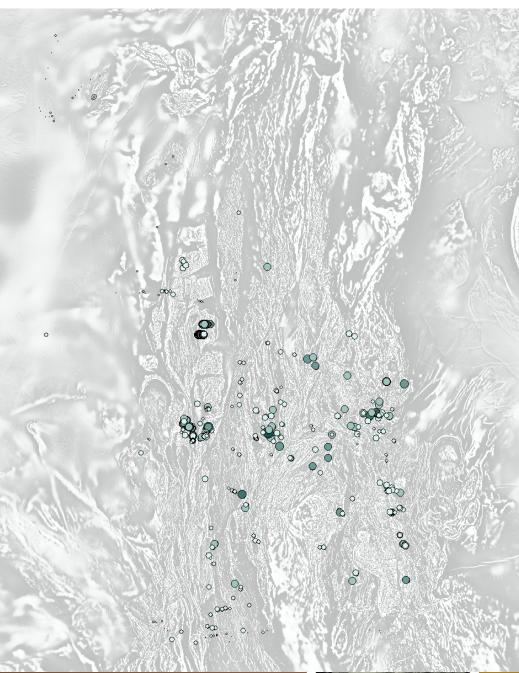




Rock Property Data

- 🖃 🗹 Rock Property Data
 - MI_Rock_Property_Data magsus_ave
 - 0.000000 11380.000000
 - I1380.000001 39890.000000
 - 39890.000001 107400.000000 ۰.
 - 107400.000001 364425.000000
 - 364425.000001 3644250.000000

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1389 samples



Geochronology

Compilation Geochronology

2017_Withnall_Isotopic_Ages_Mt_Isa

Analysis Tyoe

AR-AR

🔴 K-AR

🔵 Pb-Pb

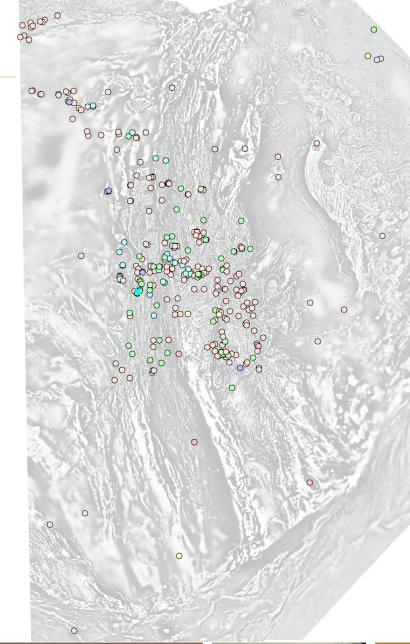
🔘 RB-SR

U-PB unspec

U-PB SHRIMP

🔘 U-PB TM

548 Samples



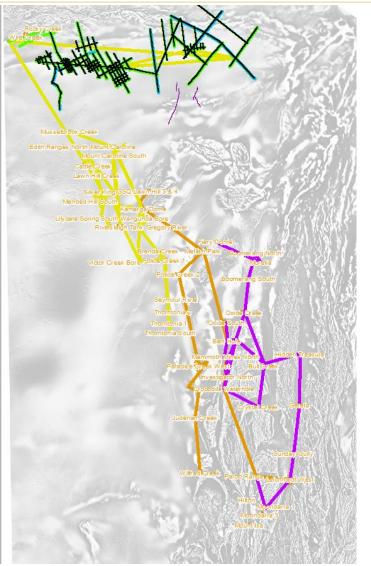






NABRE

🖃 🗹 Sequence Stratigraphy □ 1999_2002_Measured_Sections ٠ □ 1999_2002_Measured_Drillholes ര □ Seismic_Survey_2D_Comalco_Stations Seismic_Survey_2D_Comalco_Grid □ ▲ AMIRA_P552_2002_03_Transects □ VABRE_1999_19_Transects □ NABRE_1999_19_Seismic_Transects □ INABRE_1999_15_Transects □ INABRE_1999_10_Transects □ AMIRA_P552_2002_03_Sections 02 □ ■ NABRE_1999_19_Sections 62 □ INABRE_1999_15_Sections 03 □ VABRE_1999_10_Sections \odot

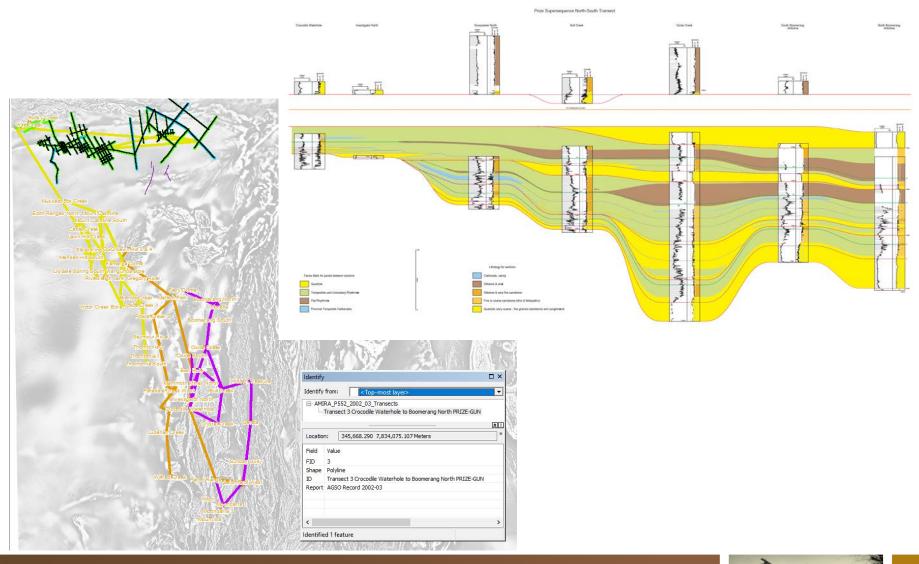








NABRE

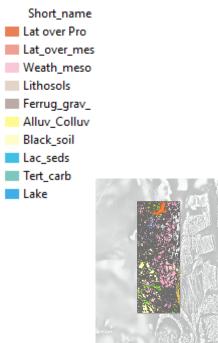








Regolith CRC LEME





CRC_LEME_seismic_regolith_map +

buckrego polygon

selwrego polygon

trinrego polygon

ELOIREGP_ATTRIB

✓ +

✓ +

+

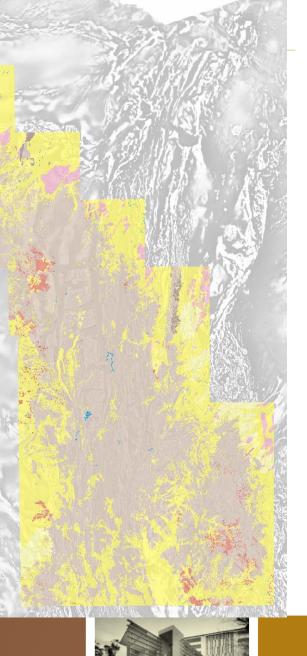
+

+ ✓

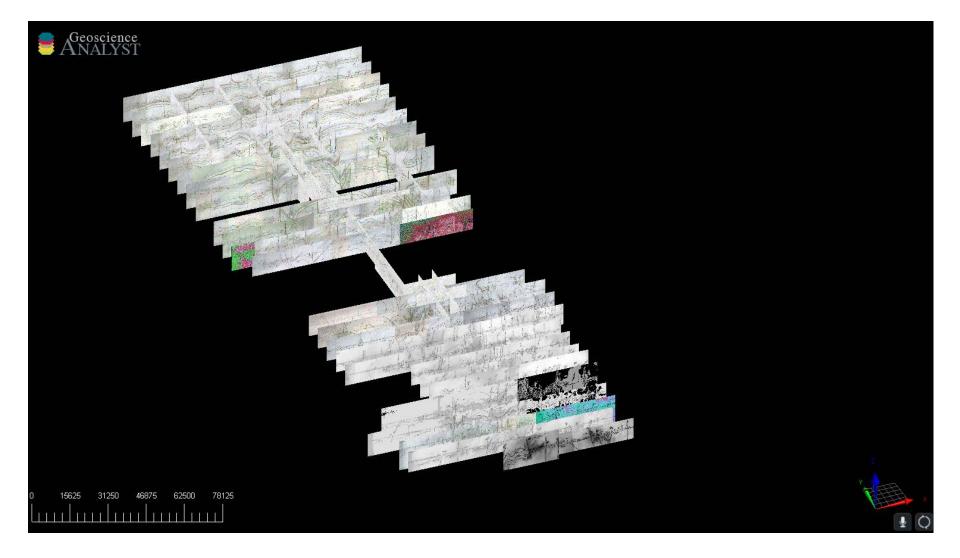








3D Information – pmd*CRC i1 and i7

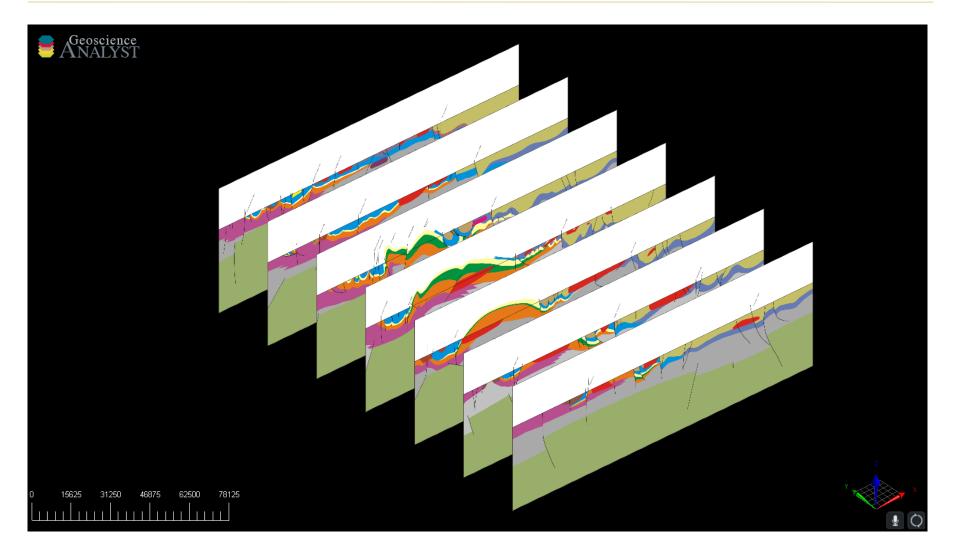








3D Information – pmd*CRC i2









3D Information - seismic

