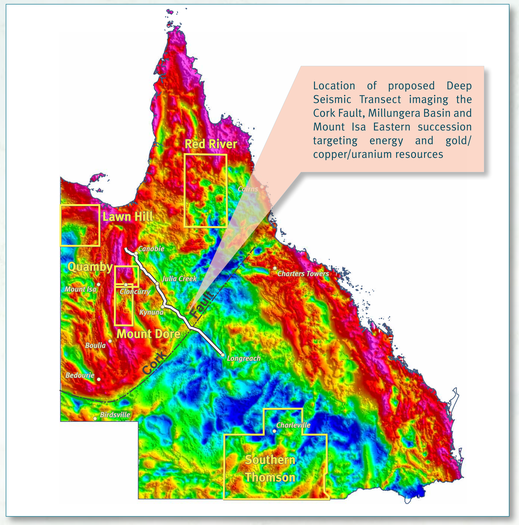
Greenfields studies

3D mineral prospectivity modelling and deep seismic transects

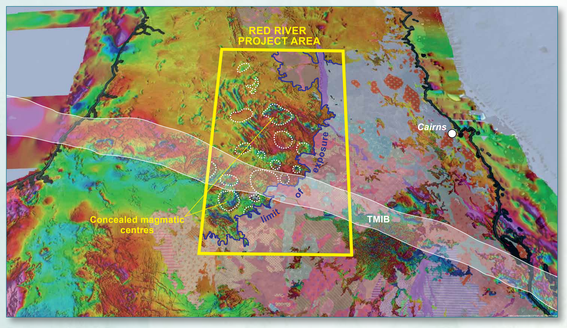
The Greenfields Prospectivity Unit has developed new workflows for 3D prospectivity modelling of regions with high greenfields potential such as the Mount Dore, Quamby and Lawn Hill areas in the Mount Isa Inlier and the Red River region of north Queensland. The Quamby project is the latest completed example.

Understanding of north–west Queensland's 3D crustal architecture will receive a major boost from GSQ's Southeast Mount Isa Deep Seismic transect, extending for over 650km north–west from Longreach to Canobie. Acquisition is proposed for 2013–14.



Future projects

Red River *(part of North Queensland Strategic Metals Project)*



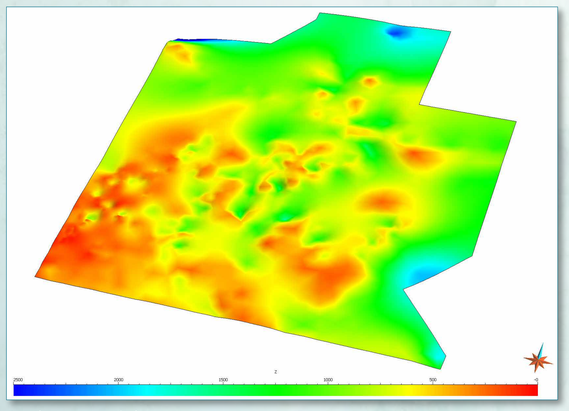
Proposed Red River project area

Targeting buried prospective magmatic systems of north Queensland (Townsville –Mornington Island Igneous Belt).

Prospective for:

- Epithermal Au/Ag
- Intrusion related Au
- Porphyry Mo-Cu-Au
- Uranium and REE

Southern Thomson


Depth to magnetic basement

- MT, AEM and gravity data acquisition
- Inversion modelling
- Depth to basement
- Solid geology
- Prospectivity analysis
- Drilling of test borehole

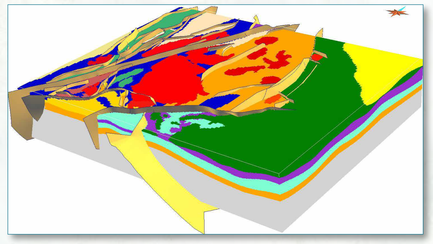
An integrated approach to reveal hidden potential

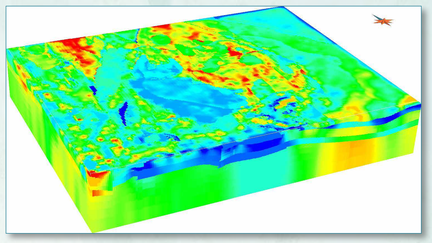
Quamby project

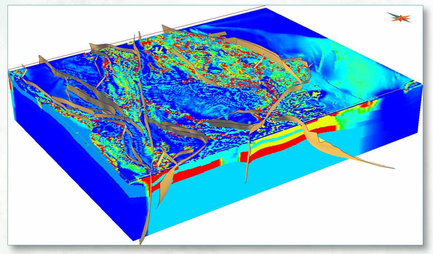
Working in greenfields terranes effectively requires integrating geology and geophysical data through iterative data validation, modelling and inversion tasks.

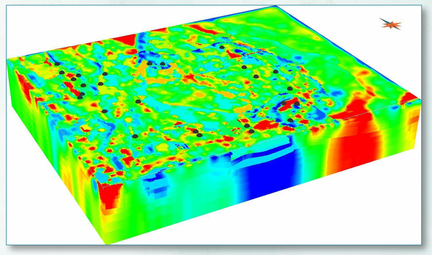
The GoCAD targeting workflow has been applied to the Quamby 3D model to better support predictive studies in concealed terranes.

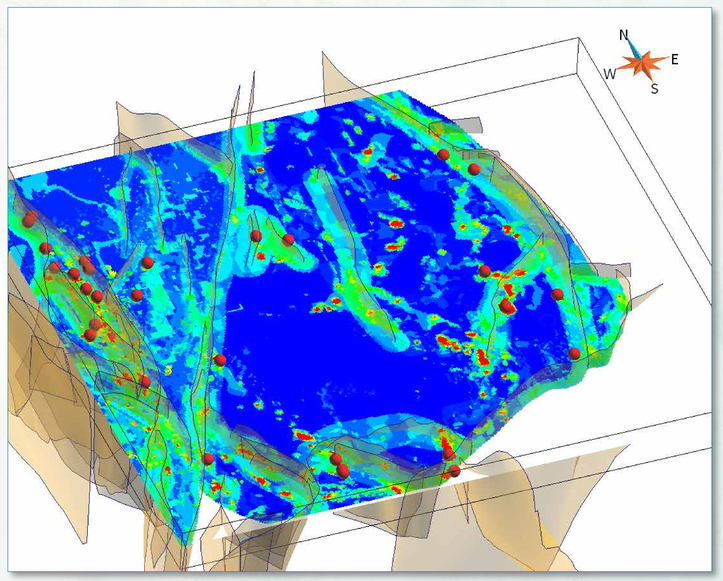
The main objective of this modelling work is to provide 3D physical property models for the Quamby region that can be directly employed in regional exploration to target prospective ground based on robust exploration criteria.


Quamby 3D voxet model and faults


3D density model of Quamby region

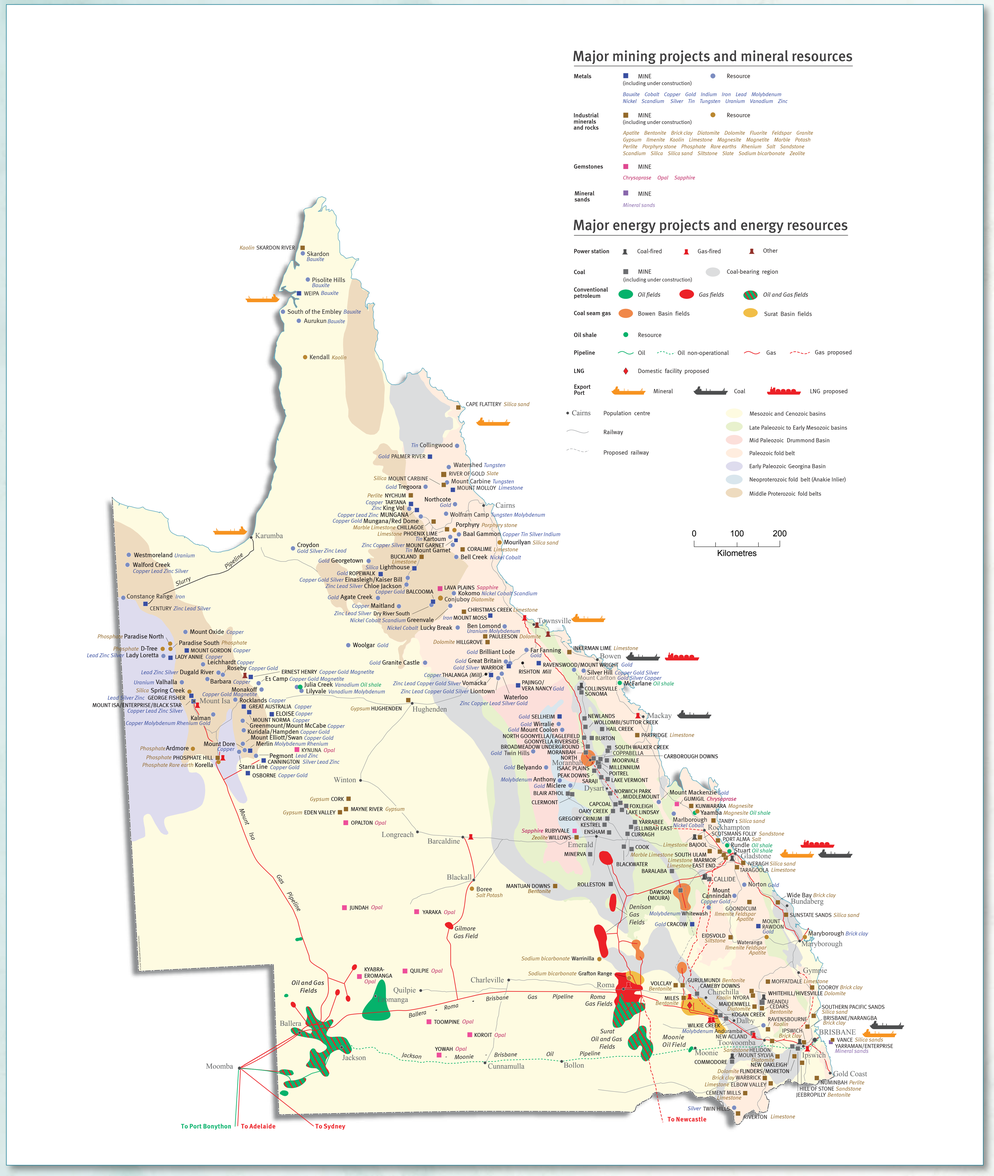

3D magnetic susceptibility model of Quamby region


Anomalous densities within the 3D density model with known mineralised locations mapped as black spheres



3D mineral potential model of the Quamby project area

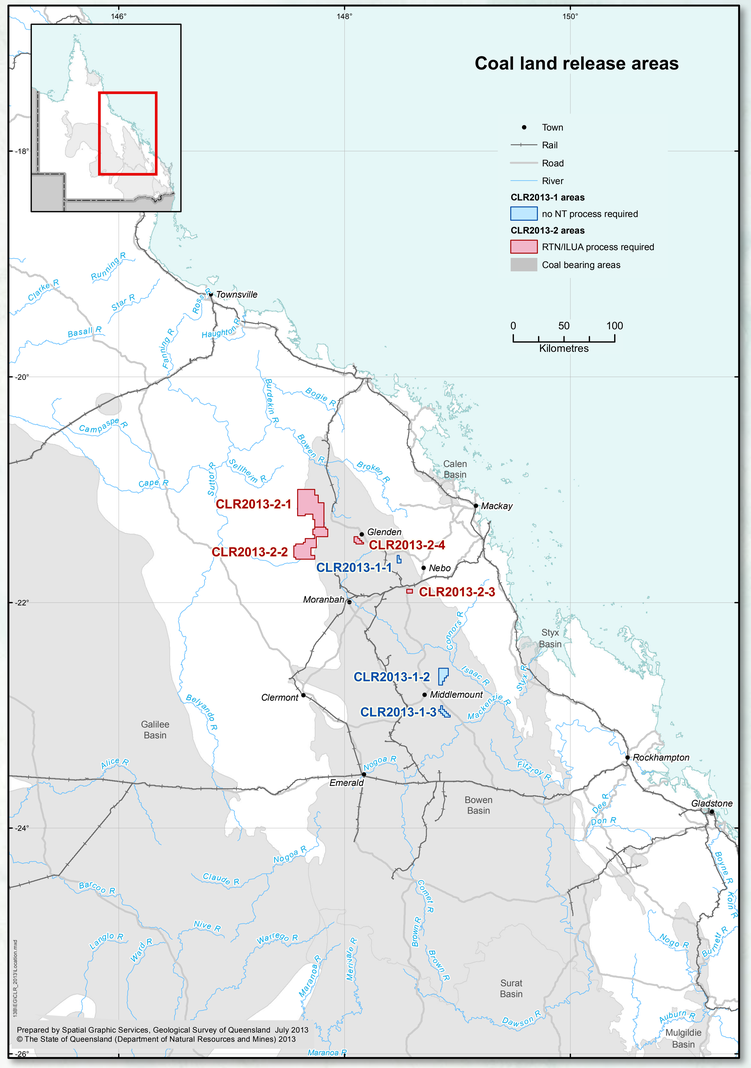
Mineral, petroleum and energy operations and resources



Queensland is one of the world's outstanding mineral and energy producing regions. The best known resource regions are the:

- Surat–Bowen basins (southern central Queensland) – coal and coal seam gas
- Weipa region (northern Queensland) – bauxite
- North West Queensland Mineral Province – base metals, phosphate and gold
- Charters Towers region (north-east Queensland) – gold and limestone
- South-west Queensland region (Cooper and Eromanga basins) – oil and gas.

Coal call for tenders



- Seven areas available for work program-based tender
- All areas in the northern Bowen Basin - more than 400 sub-blocks (>1200 km^2)
- Call for tenders closes 2:30pm Wednesday 5 March 2014
- Further information available from the Queensland Government's eTenders website

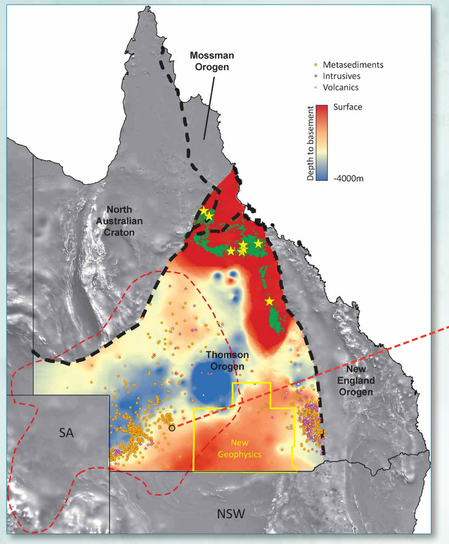
Summary details coal land release areas – northern Bowen Basin

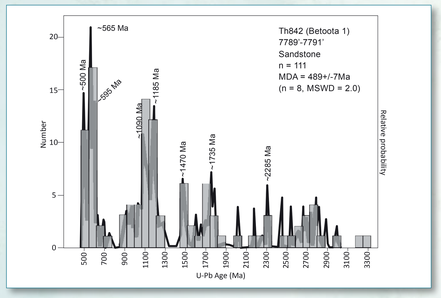
Coal Land Release Area	Location*	Sub-blocks	Area km^2
CLR2013-1-1	25 km north-west of Nebo	6	19.1
CLR2013-1-2	25 km north-east of Middlemount	34	108.1
CLR2013-1-3	25 km south-east of Middlemount	14	44.5
CLR2013-2-1	50 km west-north-west of Glenden	197	626.5
CLR2013-2-2	45 km west-south-west of Glenden	137	435.7
CLR2013-2-3	25 km south-west of Nebo	6	19.1
CLR2013-2-4	10 km south of Glenden	13	41.3

*Approximate distances to centroid of area
1 sub-block, northern Bowen Basin ~ 3.18 km^2

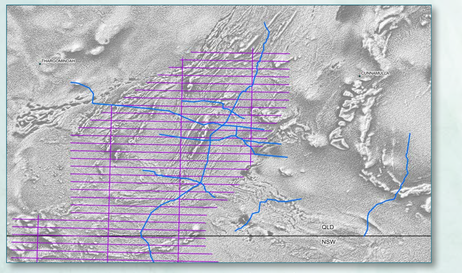
Thomson Orogen

Uncovering the geology and economic potential

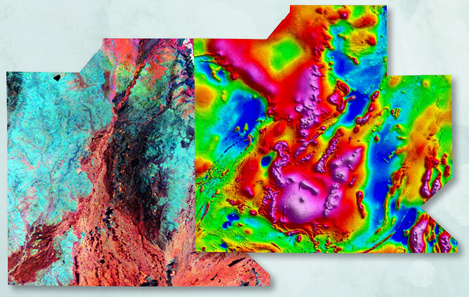




New geochronology



Planned aerial electromagnetic (purple) survey and shallow magnetotelluric (MT) survey (blue). The MT survey will be complemented by ground gravity.



Completed regional airborne magnetic and radiometric survey

Thomson Orogen is largely undercover and poorly understood.

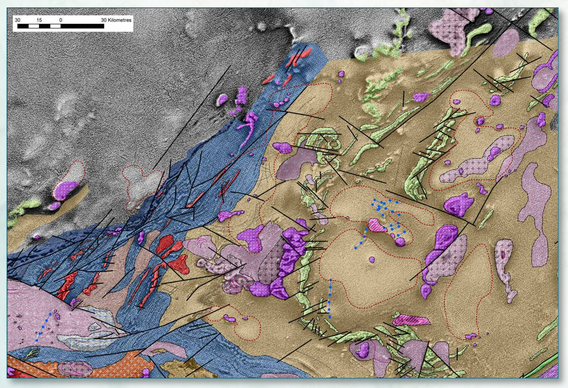
New data plus drill hole intersections from petroleum and stratigraphic drill holes have been used to piece together the geological framework of the orogen.

Data products include:

- Database of detailed basement lithologies, age, and geochemistry including new data
- Expanded detrital and magmatic geochronology
- Basement interpretation map using new and existing geophysics
- Depth to basement surface – detailed and regional
- Regional geophysics
- Detailed geophysics

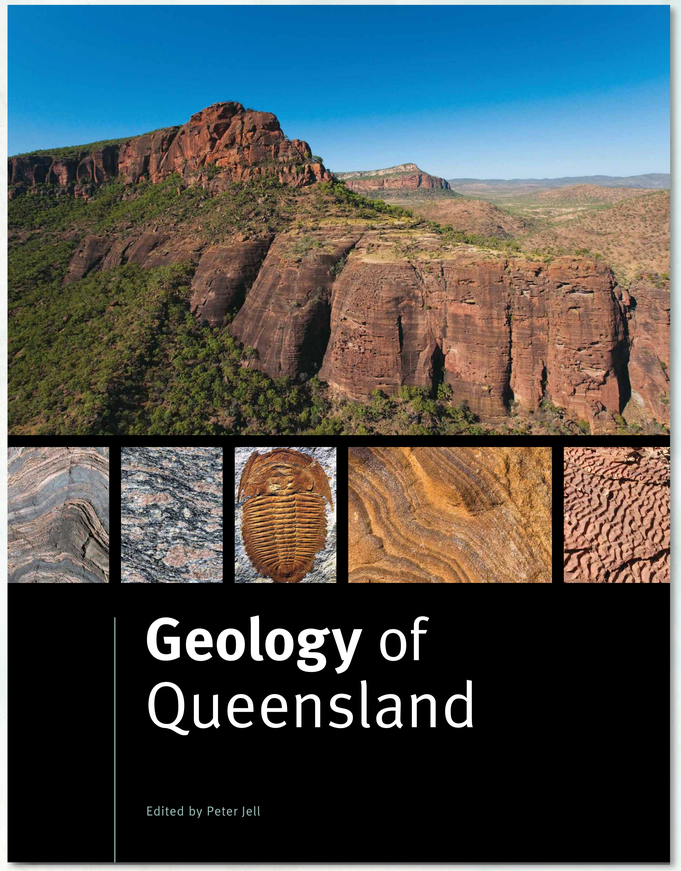
Future work:

- Major collaborative geophysical data acquisition program by GSQ, Geoscience Australia and GSNSW to track known mineralised belts into Queensland
- Includes magnetotelluric (MT), aerial electromagnetic (AEM), and gravity surveys (2013-14), followed by test drilling (2014-15)



Part of the preliminary basement interpretation

Geology of Queensland

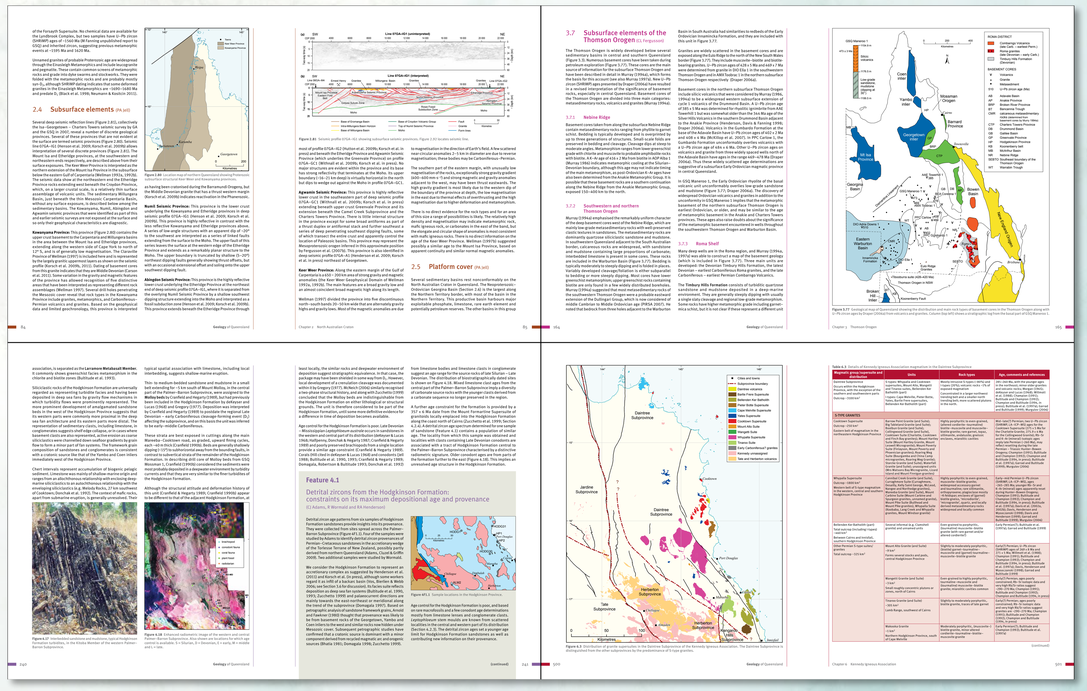


Geology of Queensland will become a standard reference for future generations of geologists.

Order now

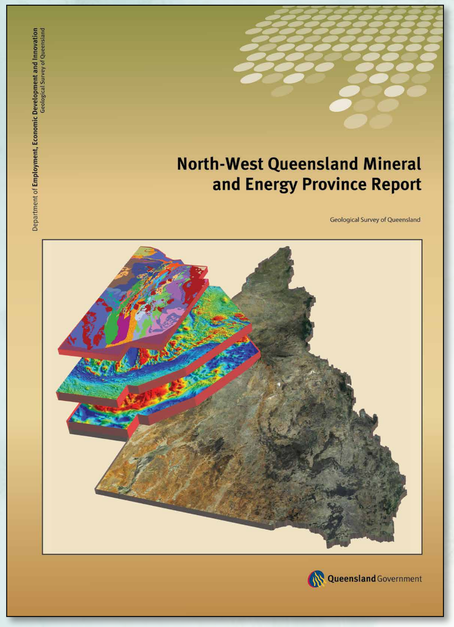
Book only (hardback or digital) A$75

Book, map and GIS DVD package A$110.90



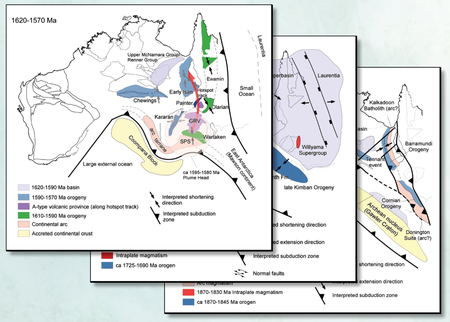
New concepts

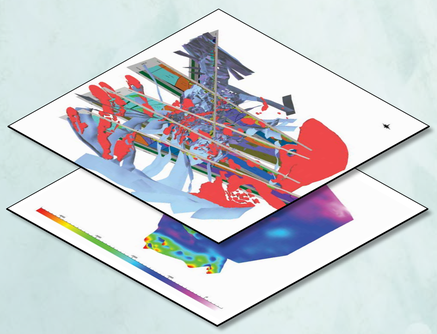
North-West Queensland Mineral and Energy Province Report



Contents

- An overview of the characteristics of the Proterozoic geological domains
- A synthesis of the Proterozoic geodynamic evolution of the Mount Isa Inlier
- A model of the Proterozoic tectonic evolution of the Mount Isa Inlier from an Australia-wide perspective
- Surface and solid geology as a seamless dataset
- A 3D model covering the entire North-West Queensland Mineral and Energy Province Study area
- Mineral systems analysis
- Exploration geochemistry and drill-hole database
- A district-scale IOCG (iron oxide copper gold) predictive study of the Mount Dore–Cloncurry region
- A geothermal prospectivity assessment of the Phanerozoic successions
- Synthesis of current knowledge of carbon-based energy resources
- Attributed GIS dataset in ArcGIS and MapInfo formats
- Bibliography





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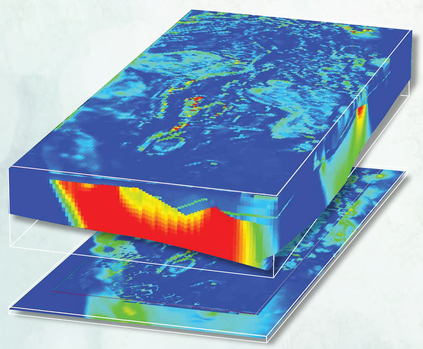
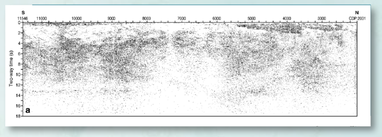


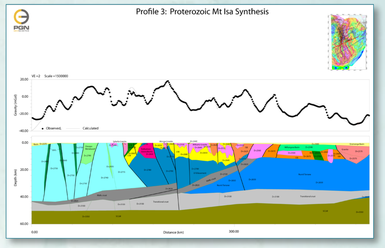
Geodynamic synthesis North-west Queensland

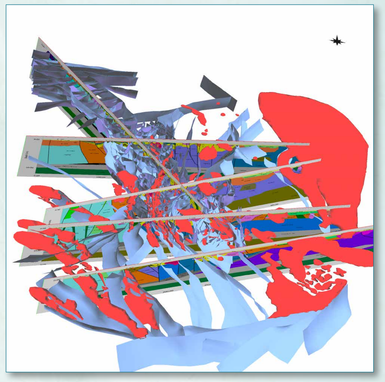
The study combines new data (e.g. seismic, geochronology, geochemistry, paleomagnetics, structural geology, regional geology, geophysics) and advanced geophysical processing techniques (e.g. 2.5D gravity forward modelling, 3D inversions) with new tectonic concepts. This provides a more complete picture of the settings of, and controls on, known ore systems and, critically, new targeting models for explorers.

Key outputs:

- five gravity 2.5D forward models
- a Proterozoic (1800–1500 Ma) geodynamic synthesis
- 11 geodynamic evolution maps of Eastern Proterozoic Australia
- two time–space plots







Arcs, accretion, plumes and orogenesis –

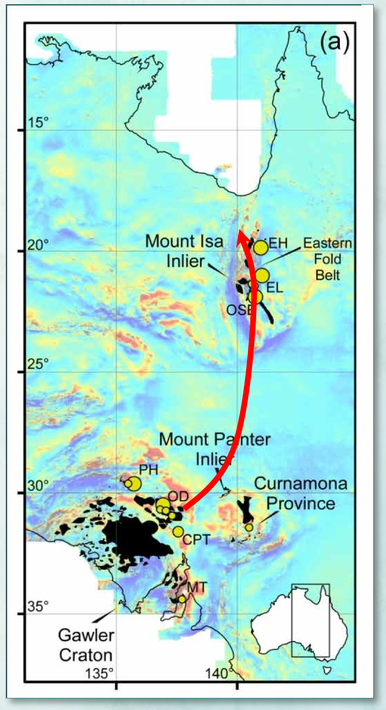
A continental-scale model for IOCG and Ni-Cu-PGE deposits

The North West Queensland Mineral Province hosts large iron oxide copper gold (IOCG) deposits (e.g. Ernest Henry, Mount Elliott). These deposits are a particularly attractive target, enriched in U, LREE, Co, Ni, Mo, W and Fe.

For IOCGs, the dynamic evolution of the region, involving subduction slabs, arcs and hotspot activity, points to crustal conditioning similar to the Olympic Dam Province.

Primitive mantle-derived magma might also have assimilated continental crust at this time, raising potential for the formation of sulphide magmas and Ni-Cu orebodies.

With 75% of the North West Queensland Mineral Province concealed by cover, there remains significant potential for discoveries in the future.

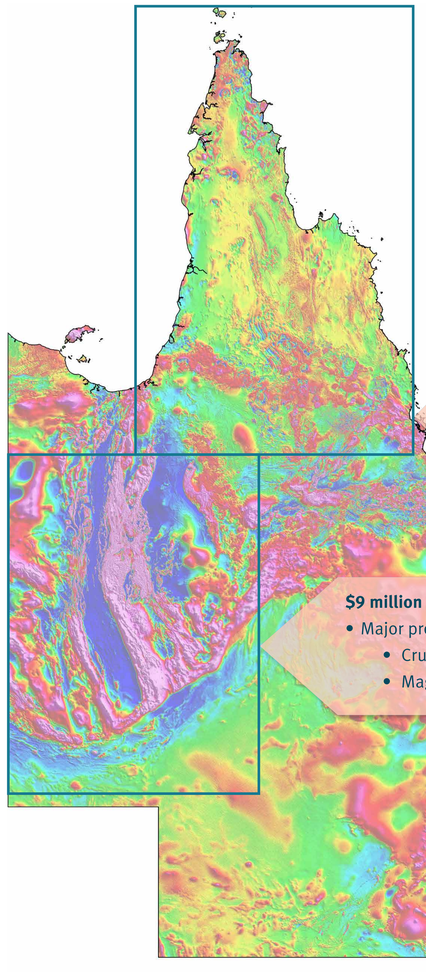


$30 million Future Resources Program

The Future Resources Program represents a $30 million investment by the Queensland Government aimed at unlocking the state's mineral and energy resource potential.

The program will be implemented by the Geological Survey of Queensland (part of the Department of Natural Resources and Mines) over the next three years (2013–14 to 2015–16).

The funding will be used to carry out seven initiatives supporting Queensland's resources and exploration industries.



$7.5 million Industry Priorities Initiative
- $2.5 million per year
- Industry priority GSQ projects to contribute to maximising exploration success
- Industry consulted through
  - Queensland Exploration Council
  - Association of Mining and Exploration Companies
  - Australian Petroleum Production and Exploration Association

$1 million Cape York Mineral Resource Assessment Initiative
- Re-evaluation of strategic mineral potential
- Investigate anomalous rare earths and uranium from geochemical sampling
- Geological mapping and sampling

$9 million Mount Isa Geophysics Initiative
- Major precompetitive data collection
  - Crustal seismic surveys
  - Magnetotelluric surveys
- Surveys will be conducted in
  - Julia Creek–Cloncurry
  - Dajarra–Boulia

Geochemical Data Extraction Initiative
- Data stripping from company reports
- Data will be available to industry, government and the public

$3 million Collaborative Drilling Initiative
- Extends the successful Collaborative Drilling Initiative of DNRM's Greenfields 2020 Program
- Co-funds the drilling costs of innovative exploration programs
- Two additional rounds of drilling grants
  - Round 8 – submissions due 11 April 2014
  - Round 9 – submissions due 21 November 2014

Seismic Section Scanning Initiative
- Preservation of data from deteriorating hard copy
- Data available in digital form

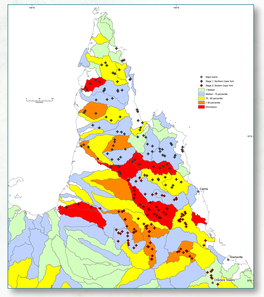
$5 million Core Library Extension Initiative

Expand the Queensland Government's capacity to store economically and scientifically valuable cores

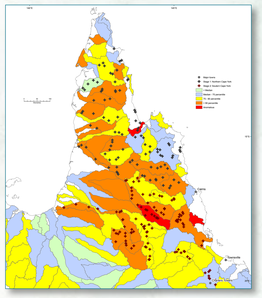
Cape York Mineral Resource Assessment Initiative

Under the Future Resource Program, the Queensland Government will re-evaluate the mineral resource potential of the Cape York region to assist with planning and to potentially create new opportunities in the region. An earlier National Geochemical Survey of Australia Program (2006-2010) has identified geochemical anomalies for a range of elements such as rare earth, tungsten, tin, uranium, gold, antimony, bismuth and arsenic.

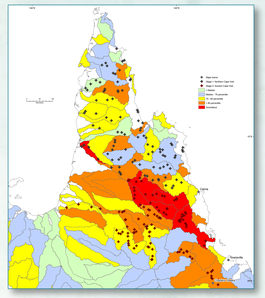
National Geochemical Survey of Australia



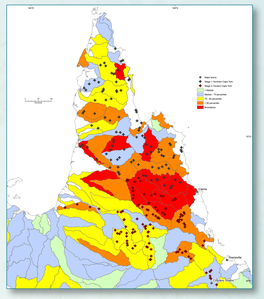
Total Rare Earth result



Uranium result



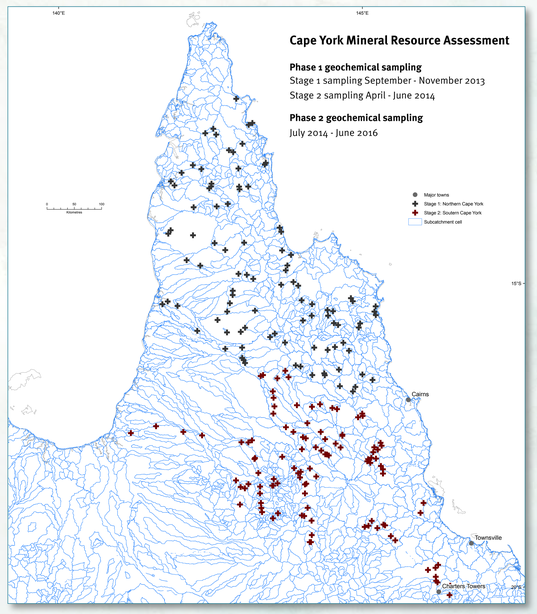
Tin result

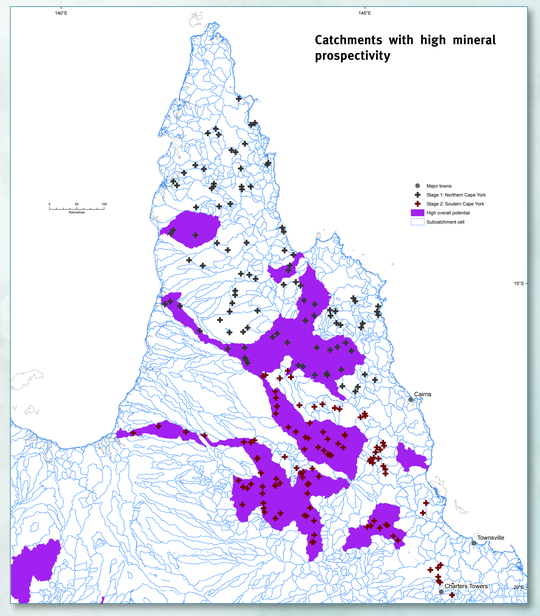


Tungsten result

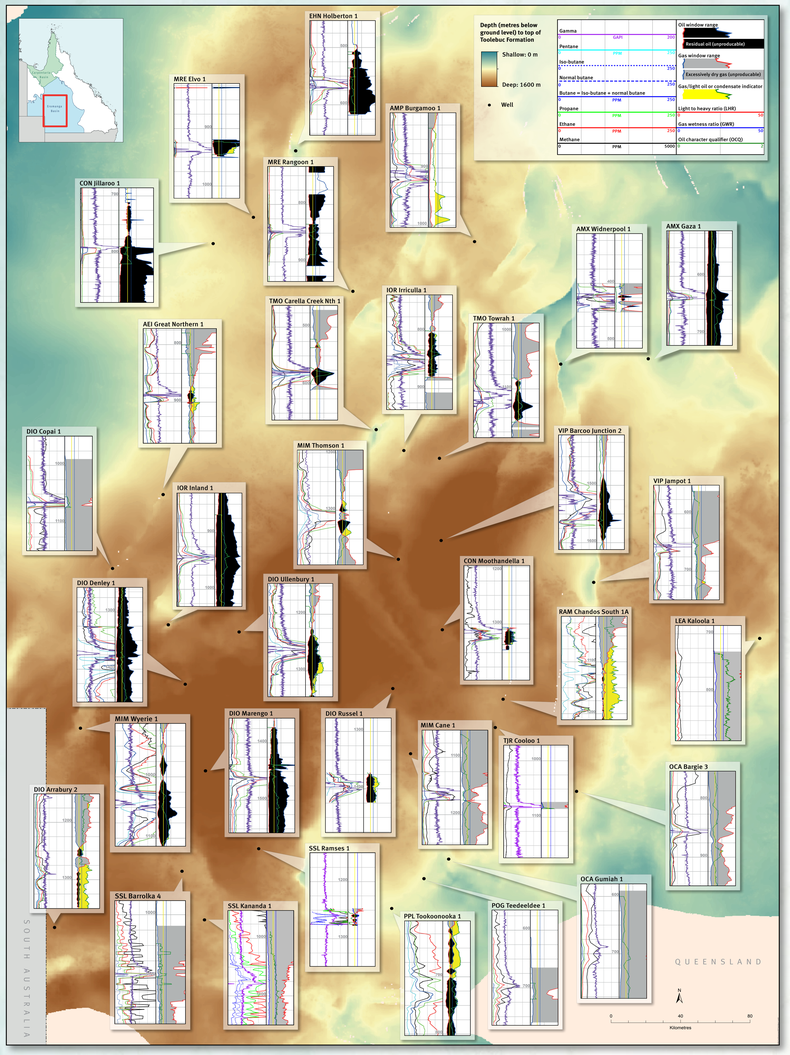
Cape York proposed work program

Follow-up work is scheduled from 2013 to 2016. 215 sub-catchment target sites are planned for stream sediment sampling. The sampling phase is divided into the Northern Cape York region, commenced on 30 September to November 2013 and the southern Cape York region planned for May–June 2014. The second phase will involve geological and mineral occurrence mapping for areas identified as anomalous from the earlier sampling (quarry rock assessment necessary for future development of Cape York region).

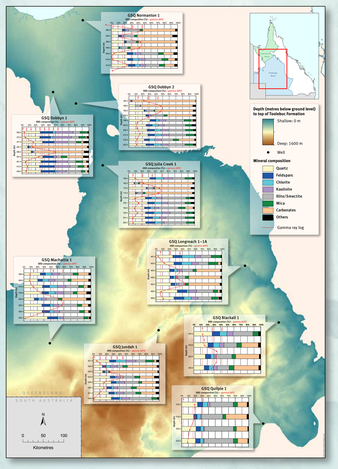




Toolebuc Formation Assessment



Gamma ray logs, mudlog curves and ratio plots over the assessment unit



Gamma ray log versus XRD mineralogy

- Unconventional petroleum resource assessment of the Toolebuc Formation following USGS assessment methodology
- Mudlogs indicate gas up to butane and pentane within the formation
- Gas wetness ratios suggest oil may be present where the formation is deepest
- XRD results correlated to the gamma ray log indicate high calcite over gamma ray peak

X-ray diffraction *versus* hyperspectral logging: A comparative mineralogical study of siliciclastic rocks

(medium-grained fluvial sandstone & fine-grained marine mudstone)

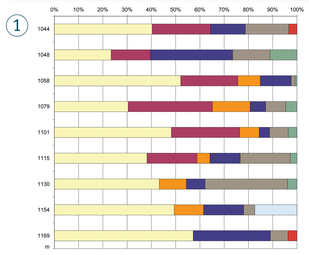
M Grigorescu and S Gopalakrishnan

Study objective

Thermal infrared (TIR) hyperspectral logging results were compared with and validated against X-ray diffraction (XRD) results by testing two different siliciclastic rocks:

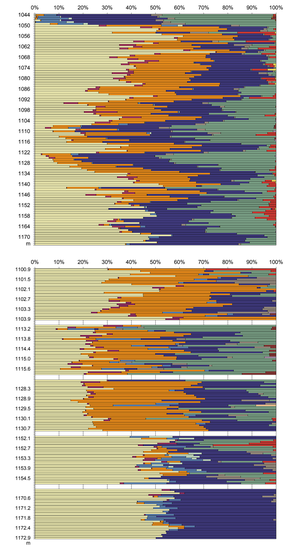
1. medium-grained fluvial sandstone interbebbed with siltstone
2. fine-grained marine mudstone interbedded with coquina,

consisting of various concentrations of quartz, feldspars, kaolinite, smectites, carbonates, with minor amounts of mica, chlorite and pyrite



XRD results (%)

- 25-50% quartz
- 10-30% feldspars
- minor mica
- kaolinite›smectites
- siderite or calcite veins

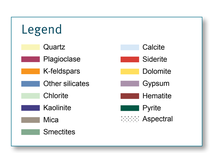


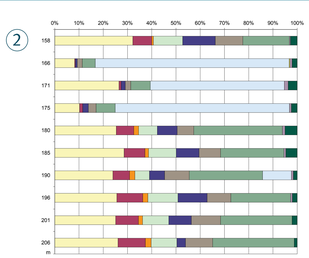
Hylogger results (normalised for comparison) – uncut core

- quartz – comparable with XRD results
- total feldspars – slightly overestimated, but not individual series
- smectite›kaolinite – overestimated
- clay –overestimated
- calcite – not detected
- siderite detected throughout

Hylogger results – slabbed core (to avoid drilling mud contamination)

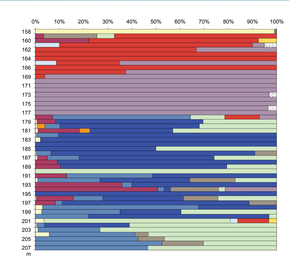
- smectite is better estimated and generally in smaller concentrations than kaolinite, as suggested by XRD





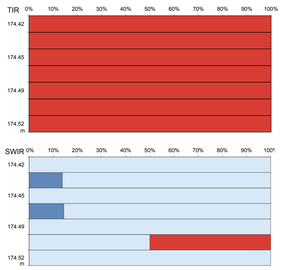
XRD results (%)

- 10-30% quartz
- minor feldspars and mica
- smectites›kaolinite
- high calcite
- ubiquitous pyrite



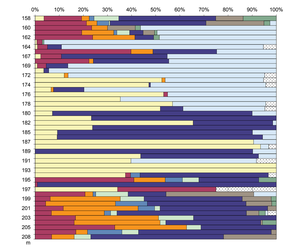
Hylogger results – uncut core

- quartz and feldspars – underestimated or not detected
- kaolinite and smectites – overestimated in places
- calcite - not detected
- siderite and gypsum detected in coquina
- pyrite – not detected
- high aspectral content



Hylogger results – slabbed core (high resolution scan of a calcite-rich area)

- calcite - not detected by the TIR scanner
- calcite -detected by the shortwave infrared (SWIR) scanner



Hylogger results – uncut core with masked siderite and gypsum

- quartz and feldspars – better detected
- kaolinite and smectites – overestimated in places
- calcite - detected
- pyrite – not detected
- lower aspectral content

Conclusions on the hyperspectral logging of sedimentary rocks

1
- Quartz and feldspars concentrations are comparable with the XRD results for medium to course-grained rocks
- Scanning of slabbed core sections limits the overestimation of smectites (which may be partly derived from drilling muds)
- Avoiding areas where drilling mud invasion and clayey grain coatings may occur also ensures better detection of primary minerals

2
- Biogenic ineral detection and identification is less accurate in fine-grained rocks when compared with the XRD results, presumably due to the dark colour of the material and/or heavy grain coating
- Calcite, in particular, is poorly detected when interbedded with organic and clay-rich layers, and usually interpreted as gypsum, siderite or both
- High resolution TIR scanning of slabbed core does not improve results; however, the SWIR scanner detects the biogenic calcite
- Identification and quantification of calcite becomes more realistic when siderite and gypsum remain masked in the dataset

The hyperspectural scanning results were obtained using The Spectral Geologist (TSG) software, which uses The Spectral Assistant (TSA) general unmixing algorithm, trained on a relatively small subset of commonly occurring Australian mineral signatures, to identify minerals and their abundances. TSA abundances are relative abundances that contain TWO most prevalent minerals in the SWIR and VNIR wavelengths and THREE most prevalent minerals in the TIR wavelengths. If more minerals are present in the sample, it WILL NOT be represented in the reported abundances. Minerals are reported as a fraction of the overall spectral fit rather than actual quantifiable concentrations, normalized to 1. TIR-TSA is still in its beta stage and are in a constant state of revision. Hence the results from TIR wavelength should be read with utmost caution. The results published in this poster were obtained using TSG Version 7.1.0.062 dated October 2013.
The quantification of minerals was assisted by Siroquant v. 3, which provides quantitative analyses of minerals based on the principle of Rietveld analysis. Phase errors of around 5% are common to most mineral phases identified; larger errors are recorded for phases, which are present in quantities larger than 30%.

The Geological Survey of Queensland's Future Resources Program 2013-16

Digging Deeper 11, 4 December 2014
Brad John, Chief Government Geologist
Geological Survey of Queensland

Geological Survey of Queensland

- Acquires data and derives geoscience and resource information through data capture programs and collating industry data
- Understanding of the geology of Queensland, its resources and resource potential
- Data and information made available to industry in easily accessible forms
- Information used to attract exploration to the State and promote resource investment and off-take opportunities
- Supports land-use planning and other exploration and resource related policy development and government decision making

Future Resources Program

$30 million 2013-16

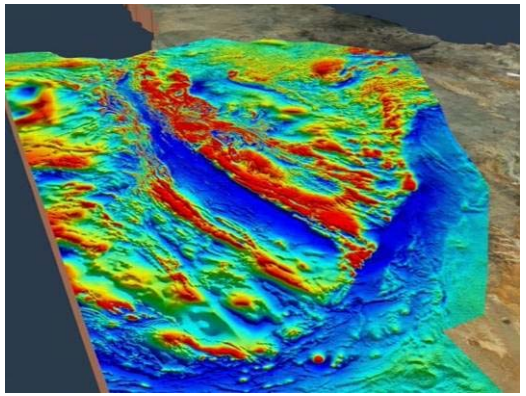
- Industry Priorities
- Mount Isa Geophysics
- Mineral Resource Assessment – Cape York Peninsula
- Collaborative Drilling Grants
- Core Library Extension
- Geochemical Data Extraction
- Seismic Section Scanning

Industry Priorities

Funding: $2.5 million (2013-14); $2.5 million (2014-15); $2.5 million (2015-16)

Optimising exploration success

- Industry consulted through peak bodies to identify priority Geological Survey of Queensland geoscience projects which will have the greatest contribution to maximising exploration success:
  - Queensland Exploration Council
  - Association of Mining and Exploration Companies
  - Australian Petroleum Production and Exploration Association

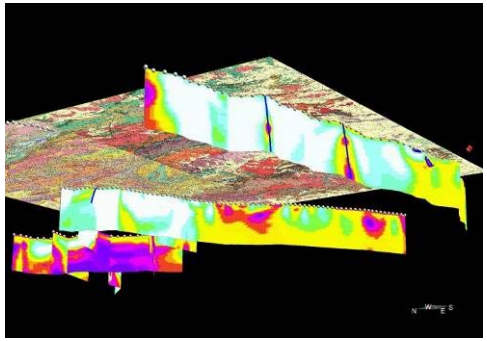


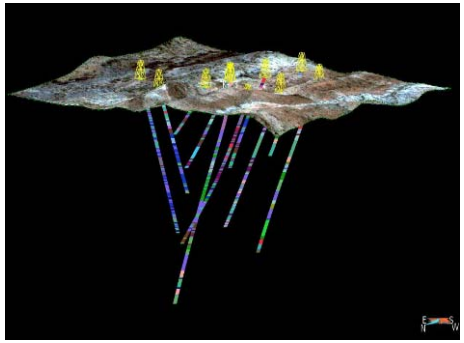
Mount Isa Geophysics

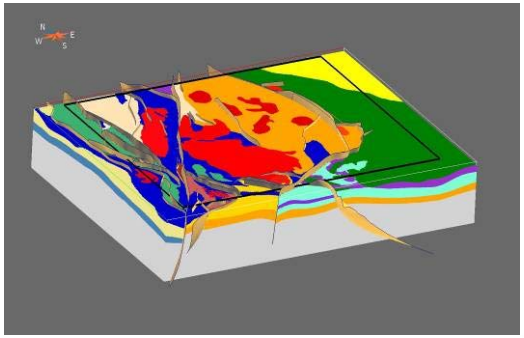
Funding: $4.5 million (2014-15); $4.5 million (2015-16)

Revealing subsurface geology and mineralisation pathways

- Seismic and crustal conductivity data allowing visualisation of 2D and 3D subsurface geology
- Surveys in the Cloncurry-Julia Creek and Dajarra-Boulia areas
- Revealing thickness of the sediment blanket and allowing targeting of highly mineralised zones under sediment cover





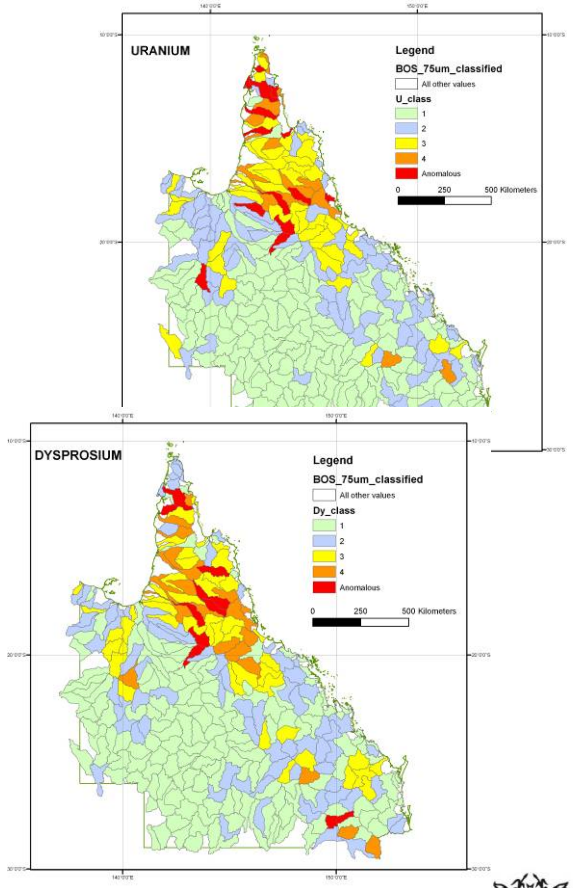


Mineral Resources Assessment – Cape York Peninsula

Funding: $0.5 million (2014-15); $0.5 million (2015-16)

Re-evaluating the strategic mineral resource potential of Cape York

- Stream catchments in Cape York Peninsular anomalous in uranium and rare earth elements
- Updated geology from field mapping, with magnetic and radiometric airborne data and ground gravity data collected through previous GSQ initiatives



Collaborative Drilling Grants

Funding: $1.5 million (2014-15); $1.5 million (2015-16)

Encouraging innovative explorers in higher risk drill targeting

- Encourages drilling in under-explored areas and testing of innovative exploration ideas
- Grants contribute towards the costs of drilling with 50% of project direct drilling costs up to $150,000

Core Library Extension

Funding: $5 million (2013-14)

Ensuring maximum future benefit to the State from company exploration drilling

- Exploration Data Centre (EDC) in Brisbane currently houses over 225,000 boxes of core and cuttings from over 8,000 drill holes
- Core at Mount Morgan facility to be relocated

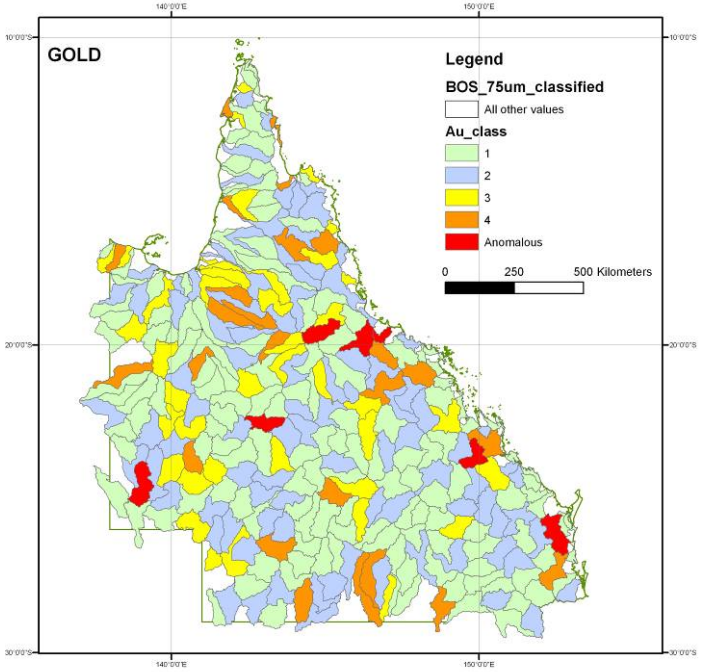
Queensland Government

Geochemical Data Extraction

Funding: $1 million (2013-14); $1 million (2014-15); $1 million (2015-16)

Realising the value of the Department of Natural Resources and Mines' exploration geochemistry asset

- Exploration companies generate large geochemical datasets and include them in reports submitted to the Department
- Easily accessed, standardised data in a structured format
- GSQ's segment of the 2008-10 national geochemical survey identified anomalous areas in stream catchments for minerals such as rare earths, base metals and gold



Seismic Section Scanning

Funding: $1.5 million (2013-14)

Preserving high-value seismic data assets for current and future generations

- Department is the custodian of a seismic dataset with an estimated acquisition value of $4.9 billion
- Initiative aims to preserve in electronic form the deteriorating archive of seismic sepia sections dating back to the 1960s and provide industry ready access
- Recent interest in unconventional gas has resulted in an increase in demand for seismic data

Geological Survey of Queensland

- Capture new geophysical and geological data and conduct mineral and petroleum resource assessments
- Assist explorers directly with grants to drill in under-explored areas or to test innovative exploration ideas
- Expand and enhance facilities to manage industry generated data and information, and provide this and GSQ data and information in easily accessible forms to assist explorers

Brad John
Chief Government Geologist
Geological Survey of Queensland

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Email: **brad.john@dnrm.qld.gov.au**
Web: **www.dnrm.qld.gov.au**

Queensland Government Exploration Incentive Funding – New Data Acquisition Programs

Paul Donchak
Geoscience Manager
Greenfields Prospectivity Unit
Geological Survey of Queensland

Talk Outline

Quick overview of main government funded industry incentive programs

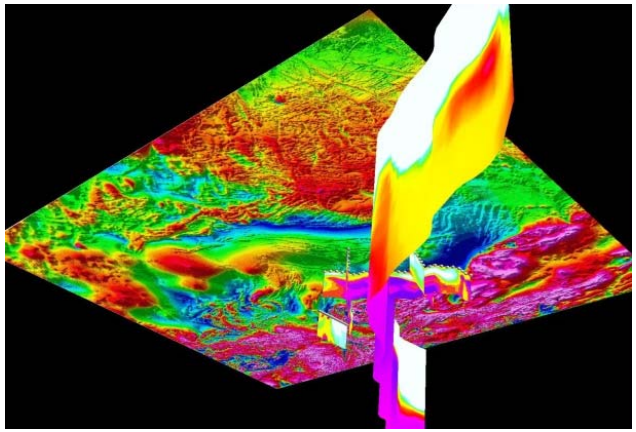
- Future Resources Program (including Industry Priorities Initiative projects)
- Greenfields 2020 Program

Geophysical Data Acquisition & Supply

Services to assist the exploration industry include:

Archiving, curating and supplying both self-acquired regional datasets and our collection of tenement-related company datasets

- Designed to open up *new exploration opportunities*
  - Assist explorers with area selection and targeting



Future Resources Program

$30 million over 3 years (2013-2016)

Data acquisition components

- Industry Priorities Initiative
- Mount Isa Geophysics Initiative
- Geochemical Data Extraction Initiative (i.e. company report data stripping)
- Cape York Mineral Resource Assessment Initiative

Industry Priorities Initiative

- $2.5 million per annum for 3 years
- Projects generated after evaluation of a raft of proposals from peak industry bodies (QEC/AMEC/APPEA)
- Round 1 : assessment process completed by October → 4 projects to be implemented

Industry Priorities – Project 1

Prospectivity of the magmatic-related systems of north Queensland

- Amalgamation of 2 QEC proposals

(i) JCU/Evolution etc → focussing on Permo-Carb magmatic systems (Kennedy Association)

(ii) Terrasearch/Klondike → focussing on Charters Towers

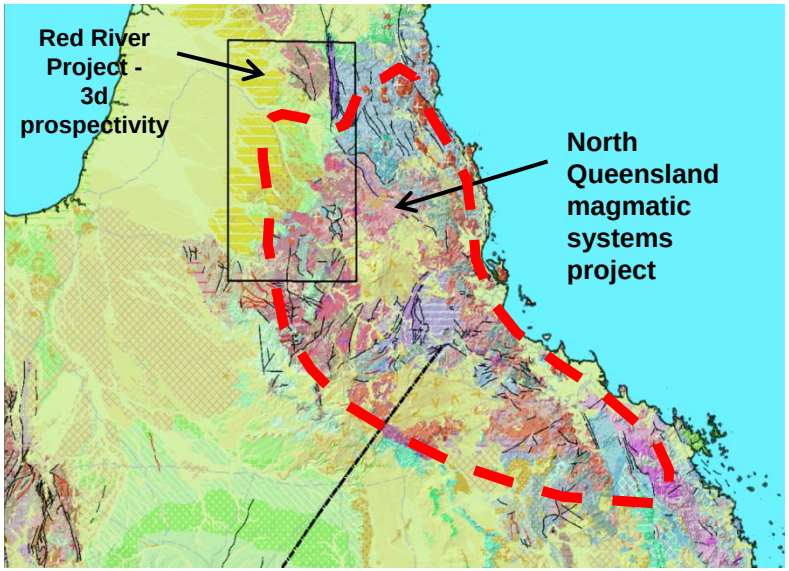
- 3 year duration

Industry Priorities – Project 1

North Qld Magmatic-related Systems Project

AIMS

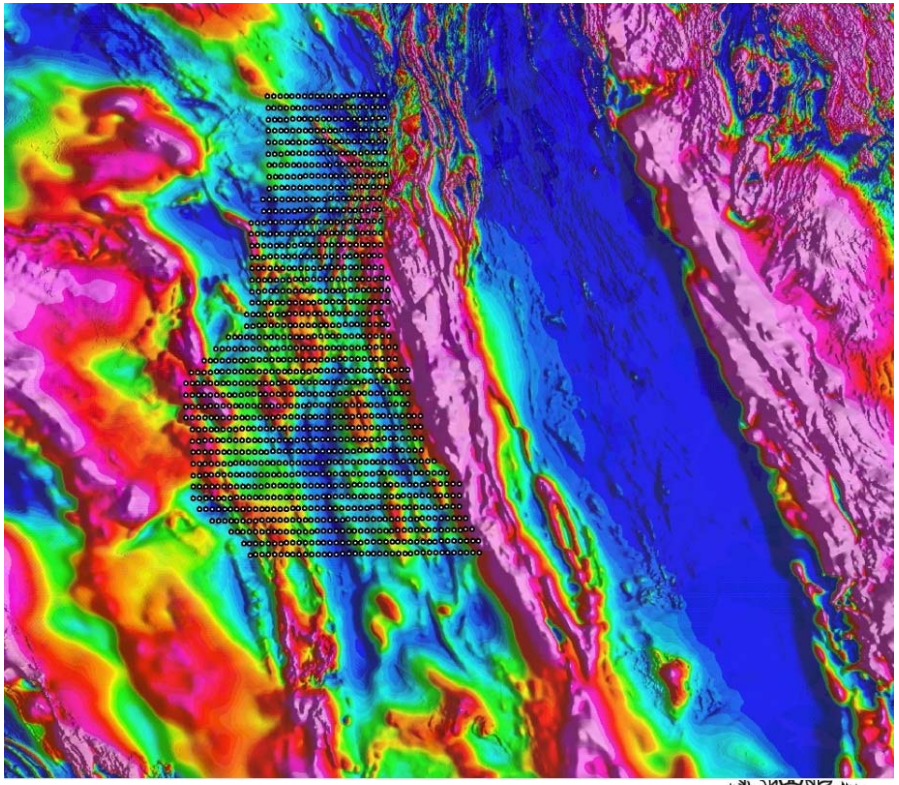
- Characterise ***timing*** of mineralising events
- Characterise ***fertility*** and geochemical properties of intrusion-related mineral systems
- Define ***spatial extents*** of genetically distinct mineral systems and location of focussed mineralising centres
- Formulate mineral system descriptions and ***deposit models***
- Develop exploration models and ***exploration "toolkits"*** based in these models
- Assess ***regional to camp-scale prospectivity*** and conceptual targets
- ***Promote results*** to the geoscientific and wider exploration community to maximise investment impact



Industry Priorities – Project 2

Magnetotelluric Survey of Covered Southern Extension of the Mount Isa Inlier

- Grid-style coverage of key features
- imaging major faults (e.g. Mount Isa Fault)
- Isa-equivalent shale basins
- Survey aimed for completion by mid-2014



Industry Priorities – Project 3

Spinifex Geochemistry of NW Qld

- To be completed in 2014
- Trial the use of spinifex analysis with background soil analysis techniques as a control
- Identify anomalies along southern margin of Mount Isa Inlier

Industry Priorities – Project 4

Energy Prospectivity of the Maryborough and Galilee Basins

- To be completed in 2014
- Geochemistry, petrology and kinetic analysis studies of potential petroleum source rocks of the Galilee Basin (Lower Permian sections in existing boreholes)
- Geochemistry, petrology and kinetic analysis studies of potential shale gas source rocks of the Maryborough Basin (e.g. Goodwood and Cherwell Mudstones) from sections in existing boreholes

Future Resources Program

Mount Isa Geophysics Initiative

- $9 million over 2 years (mid-2014 to mid 2016)
- Focussed on covered “greenfields” extensions of the Mount Isa Inlier

Mount Isa Geophysical data Acquisition

Foundation 3D datasets to reveal large buried mineral systems and fluid conduits

Regional conductivity/susceptibility/density inversion models constrained by seismic data

Potential to assess basement depth, lithology, and alteration pathways and prospectivity potential

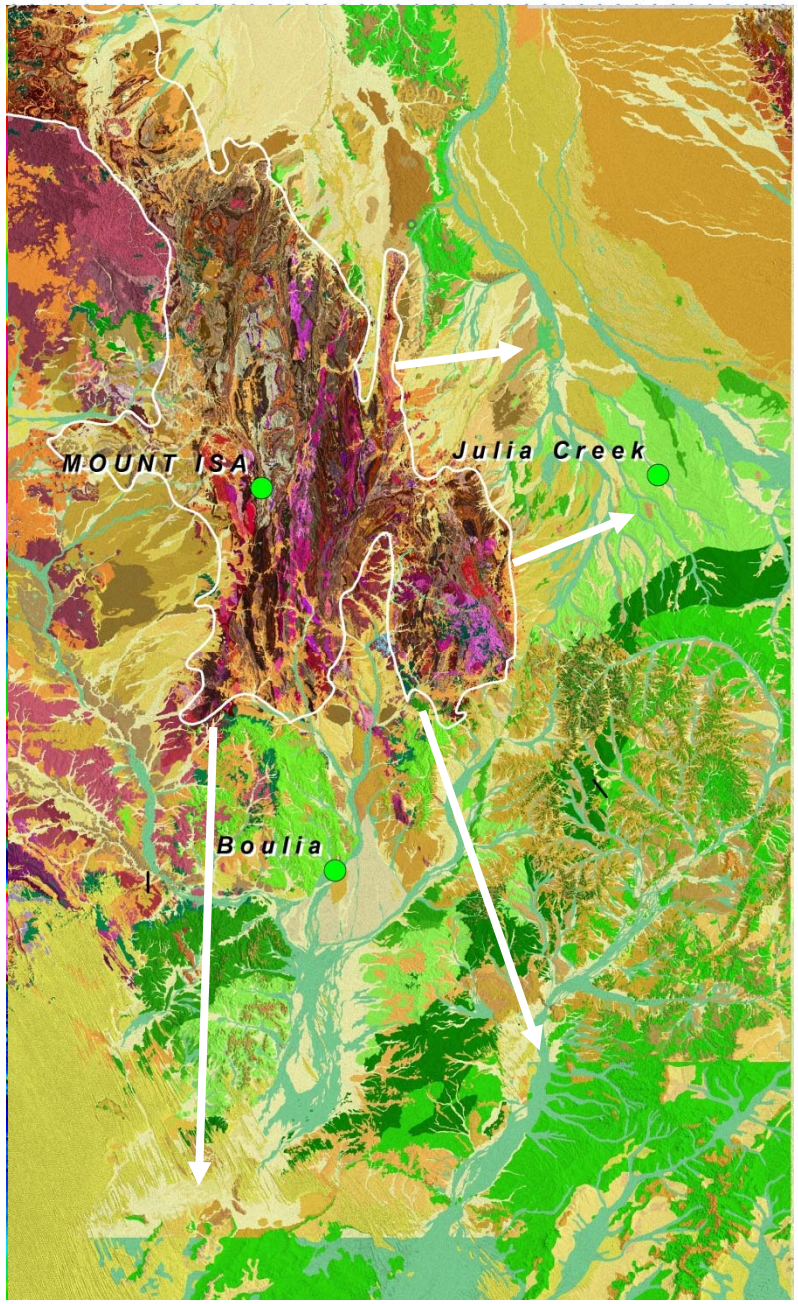
Focus on Eastern & Southern Mount Isa

Future Resources

Mount Isa – extent of Greenfields cover

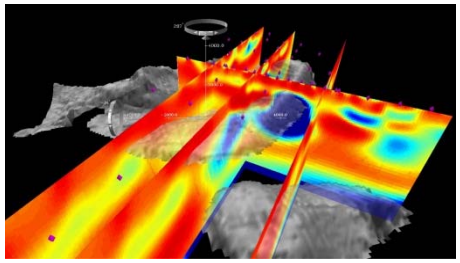
- 60-130km to E

- >300km to S

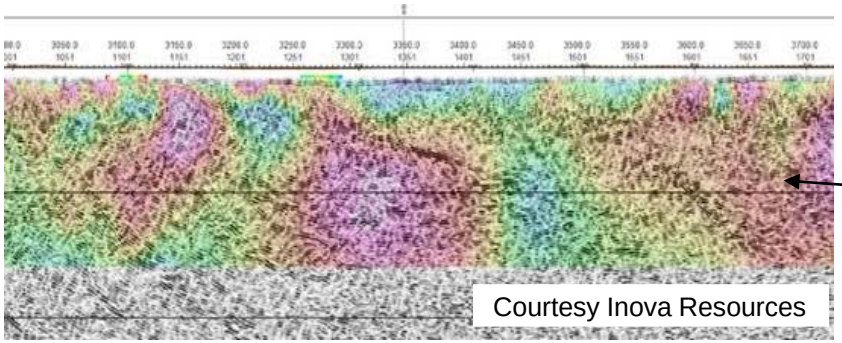


Proposed outputs

- 3D resistivity models of selected regions



- Interpreted 2D seismic profiles; structure assessed in combination with 3D MT and magnetic inversion models



Magnetic inversion results merged with seismic profile - Isa eastern Succession

- Updated mineral systems models
- Updated depth to basement surfaces

Future Resources

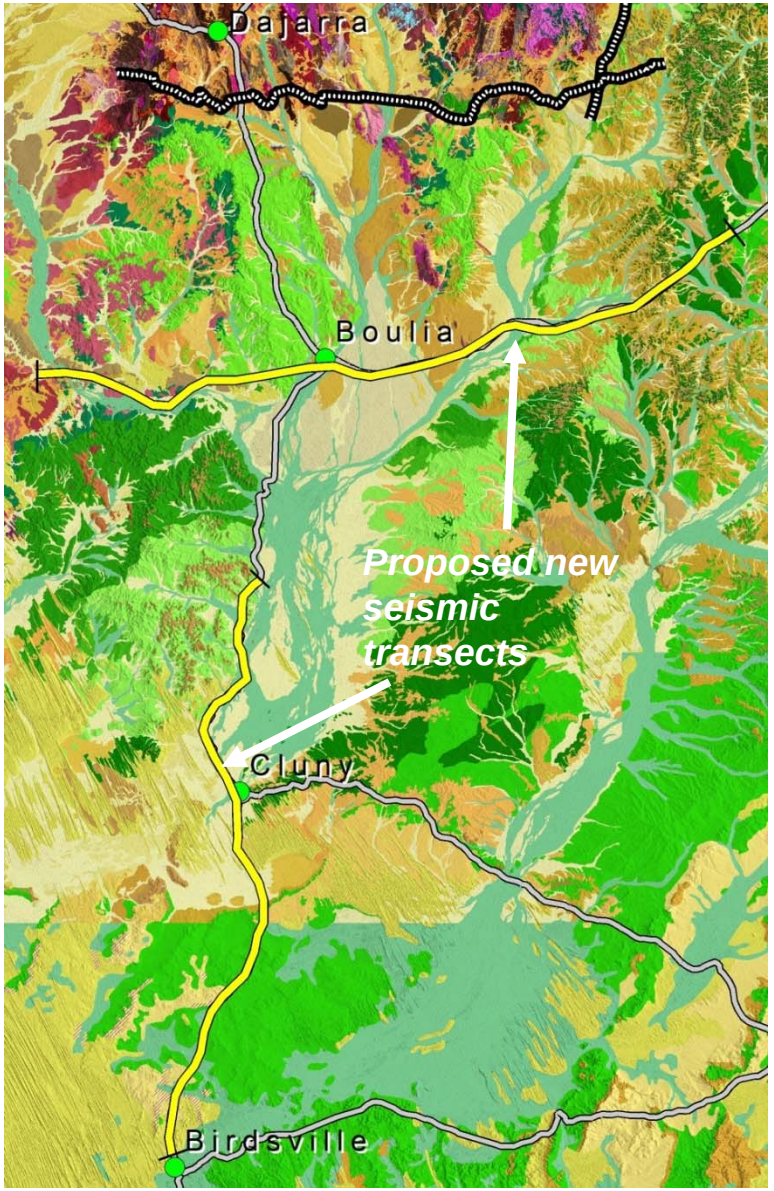
Birdsville - Dajarra Seismic / MT Surveys

- Determine nature and mineralisation potential of the southern termination of the Mount Isa Inlier (Cork Fault)

- Locate extensions of major crustal boundary faults e.g Pilgrim Fault, Mount Isa Fault

- Locate major sulphide alteration zones and shale basins

- Uncover variations in topography of basement-cover interface

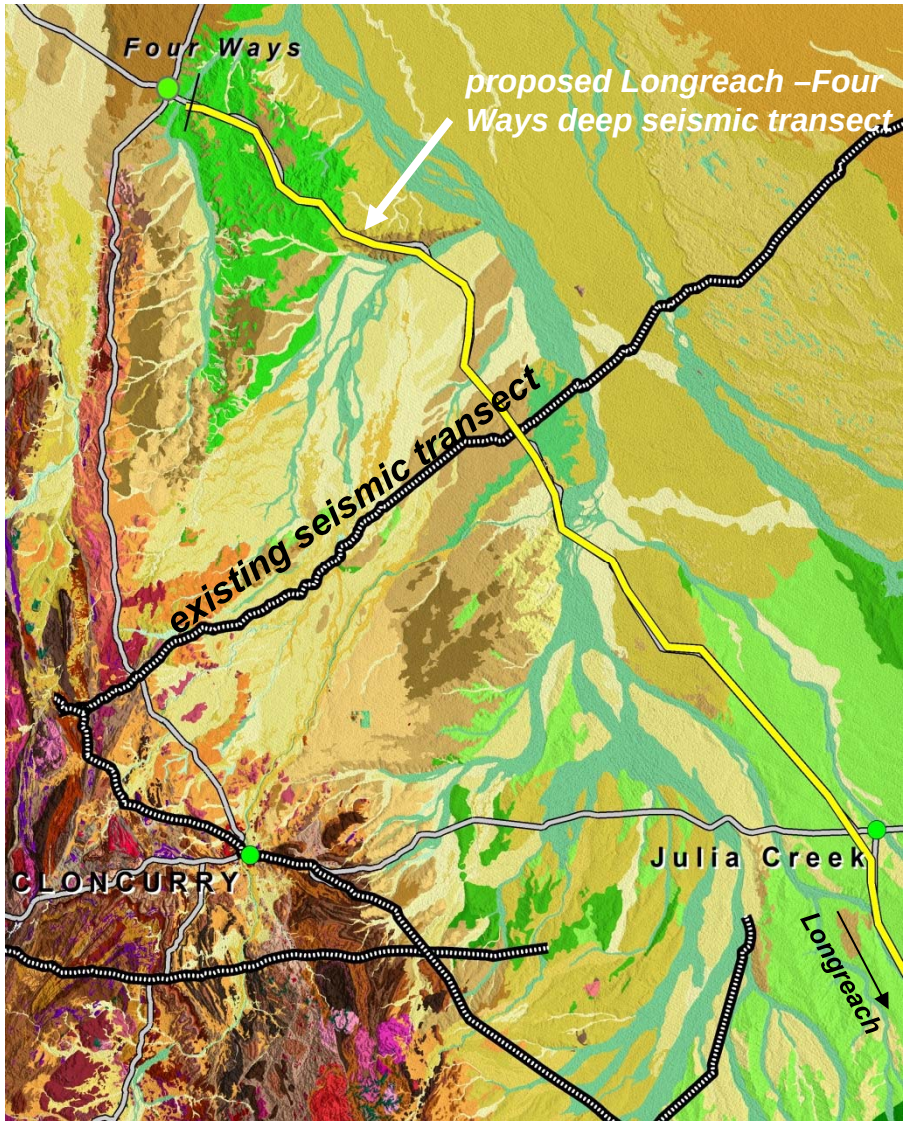


Cloncurry – Julia Creek

MT grid survey in 2014-16

- *To complement planned and existing seismic and MT surveys*

- Aims to reveal major structurally controlled mineralising systems



Greenfields 2020

Two major geophysical data acquisition projects for 2013/14

(1) Southern Thomson collaborative GSQ/GA/GSNSW Project

(2) South-east Mount Isa Deep Seismic transect

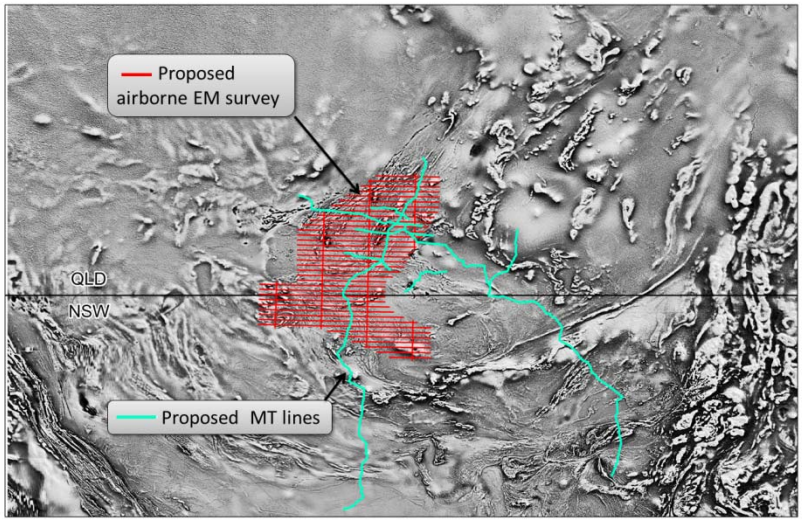
(1) Southern Thomson Collaborative GSQ/GA/GSNSW Project

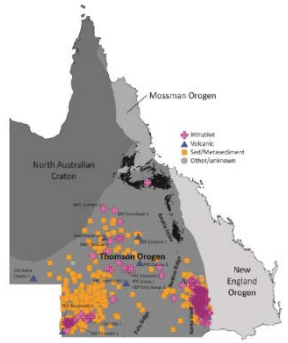
Designed to build on -

- •Ongoing GSQ studies of basement geology, geochronology, mineralisation and geothermal potential
- •Completed 400m airborne geophysical (magnetics/radiometrics) coverage and upgraded gravity data for Southern Thomson region
- •Thomson Orogen workshop held June 2013

New Phase of Collaboration for 2014 -

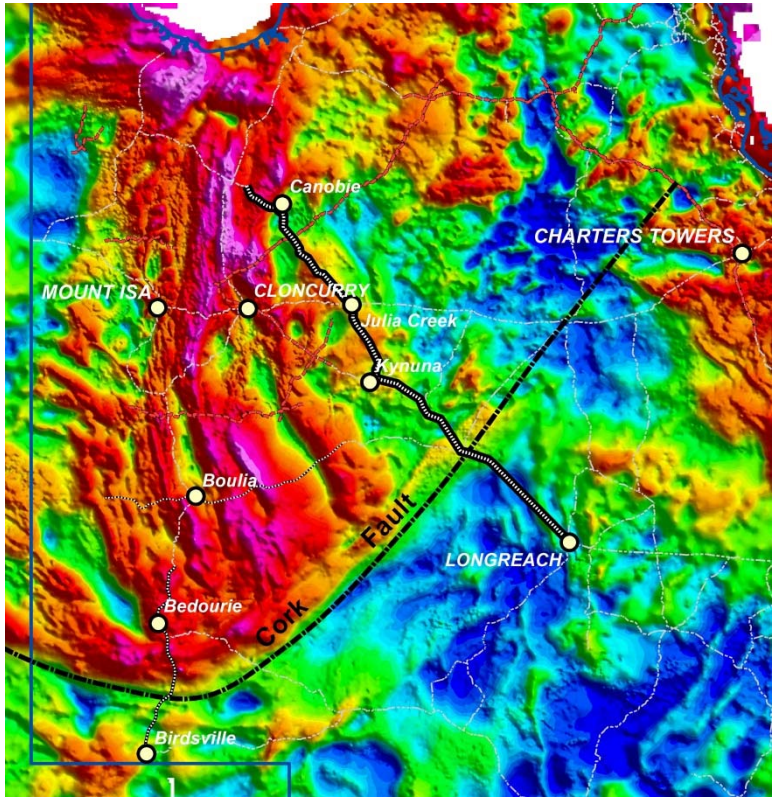
GSQ / Geoscience Australia / GNSW partnership to acquire AEM and MT data in preparation for drill-testing of target strata





(2) SE Mount Isa Deep Seismic / MT Transect

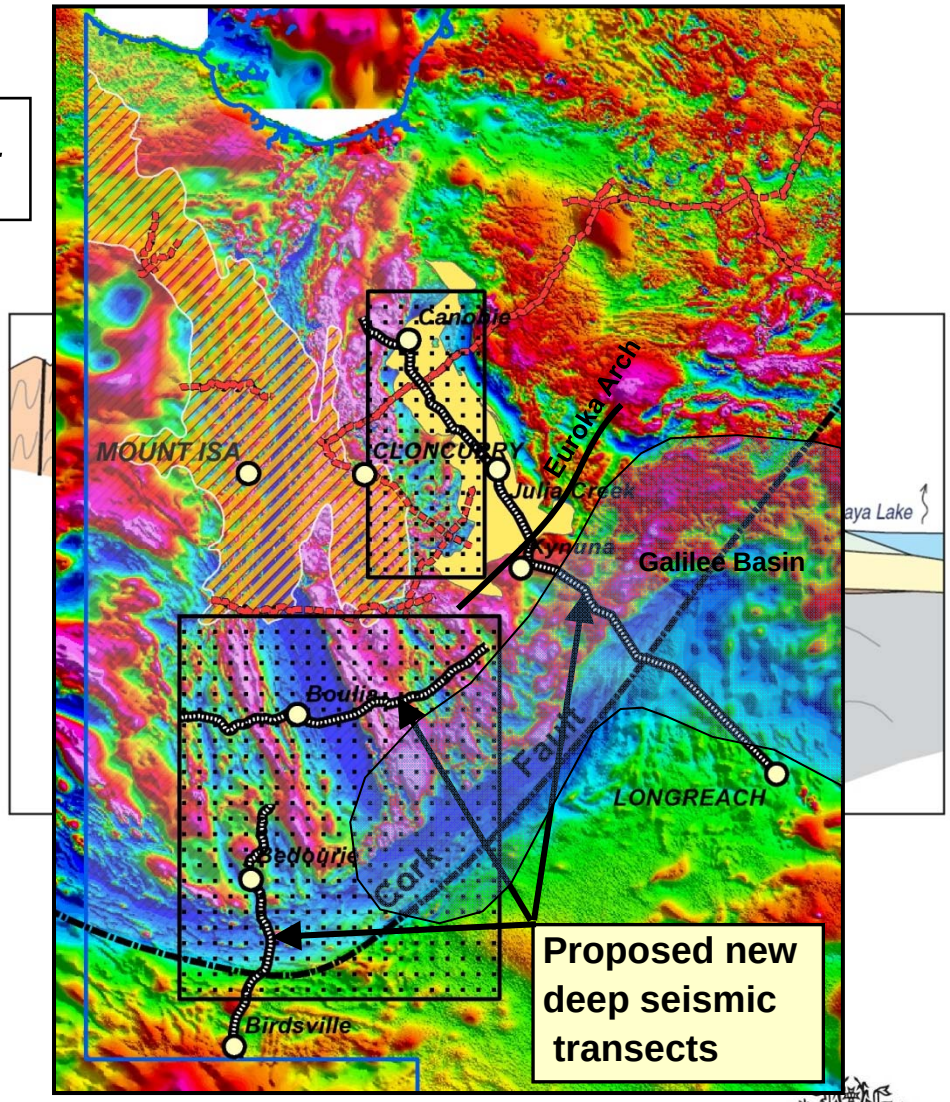
- Locate major mineralising crustal faults
- Determine nature of faulted eastern margin of Mount Isa Inlier
- Locate major suphide alteration zones
- Determine nature of structural repetition of the Toole Creek Volcanics
- Stratigraphy and extent of Millungera Basin
- Correlate “Canobie sequence” in Dobbyn 1 with Millungera Basin to SE?
- Improve understanding of variation in Eromanga/Carpentaria Basin cover depth



(2) SE Mount Isa deep Seismic transect

Longreach-Julia Creek segment

- Northern Galilee basin stratigraphy and structure
- Eromanga-Carpentaria stratigraphy across Euroka Arch
- Assess nature and mineralisation potential of Cork Fault (Au, rollfront U?)



Conclusion

- The ***FUTURE RESOURCES*** and ***GREENFIELDS 2020 PROGRAM***s are focussed on using modern technologies to narrow down the search for Queensland's next major resource discoveries.

- The GSQ is committed to supplying industry with a range of pre-competitive geoscientific datasets as well a variety of 2D and 3D prospectivity analyses and exploration models so that explorers can take advantage of these technological advances.

- Our data and service provision is particularly aimed at lowering exploration risk for the greenfields explorers who will be needed to secure Queensland's long term future.

Digging Deeper 11

Queensland Government

Exploration Grant Initiatives

Round 5 to Round 9

4 December 2013

Simon Crouch
Director, Exploration Attraction
Geological Survey of Queensland

Summary of Initiatives

Greenfields 2020 Program

- In July 2010, $3 million over 4 years was allocated to new rounds under the Collaborative Drilling Initiative.
- Three rounds were planned with closing dates in November 2010 (Round 5), April 2011 (Round 6), and November 2011 (Round 7).
- Collaborative Drilling – provides funding assistance of 50% of a project up to $150,000 for the drill testing of innovative exploration concepts including targets in under-explored regions of Queensland.

Summary of Initiatives

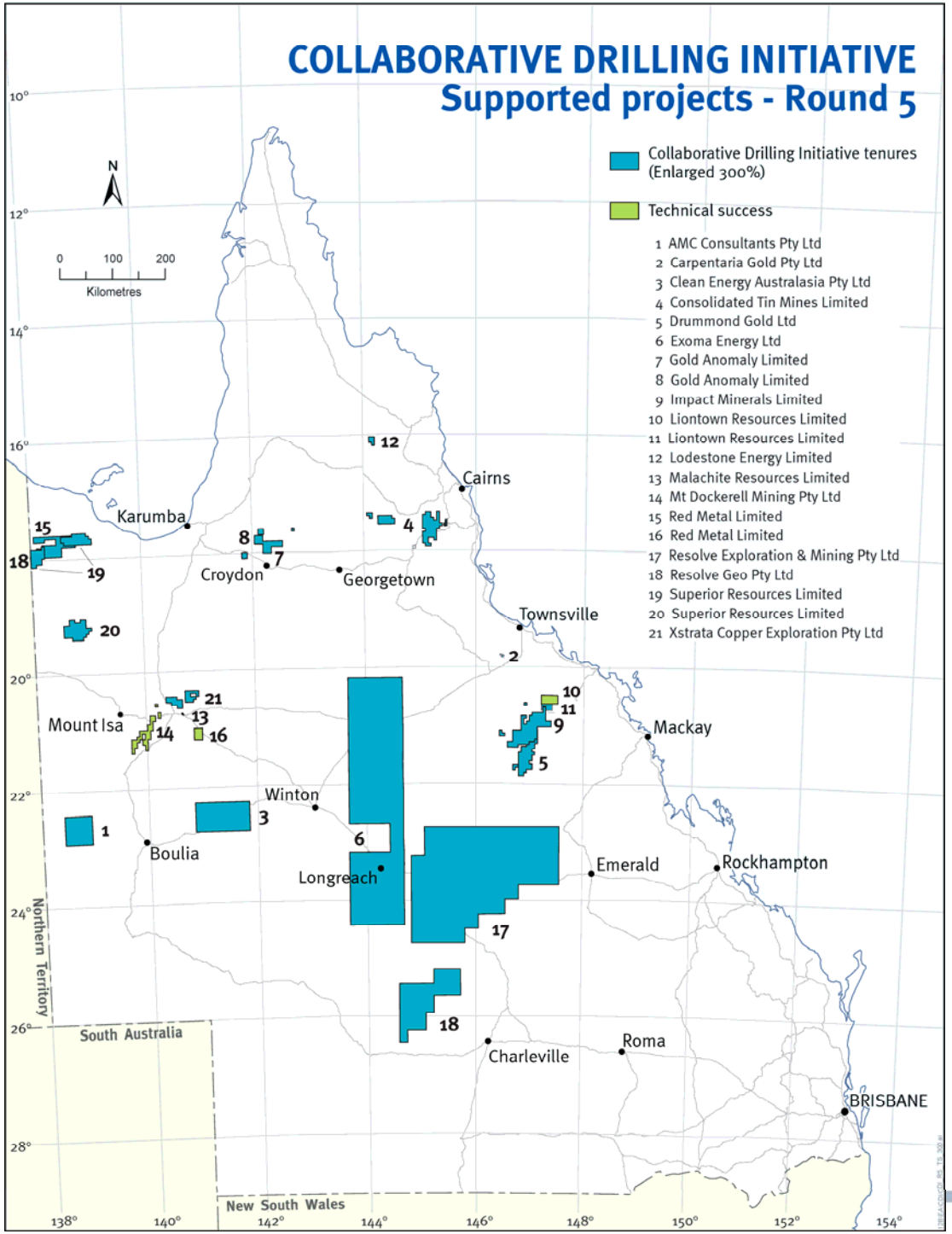
Future Resources Program

- **In July 2013, $3 million over 3 years was allocated to new rounds under the Collaborative Drilling Initiative.**
- **Two rounds are planned with closing dates in April 2014 (Round 8), and November 2014 (Round 9).**
- **Collaborative Drilling – provides funding assistance of 50% of a project up to $150,000 for the drill testing of innovative exploration concepts including targets in under-explored regions of Queensland.**

Round 5 Collaborative Drilling Initiative (2011)

Status of Round 5:

- **$2.2 million available**
- **56 submissions received**
- **21 were successful**
- **Project period of 15 months**
- **Final reports received 3 months after completion of project**
- **Payments were dependent on acceptance of submitted reports after project completion**
- **Round 5 completed**
- **Over $1.14 million paid**



Round 5 Collaborative Drilling Initiative (2011)

Results from Round 5:

21 projects successful

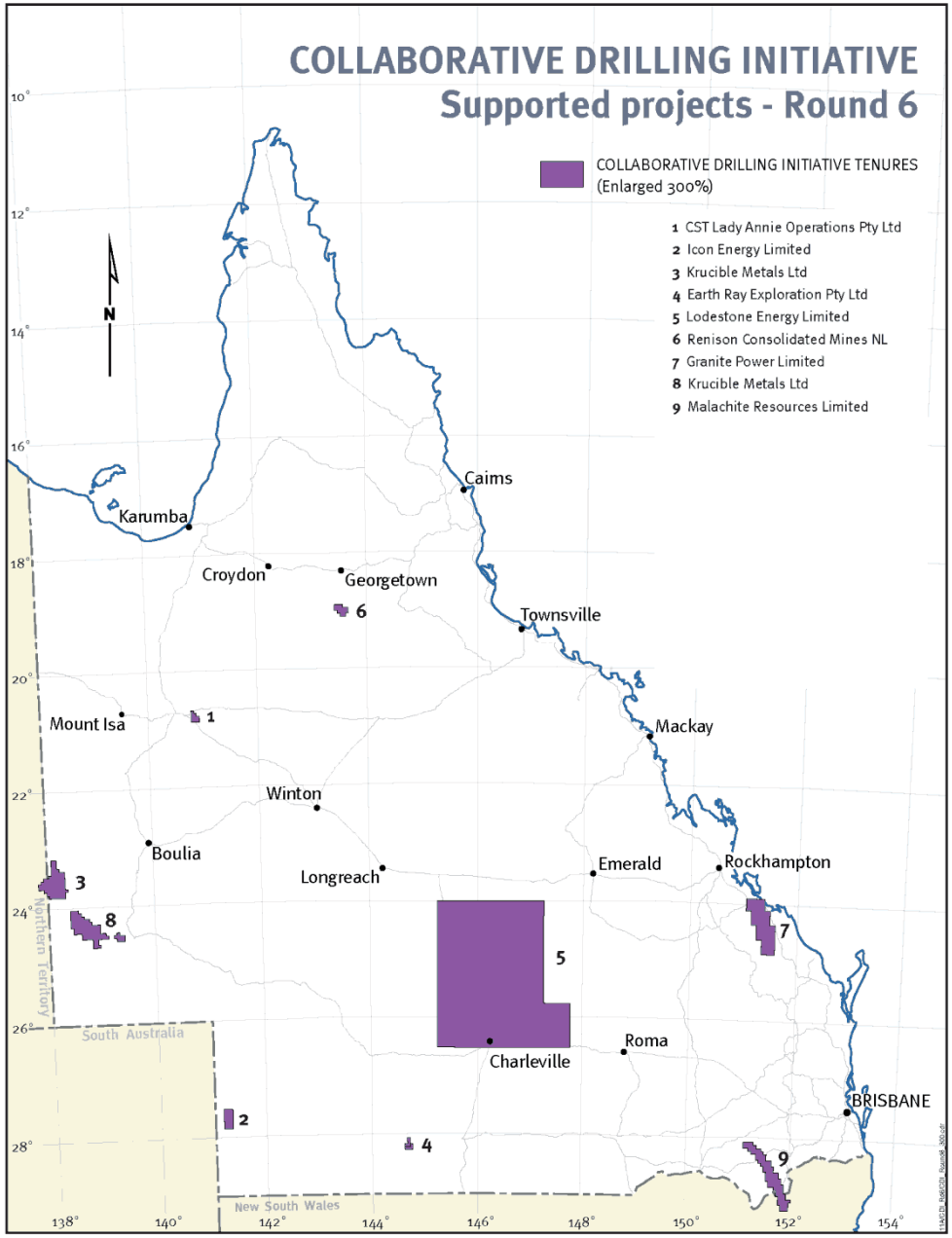
$2.35 million allocated

$1.14 million paid

Round 6 Collaborative Drilling Initiative (2011)

Status for Round 6:

- **$1.0 million available**
- **23 submissions received**
- **9 were successful**
- **Project period of 15 months**
- **Final reports received 3 months after completion of project**
- **Payments were dependent on acceptance of submitted reports after project completion**
- **Round 6 completion 2014**
- **Over $382,900 paid**



Round 6 Collaborative Drilling Initiative (2011)

Results from Round 6:

9 projects successful

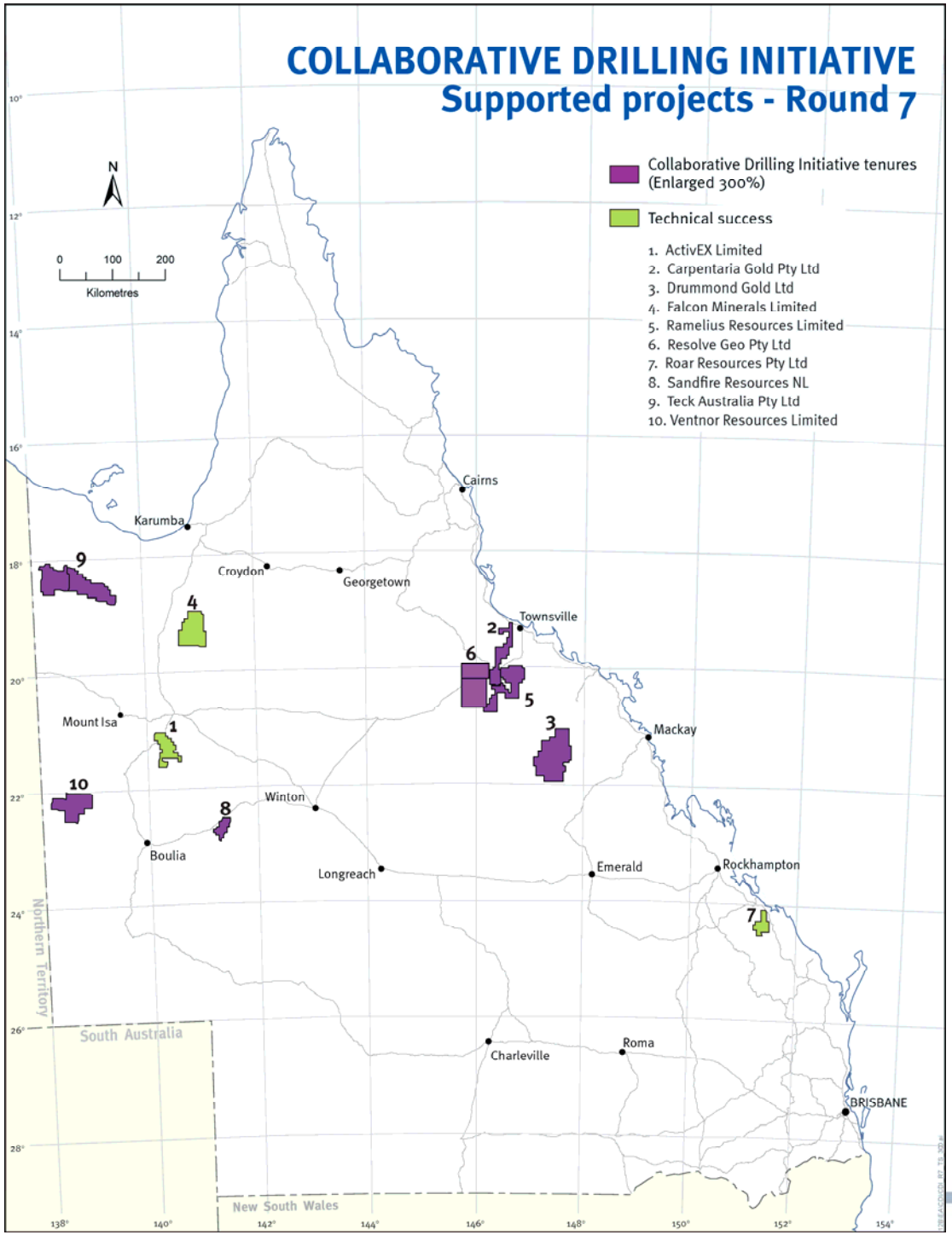
$1.17 million allocated

$382,976 paid

Round 7 Collaborative Drilling Initiative (2012)

Status for Round 7:

- **$1.0 million available**
- **22 submissions received**
- **10 were successful**
- **Project period of 15 months**
- **Final reports received 3 months after completion of project**
- **Payments were dependent on acceptance of submitted reports after project completion**
- **Round 7 completion 2014**
- **Over $550,900 paid**



Round 7 Collaborative Drilling Initiative (2012)

Results from Round 7:

10 projects successful
$990,250 allocated
$550,910 paid

Rounds 8 and 9
Collaborative Drilling Initiative (2014)

Status for Rounds 8 and 9:

- **$1.5 million made available to each round**
  - Round 8 closing date 11 April 2014
  - Round 9 closing date 21 November 2014
- **Project period of 21 months**
- **Final reports received 3 months after completion of project**
- **Payments dependent on acceptance of submitted reports after project completion**
- **Rounds to be completed 2016-2017**

Highlights

- **For the grants paid of over $5.56 million there has been over $17.29 million of direct expenditure by industry. This equates to a leverage of 3.11.**
- **In addition, this drilling has been carried out in frontier areas of perceived high exploration risk.**
- **39 technical successes of which 29 are related to discovery of new mineralisation by drilling.**
- **Technical success has led to companies recommending further drilling on these programs.**

Summary

- CDI Round 5 completed with over $1.14 million paid.
- CDI Round 6 to finish in 2014 with over $382,900 paid to date.
- CDI Round 7 to finish in 2014 with over $550,900 paid to date .
- Project period extended from 15 months to 21 months with no extension.
- Final reports to be received 3 months after completion of project.
- Payments dependent on acceptance of submitted reports after project completion.
- To date there are 39 technical successes with 29 discovering new mineralisation.
- The Greenfields 2020 CDI to be completed 2014.
- The $3 million Future Resources Program CDI Rounds 8 and 9 to commence in 2014.
- Leverage of the grants program is currently 3.11 over the entire CDI program. The government is getting a significant return on its investment.

Further information

Website at:

http://mines.industry.qld.gov.au/mining/collaborative-drilling.htm

AND PLEASE SUBSCRIBE ONLINE

Contact Exploration Attraction:

- **Phone: +61 (0)7 3035 5253**
- **Email: sarah.sargent@dnrm.qld.gov.au**

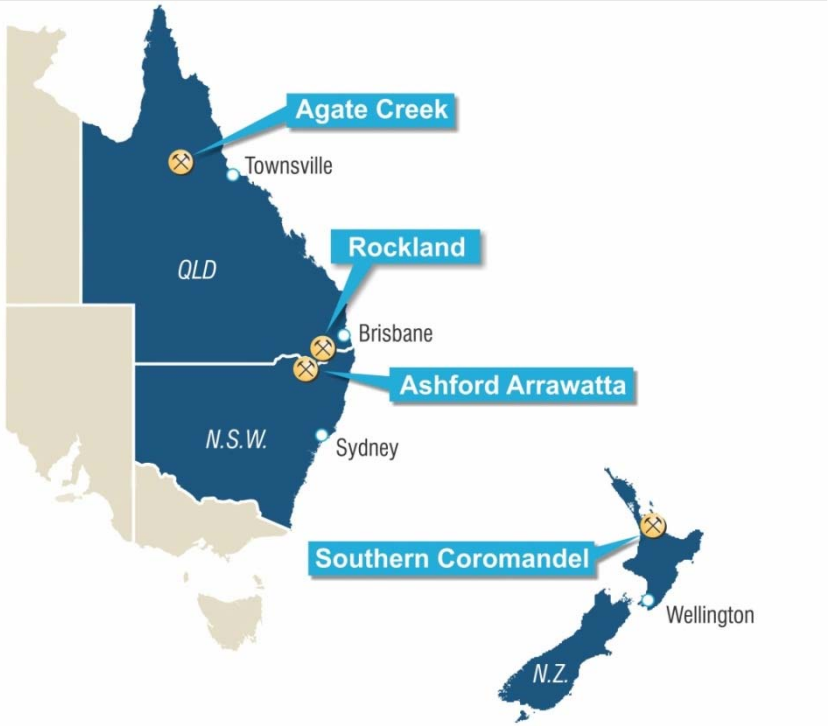
New Ideas on Mineralisation at Sherwood Deposit, Agate Creek, North Queensland December 2013

PROJECT OVERVIEW

Key Projects

- **Agate Creek** in north Queensland
  - (100% interest – Epithermal Gold)
- **Ashford** in north New South Wales
  - (50% interest – Coking Coal)
- **Arrawatta** in north New South Wales
  - (100% interest – Coking and Thermal Coal)
- **Southern Coromandel Project** in north New Zealand
  - (100% interest – Epithermal Gold)
- **Rockland Project** in south Queensland
  - (100% interest – IRGS gold project)

Laneway Project Location



Gold JORC Resources[1]

Agate Creek Gold	414,000oz (grade 1.4g/t) 0.5g/t cut off

Coal JORC Resources[1]

Ashford Coal (Indicated & Inferred)	13Mt (100%)

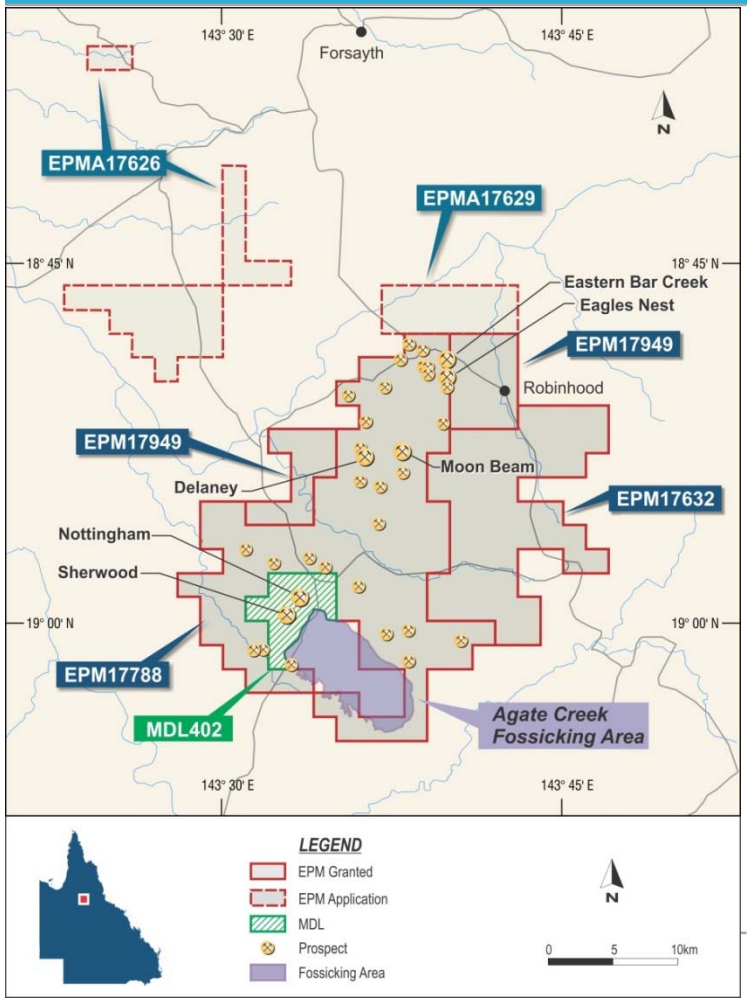
SUMMARY

- In 2011 Laneway successfully applied for funding in Round 6 of the Queensland Governments Greenfields 2020 Collaborative Drilling Initiative (CDI) which proposed drilling that targeted the potential boiling zone and bonanza grades associated with the Sherwood Deposit
- The drilling program at Sherwood returned significant results of 31m at 6g/t gold from 124m but failed to intercept any bonanza zone at depth
- Historically The Agate Creek Fault has been targeted as the main fluid conduit during mineralisation and as such held the highest potential for a bonanza zone at depth
- Interpretation of drilling has highlighted the importance of brittle rhyolites during mineralisation and indicated that the Agate Creek Fault may not have been the main fluid conduit during the mineralising event at Sherwood
- This has led to a re-evaluation of existing data and interpretation of the Sherwood mineralised system which will influence drill targeting in the future
- Further work includes drill targeting the Sherwood West and Zig Zag Faults at depth for a potential bonanza zone. Vein sampling and petrographic study. New geological modelling

AGATE CREEK
Summary & Project Location

- Agate Creek Project is located approximately 40km south of Forsayth in North Queensland
  - Sherwood resource area is covered by Mineral Development License (MDL) 402
  - Highly prospective gold and base metal prospects located in three EPM's covering over 550km^2
  - Two additional EPM applications expected to be granted during 2014 which will take the total tenement package to over 700km^2
- Within 60km of the world class Kidston Deposit which historically produced over 3.4Moz Au/Ag
- Advanced project with more than $15m already spent, more than 500 historic drill holes and majority of current drilling less than 200m deep
- Current JORC Resource[(1)]
  - 9.5 Mt @ 1.4g/t for 414,000oz Au at 0.5g/t cut-off
  - 17.0 Mt @ 0.94g/t for 514,000oz Au at 0.3g/t cut-off

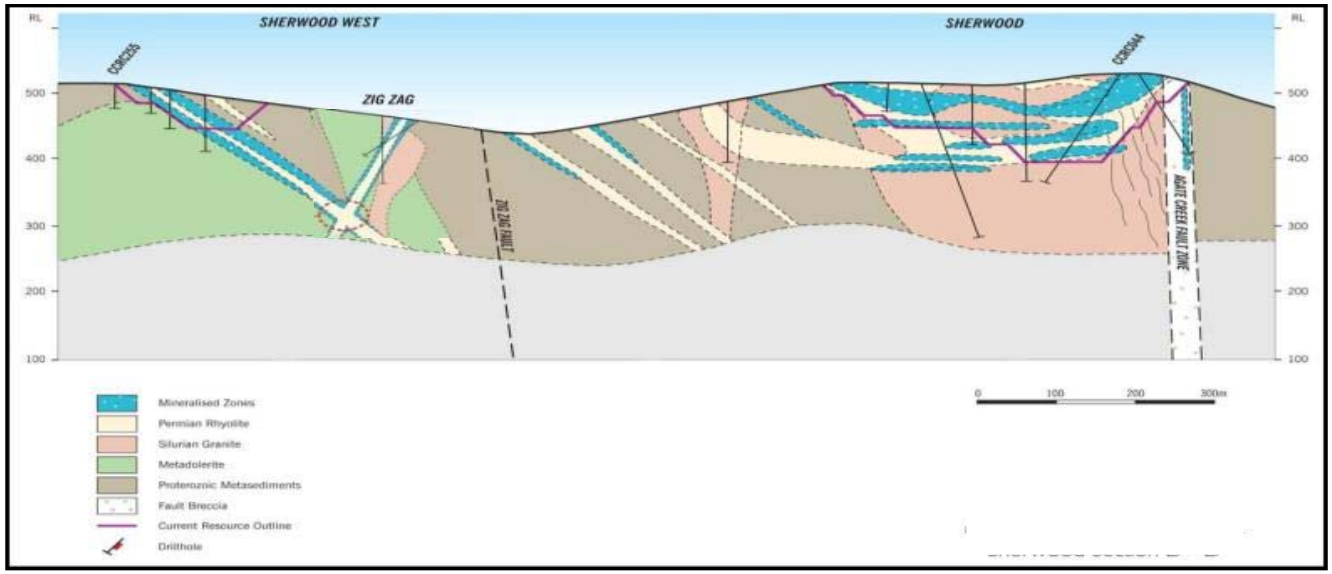
Agate Creek Cross-section



AGATE CREEK
Sherwood Resource Data & Pit Shells

0.3 g/t cut-off	Sherwood			Sherwood South			Sherwood West			Total		
Resource Classification	Mt	Gold (g/t)	Gold (oz)	Mt	Gold (g/t)	Gold (oz)	Mt	Gold (g/t)	Gold (oz)	Mt	Gold (g/t)	Gold (oz)
Indicated	5.4	1.0	180,000				5.2	0.9	154,000	10.7	1.0	334,000
Indferred	2.6	0.9	76,000	0.4	1.1	15,000	3.3	0.8	89,000	6.4	0.9	180,000
Total	**8.0**	**1.0**	**256,000**	**0.4**	**1.1**	**15,000**	**8.6**	**0.9**	**243,000**	**17.0**	**0.9**	**514,000**

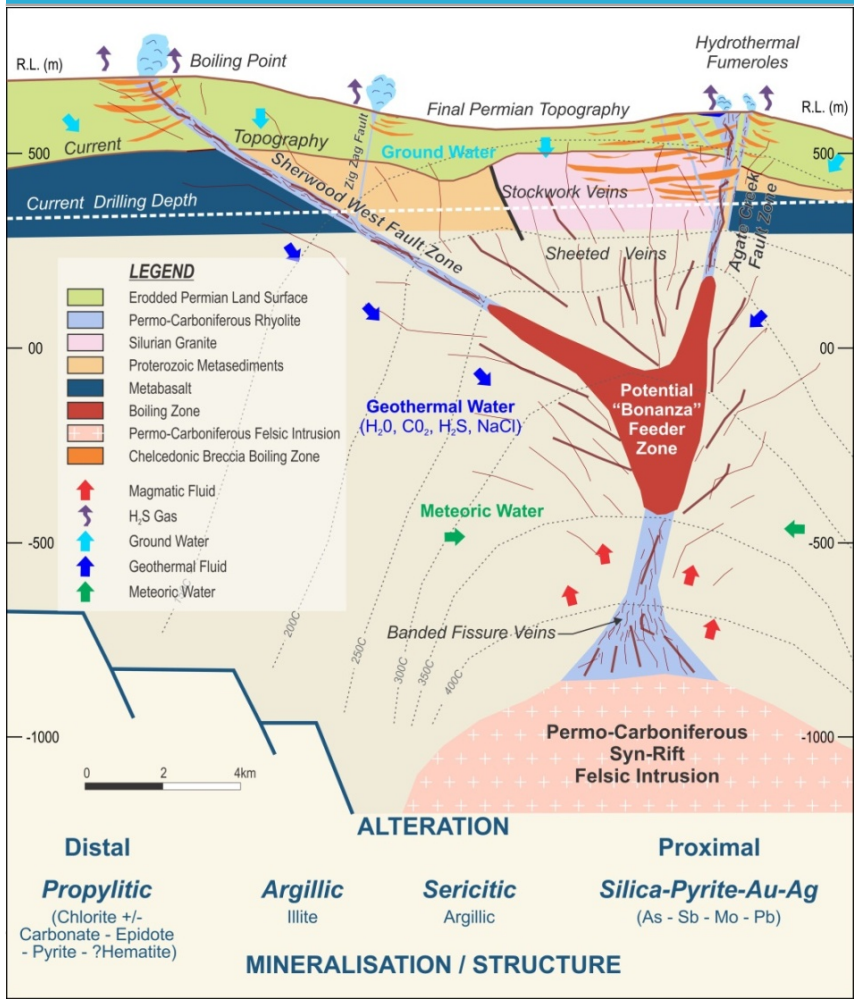
0.5 g/t cut-off	Sherwood			Sherwood South			Sherwood West			Total		
Resource Classification	Mt	Gold (g/t)	Gold (oz)	Mt	Gold (g/t)	Gold (oz)	Mt	Gold (g/t)	Gold (oz)	Mt	Gold (g/t)	Gold (oz)
Indicated	3.0	1.5	147,000				2.9	1.3	124,000	6.0	1.4	271,000
Indferred	1.4	1.4	60,000	0.3	1.3	13,000	1.8	1.2	70,000	3.5	1.3	143,000
Total	**4.4**	**1.5**	**207,000**	**0.3**	**1.3**	**13,000**	**4.8**	**1.3**	**194,000**	**9.5**	**1.4**	**414,000**



AGATE CREEK
Geology and Geological Model

- Sherwood is a low-sulphidation adularia-sericite type epithermal gold system characterised by swarms of narrow chalcedonic quartz veins
- Model based on historical information and now needs reviewing
- The alteration zonation pattern is a distal propylitic zone (pervasive chloritisation ± carbonate-epidote-pyrite-hematite) grading inwards to a more proximal variably argyllic to sericitic and locally phyllic zone with inner silica flooding (± pyrite) surrounding a gold only zone
- Gold is fine grained, occurs either as free gold or electrum and is associated with weakly anomalous Ag-Sb-As-Mo-Pb
- Within Proterozoic metasediments and volcanics of the Daniel Creek, Corbett and Lane Creek Formations
- Intruded by Silurian Robinhood Granodiorite and Permian rhyolites of the Agate Creek Volcanic Group
- Sherwood is within the NW trending Robertson Fault Zone of which the Agate Creek Fault is a dominant feature
- Mineralisation is Permian and closely associated with the Permian rhyolites , lithological boundaries and local faulting

Agate Creek Cross-section



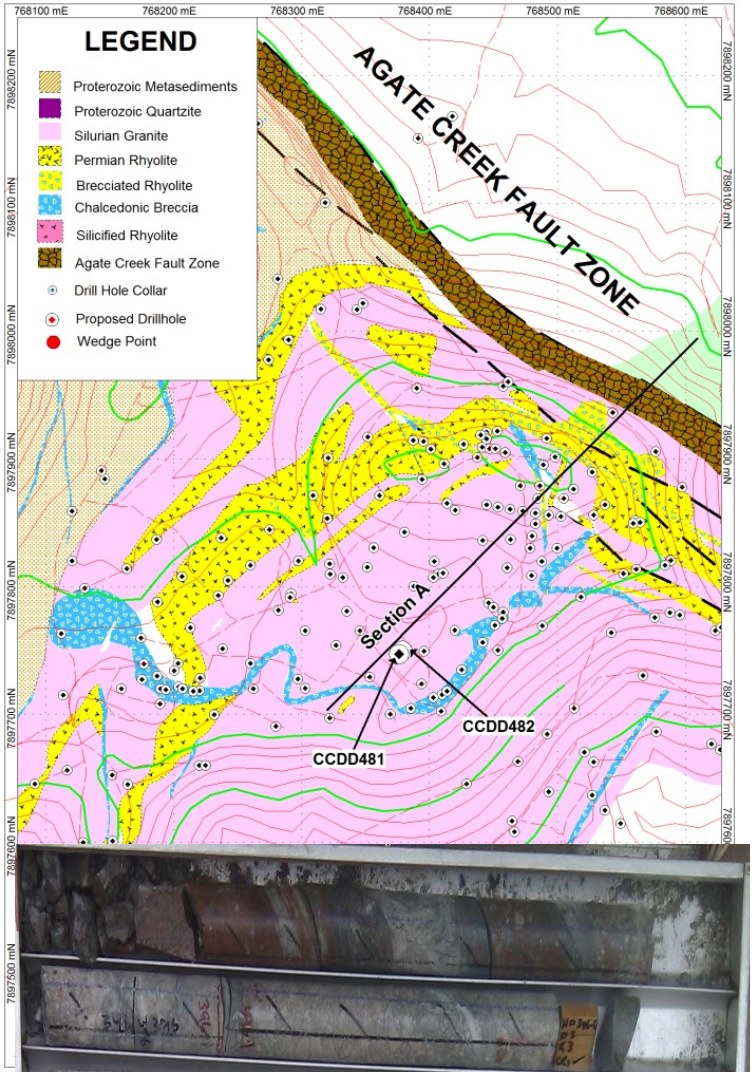
AGATE CREEK
CDI Drilling Target and Results

- Drilling was planned to intersect the potential Bonanza Zone just above the interpreted intersection of the Agate Creek and Sherwood West Faults
- QLD government CDI grant funded 50% of direct costs of the program which totalled $141,708
- Bonanza veins occur within the boiling zones of the epithermal system, commonly around 200-600m below land surface. Bonanza veins are a common feature of low-sulphidation epithermal deposits worldwide, e.g. Pajingo, Hishikari
- The Vera-Nancy lodes, the bonanza portion of the Pajingo Deposit, was initially discovered by deep drilling under a lower grade resource closer to surface
- At Hishikari the top of the bonanza vein was discovered by an intersection of 15cm @ 290g/t Au 200m below surface
- Deep drilling was completed in June 2013 with two holes for a total of 903.8m
- Significant high grade gold intercept of 31m at 5.96 g/t Au from 124m including 1m at 73g/t Au
- This result was excellent but failed to intercept any bonanza zone, fluid pathways or veining at depth

Example of bonanza vein

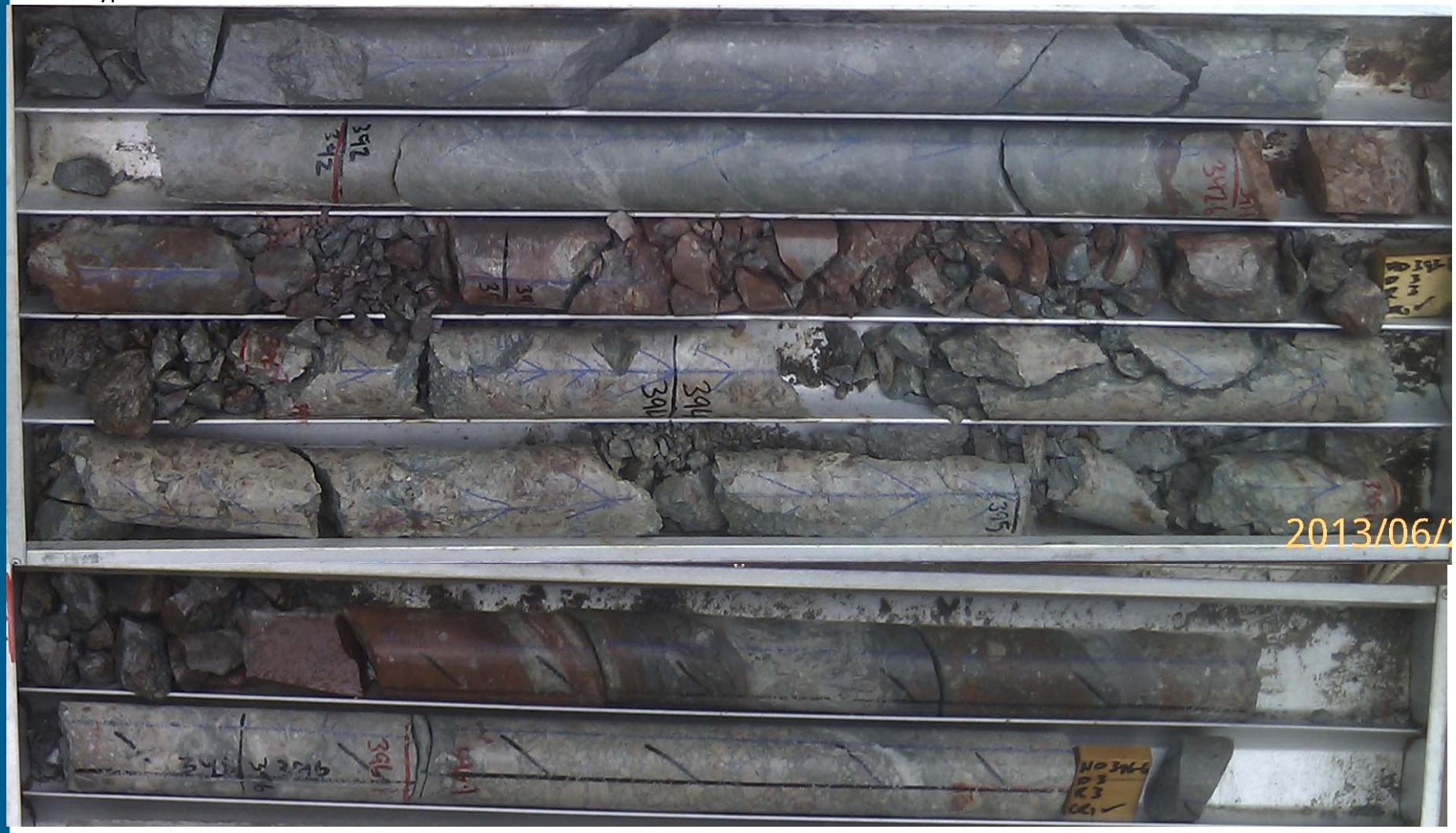
AGATE CREEK
Interpretation of Drilling

- CCDD481 was drilled PQ to 149.5m then HQ to 513.5m
- CCDD482 was drilled HQ from surface to 390.3m
- The mineralised zone is chalcedonic quartz veining within brittle sericite altered Permian rhyolites intruded into the Robinhood Granodiorite
- Both holes intersected the Agate Creek Fault trace (brown breccia) but at shallower depths than expected due to the dip of the fault being shallower (65 degrees rather than the expected 85 degrees interp from prev drilling).
- The eastern edge of the fault (brown breccia) was up to 10m wide and is a matrix supported chlorite clay altered zone with minor subrounded clasts of quartz and metasediments. The western side of the fault zone was less clear
- The fault contained large zones breccia indicating multiple episodes of activation, however rhyolite noticeably absent. Breccias showed a range of textures from milled through to angular clast supported. The majority of breccias were clay altered with rare zones of silicification. The silicified zones may have sealed the upper portion of the Agate Creek Fault prior to both the emplacement of rhyolite and the mineralising events at Sherwood



AGATE CREEK
Fault Zone

- Typical Fault breccia



AGATE CREEK
Mineralised Zone

- The mineralised rhyolite 31m@6g/t Au from 124m including the upper an lower granite contacts

AGATE CREEK
Mineralised Zone

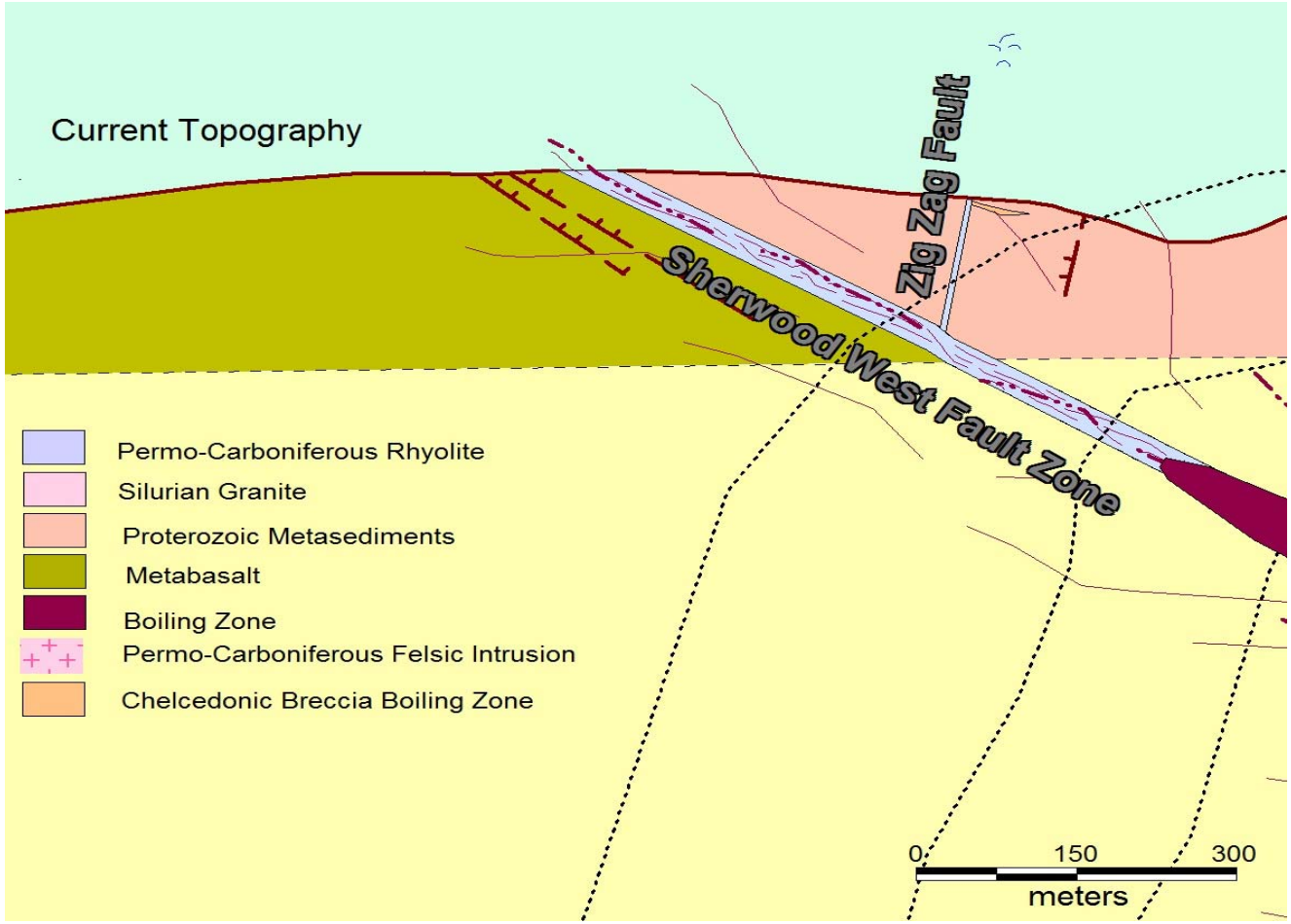
- The mineralised rhyolite 125-126m returned 73g/t Au

- A small quartz vein in the altered granite just below the rhyolite at 153.2 to 153.75 returned 36 g/t Au

AGATE CREEK
Interpretation of Drilling

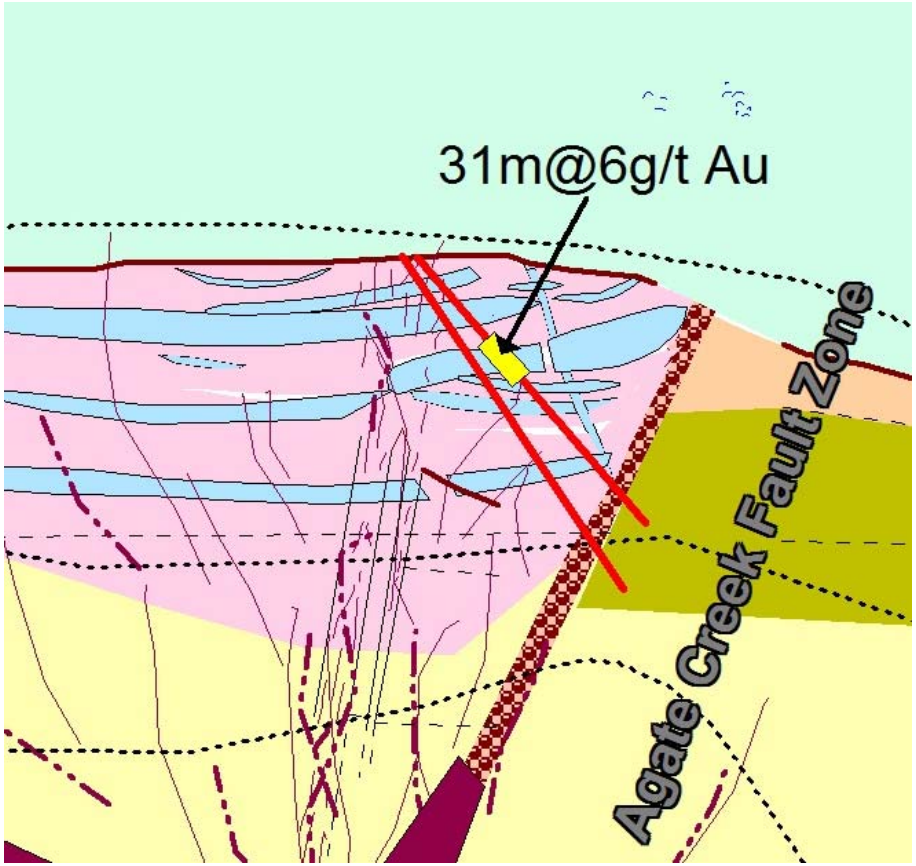
- Rhyolite intrusion has largely been structurally controlled however lithological boundaries were also active during emplacement. Dating by Nethery (2009) as part of Project INI001 determined intrusive ages between 286-283Ma +/- 2Ma which predates the mineralisation at Sherwood

- At Sherwood West and Zig Zag the mineralisation is dominantly contained within the rhyolites which have been intruded along active open structures. Mineralisation along both of these structures shows solid geological constraints and is relatively simple



AGATE CREEK
Interpretation of Drilling

- At Sherwood the mineralisation is far more complex due to the proximity of the Agate Creek Fault and the chilled margin of the Robinhood Granodiorite. While it has been recognised that mineralisation is intimately associated with the rhyolites it is also in veining and stockworks throughout the granites and there has always been the assumption that the Agate Creek Fault must have been the main fluid conduit
- Mapped geology suggests that the Agate Creek Fault has provided dilational sites for rhyolite emplacement and recent drilling suggests it is these sites that were still available during the mineralising event rather than the upper parts of the fault itself
- Numerous sub parallel and splay faults exist which further complicates geological interpretation. Limited orientated diamond drilling to date has severely restricted structural information on the deposit



GATE CREEK
scussion

uctural studies done in 2011 show the highest grade veins at erwood dip moderately to steeply to the NE which was confirmed structural measurements in drilling

s study also indicated the potential for high grade mineralised ds dipping at shallow angles to the southeast which may explain y the mineralised zone seen in CCDD482 is not seen in CCDD481 ectly below it)

e Agate Creek Fault has formed the eastern boundary to neralisation at Sherwood. The upper part Agate Creek Fault was the main fluid conduit but the possibility remains that it may be neralised at depth

volites have intruded along faults, lithological boundaries and aknesses in the Robinhood Granodiorite. They are strongly ered, silicified, brittle and intimately associated with neralisation

GATE CREEK
nclusions And Further Work

ntersection of the Sherwood West and Zig Zag Faults is a priority target

ip of the Agate Creek Fault is shallower than previously thought so the tial intersection of this and the Sherwood West faults may be further e west than originally thought

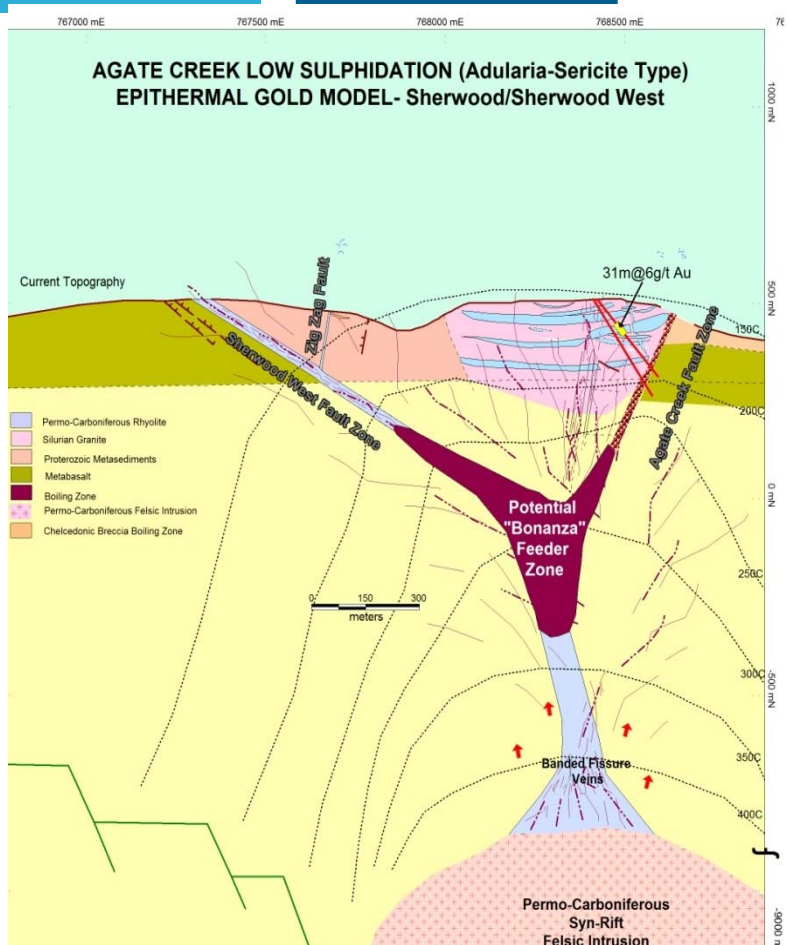
ntersection of these two faults with the Agate Creek Fault becomes a t for further deep drilling to extend mineralisation

prittle rhyolites at Sherwood should be targeted down dip to the east for extensions to existing mineralisation

ete vein sampling and petrographic study of is planned to further define ralisation at Sherwood

geological model taking into account the new information regarding the Creek Fault will assist in targeting further drilling for both the bonanza and extensions to existing resource

y a well placed orientated stratigraphic hole may assist with further gical interpretation

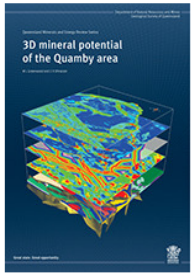


New Ideas on Mineralisation at erwood Deposit, Agate Creek, orth Queensland December 2013

One Stop Shop and Open Data

Changes to GSQ Information Delivery

Queensland Minerals and Energy Review
3D mineral potential of the Quamby area



3D geological and geophysical modelling was used in conjunction with mineral potential modelling to assess unrealised Cu-Au potential in the Quamby area in the Eastern Succession of the Mount Isa Inlier.

This report documents the process used by the Geological Survey of Queensland, including 3D modelling and geophysical inversion, to create a Common Earth Model for 3D mineral potential modelling over the Quamby Project area.

This product comes in a folder containing:

- Quamby report (pdf), GIS project, and 3D GOCAD project and objects (DVD)
- Quamby Time-Space plot and reference geological and geophysical images of the Quamby project area (hard copy).

Sale price $33.20 (incl. GST) from GSQ Sales.

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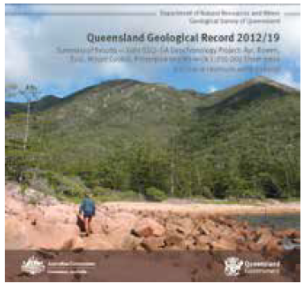
Queensland Geological Record 2012/19
Summary of Results — Joint GSQ-GA Geochronology Project:
Ayr, Bowen, Eulo, Mount Coolon, Proserpine and Warwick 1:250 000 Sheet areas



This report presents new Sensitive High Resolution Ion Microprobe (SHRIMP) U-Pb zircon results for 32 igneous and two metamorphic rocks, mainly from the Bowen region of north Queensland.

Three samples are of granites from the northern New England Batholith in southern Queensland, and one granite sample is from the Eulo Ridge (Thomson Orogen) in south-western Queensland. The work was carried out under the auspices of the National Geoscience Agreement between Geoscience Australia and the Geological Survey of Queensland.

The data and age interpretations contained in this report are available from Geoscience Australia's Geochronology Delivery database.

Sale price $15.75 (incl. GST) on CD from the GSQ Sales Centre. On the web:
http://mines.industry.qld.gov.au/geoscience/queensland-geological-record-2012-19.htm

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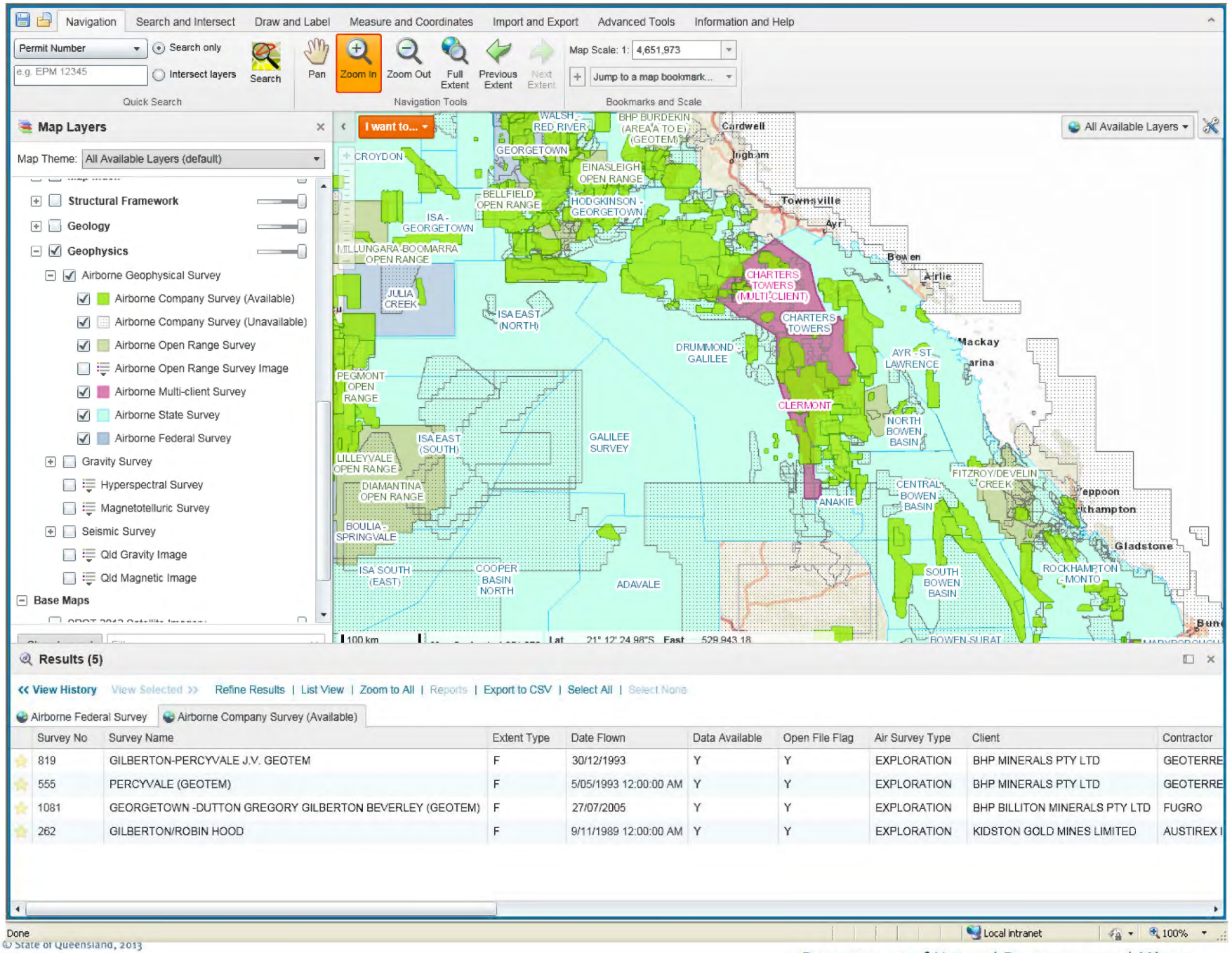

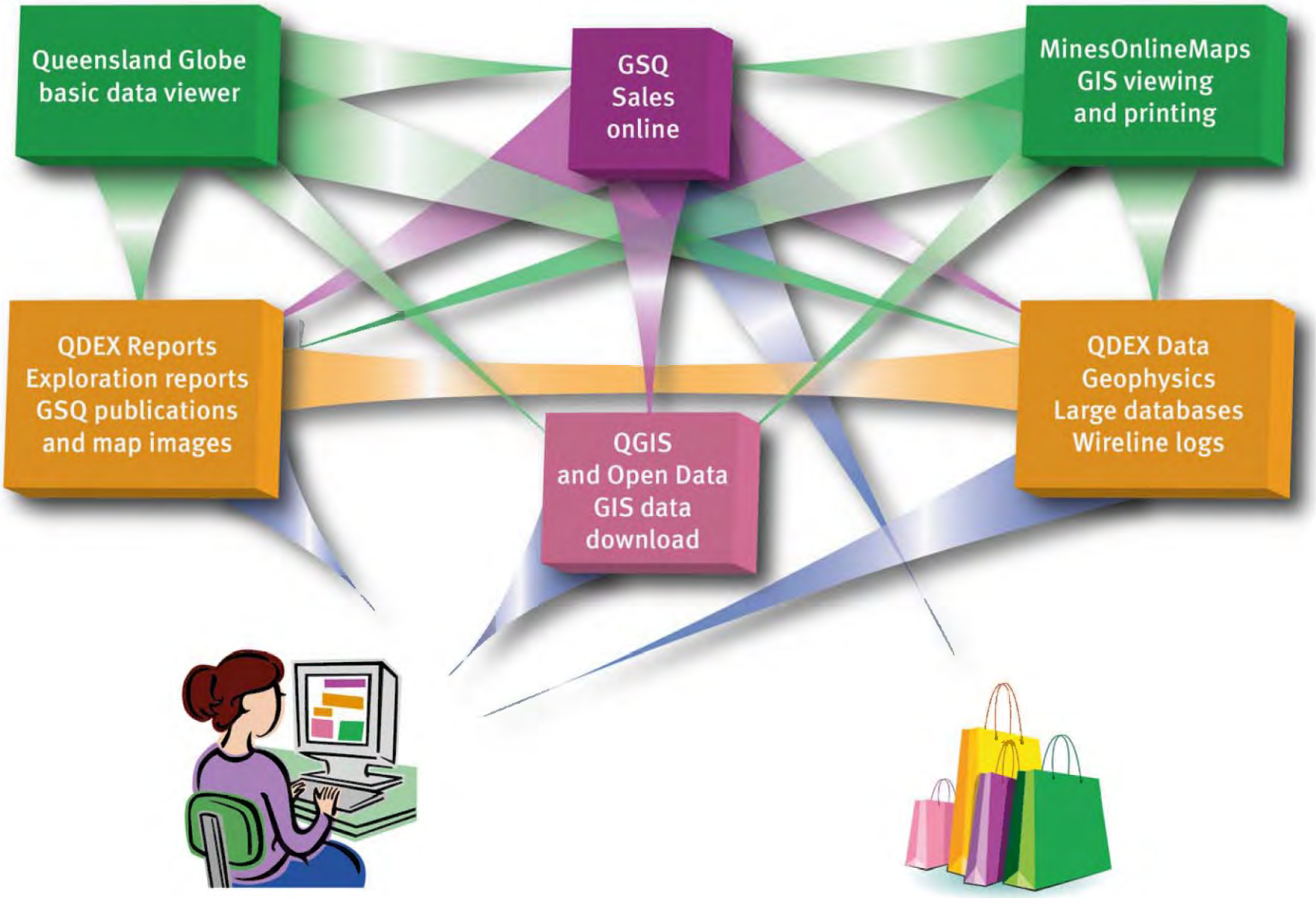

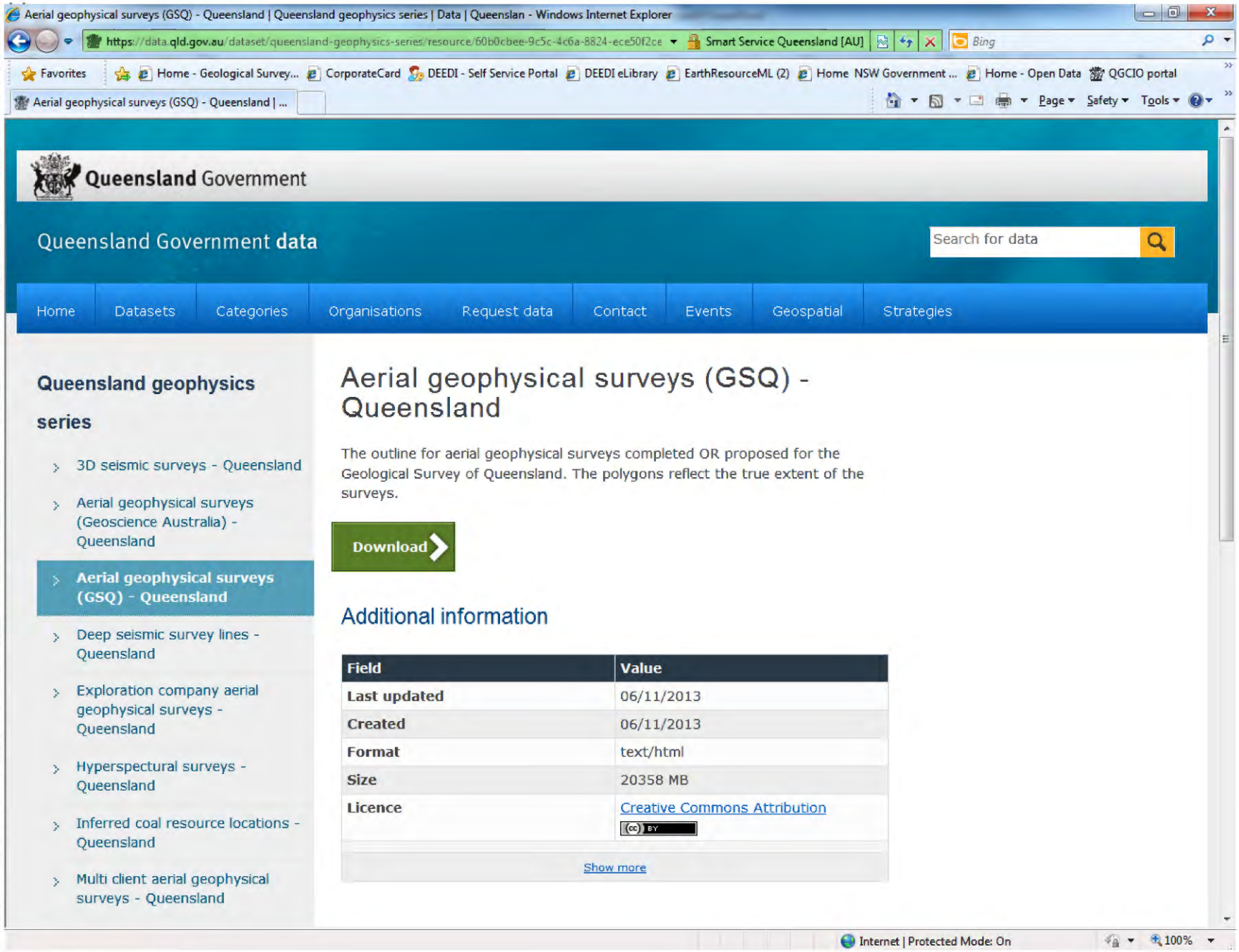

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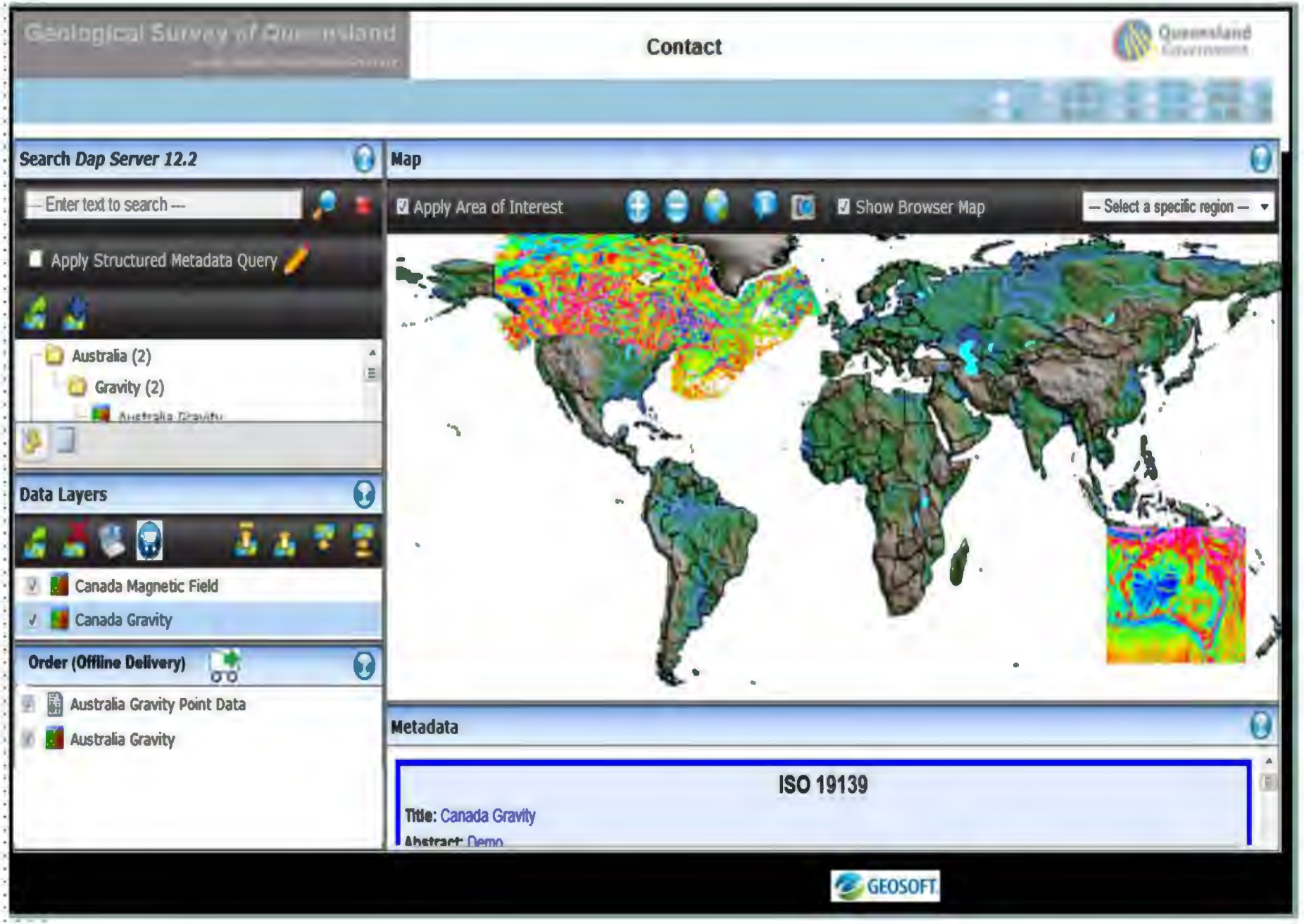

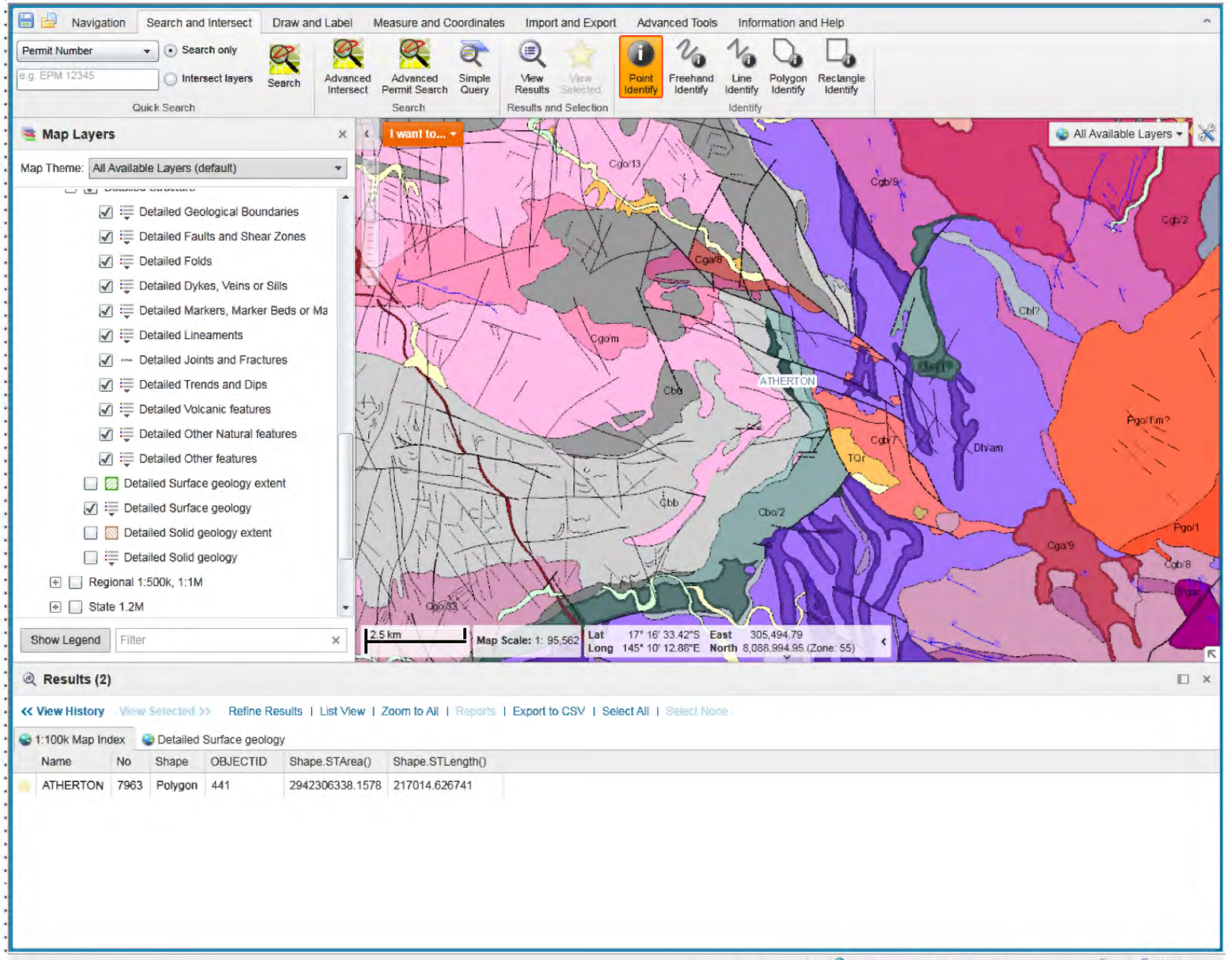

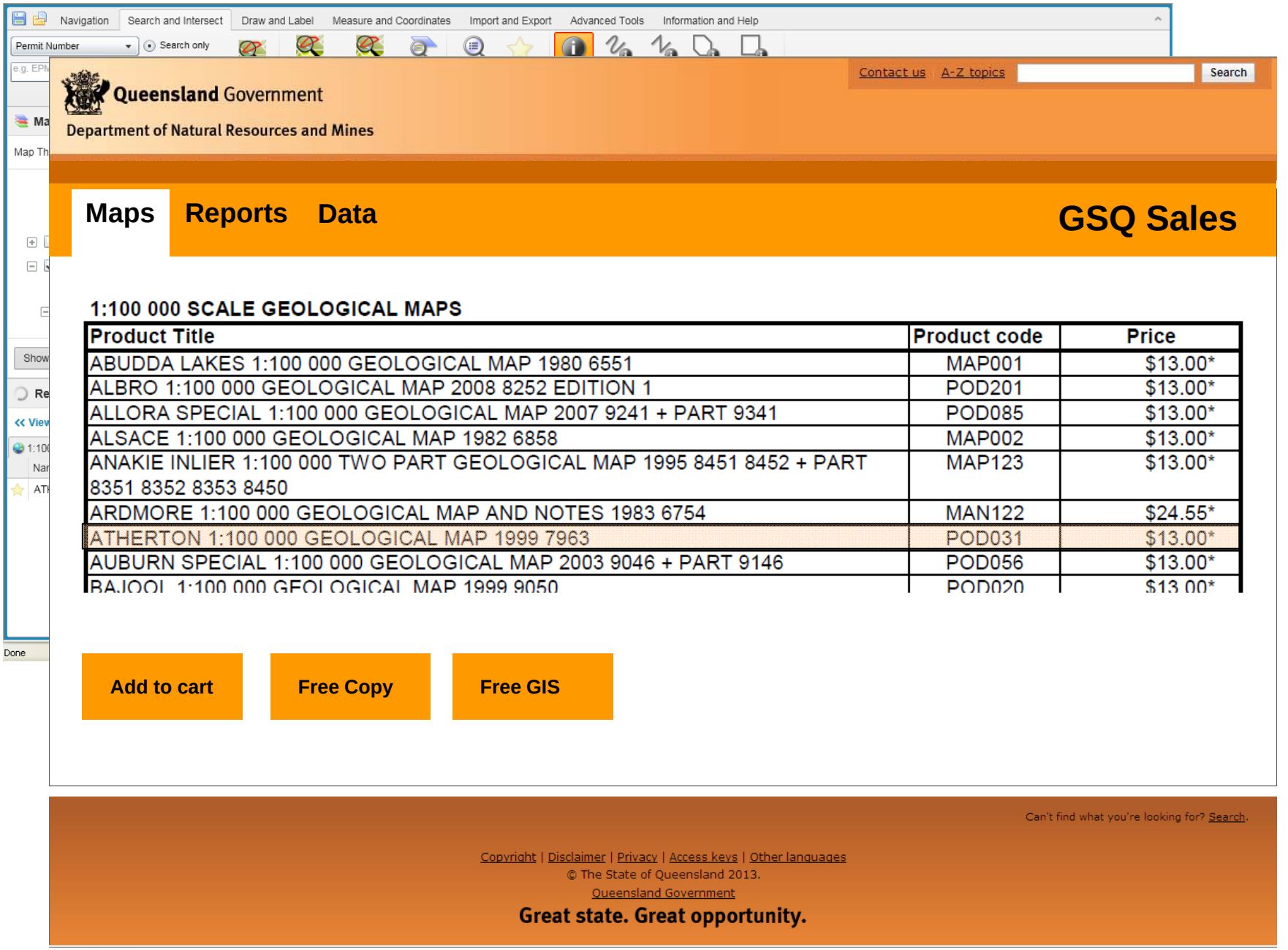

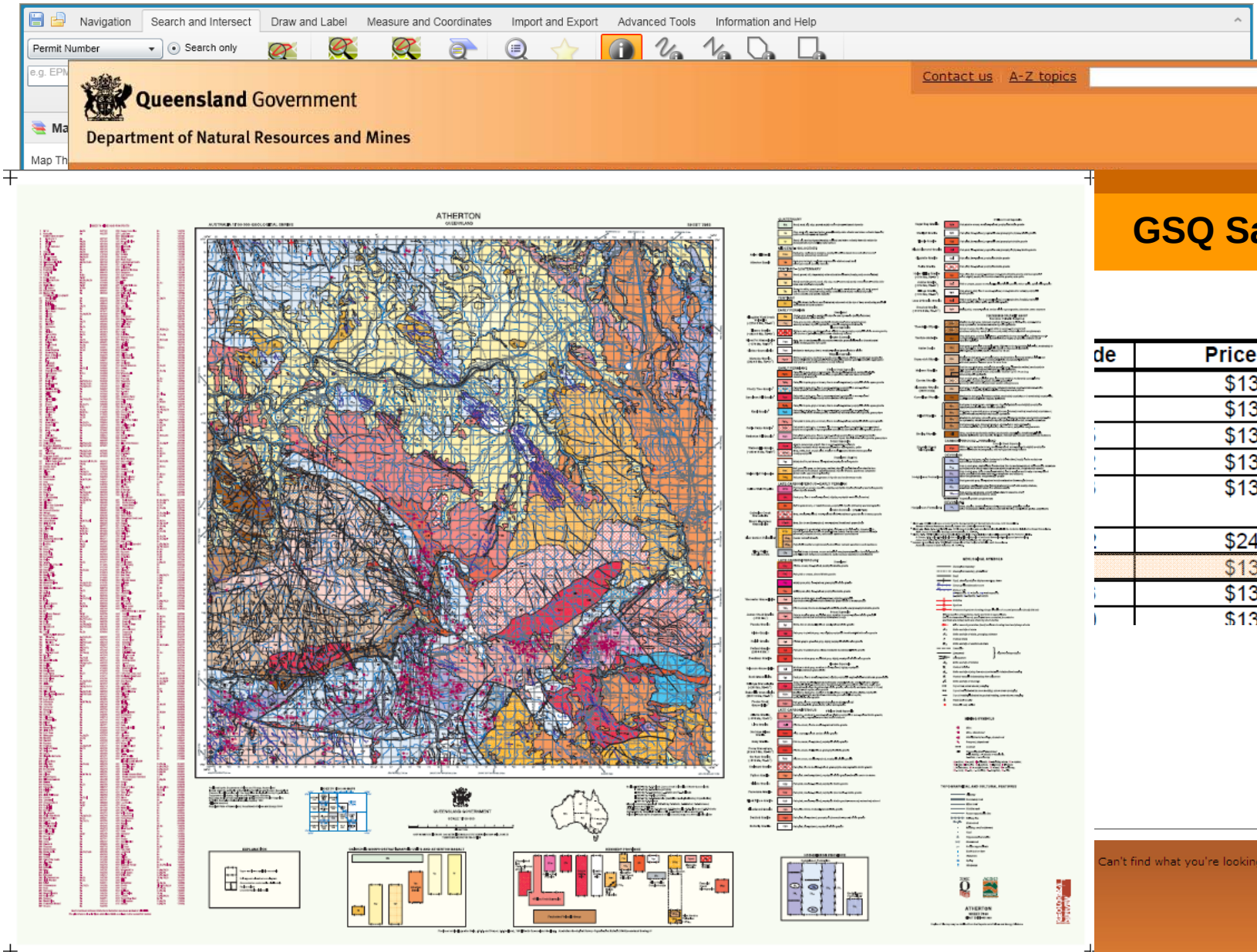

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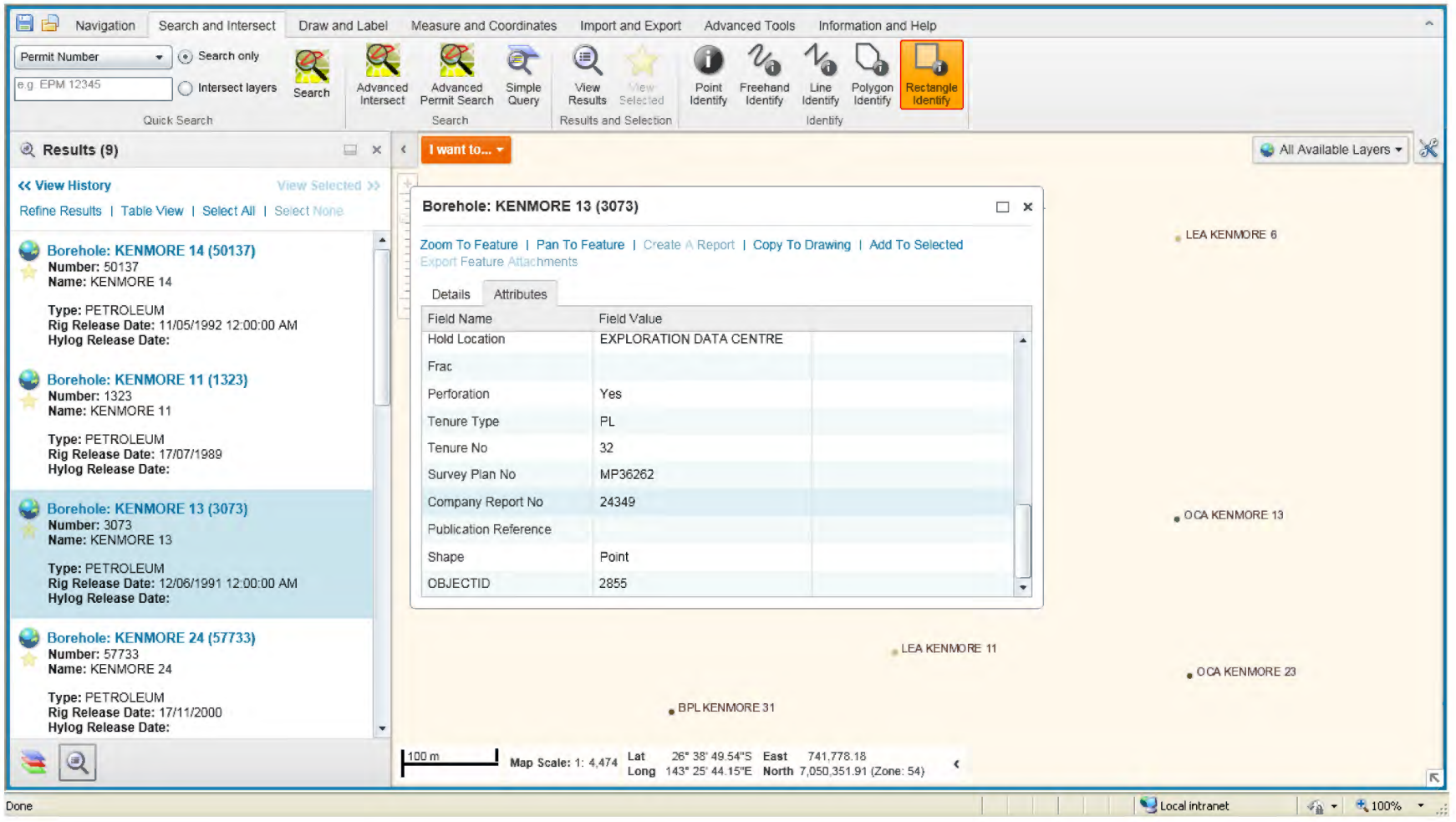

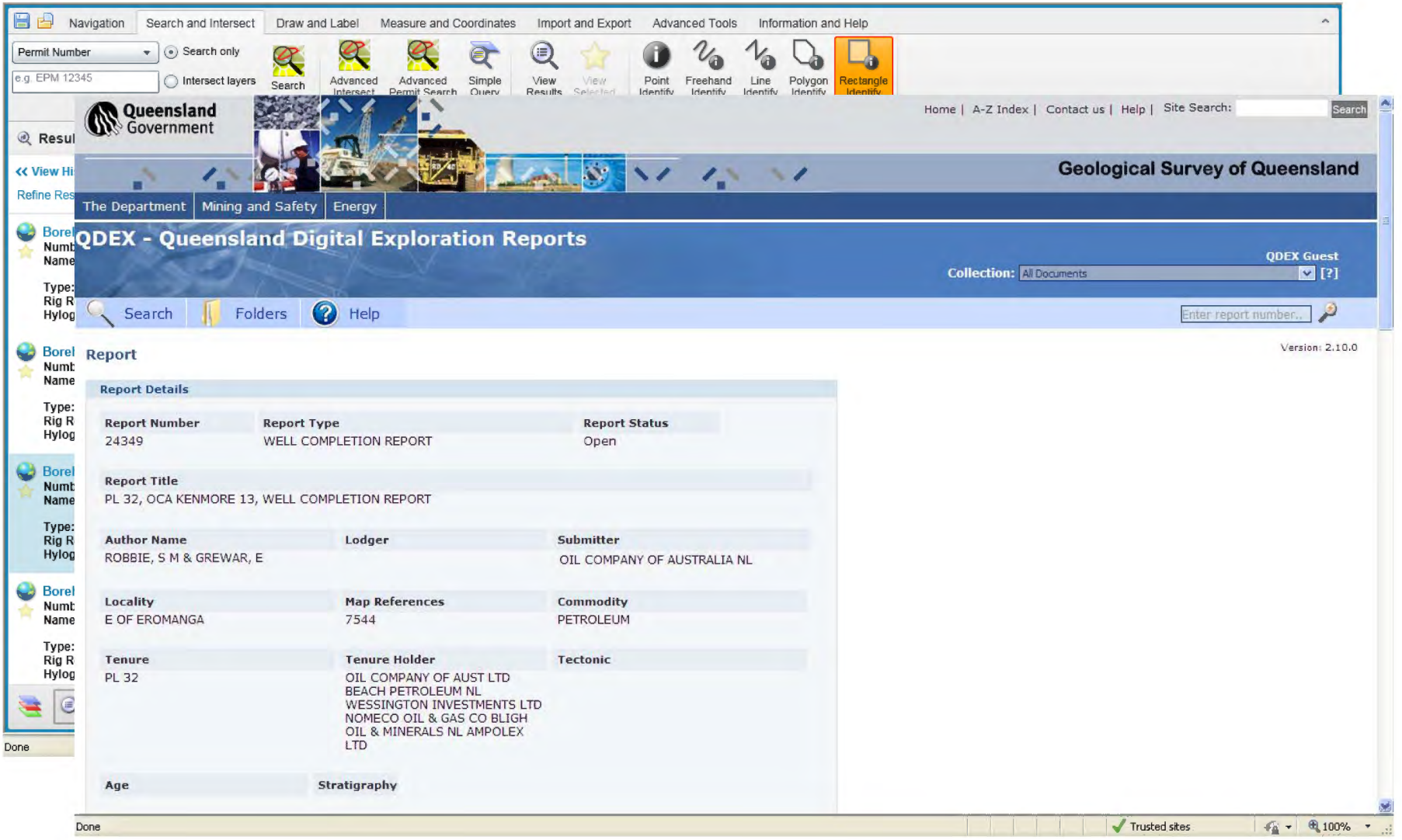

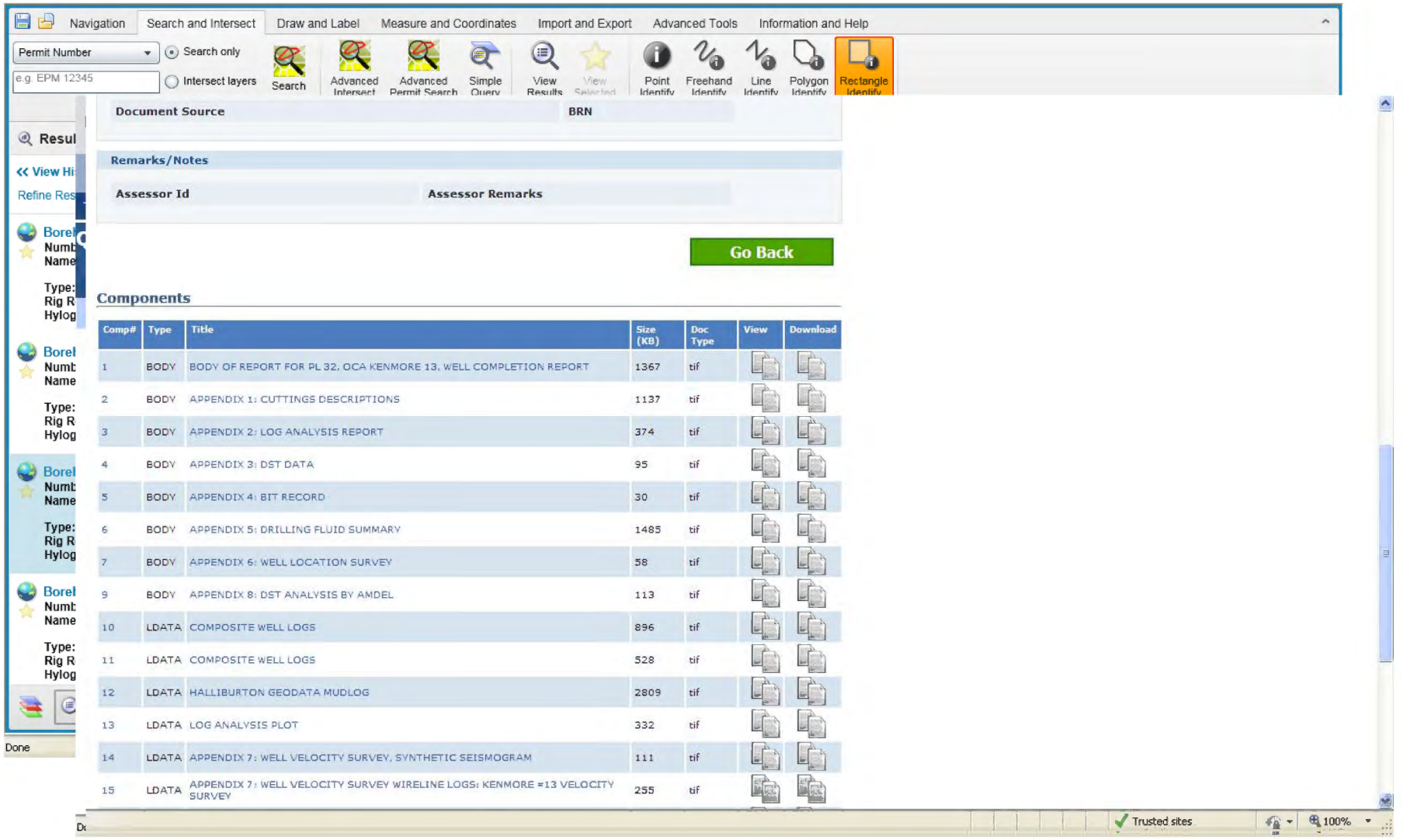

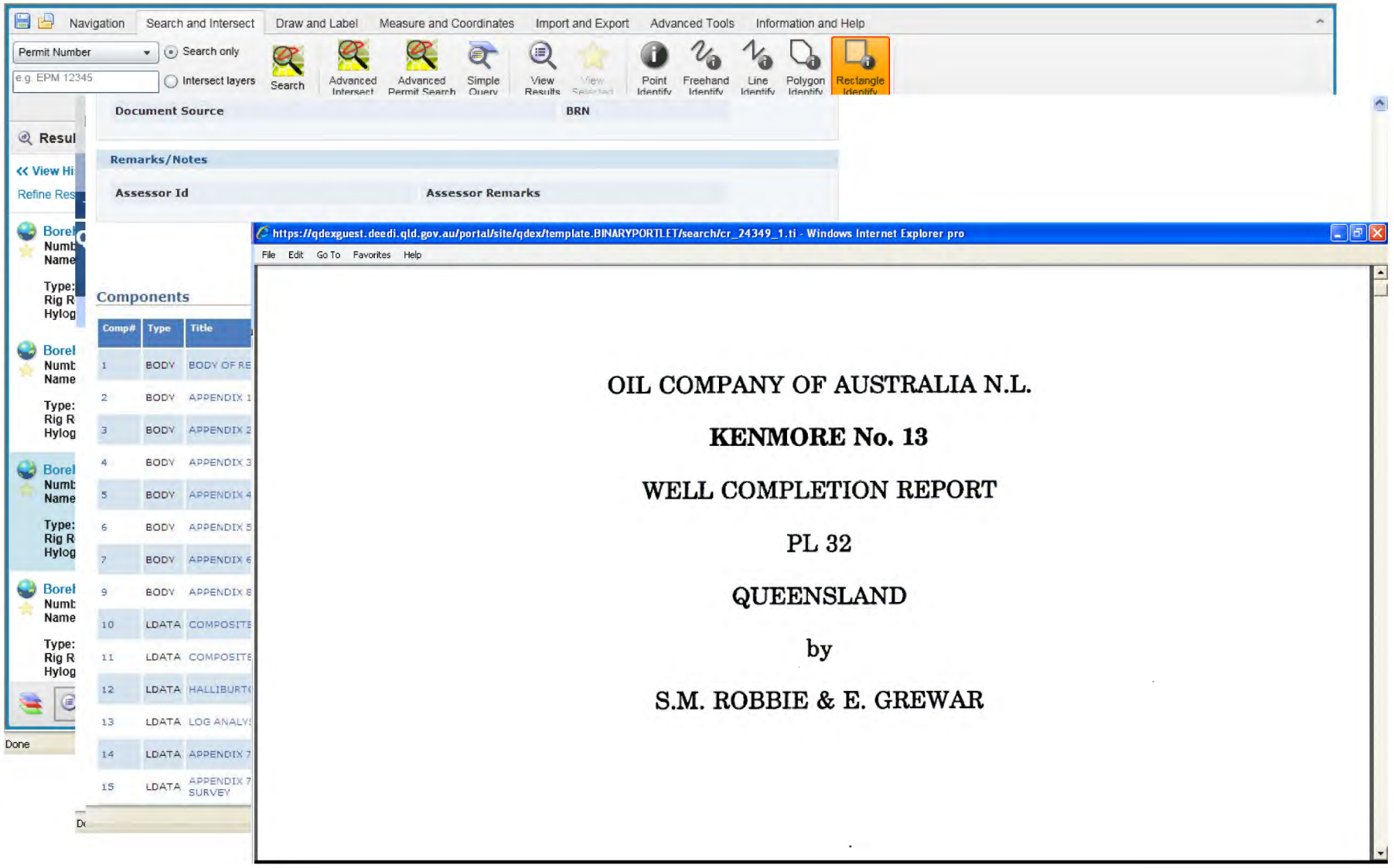

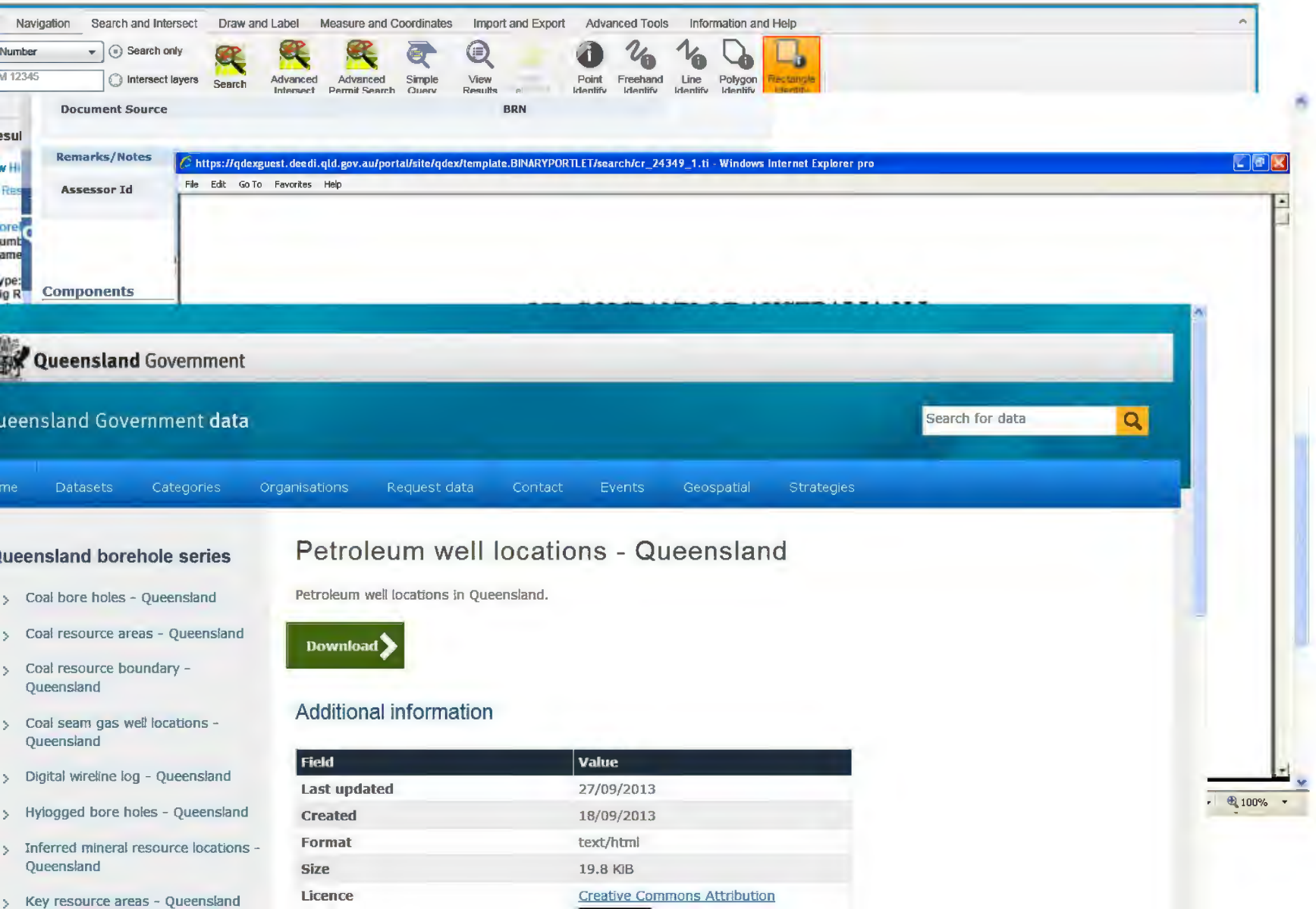
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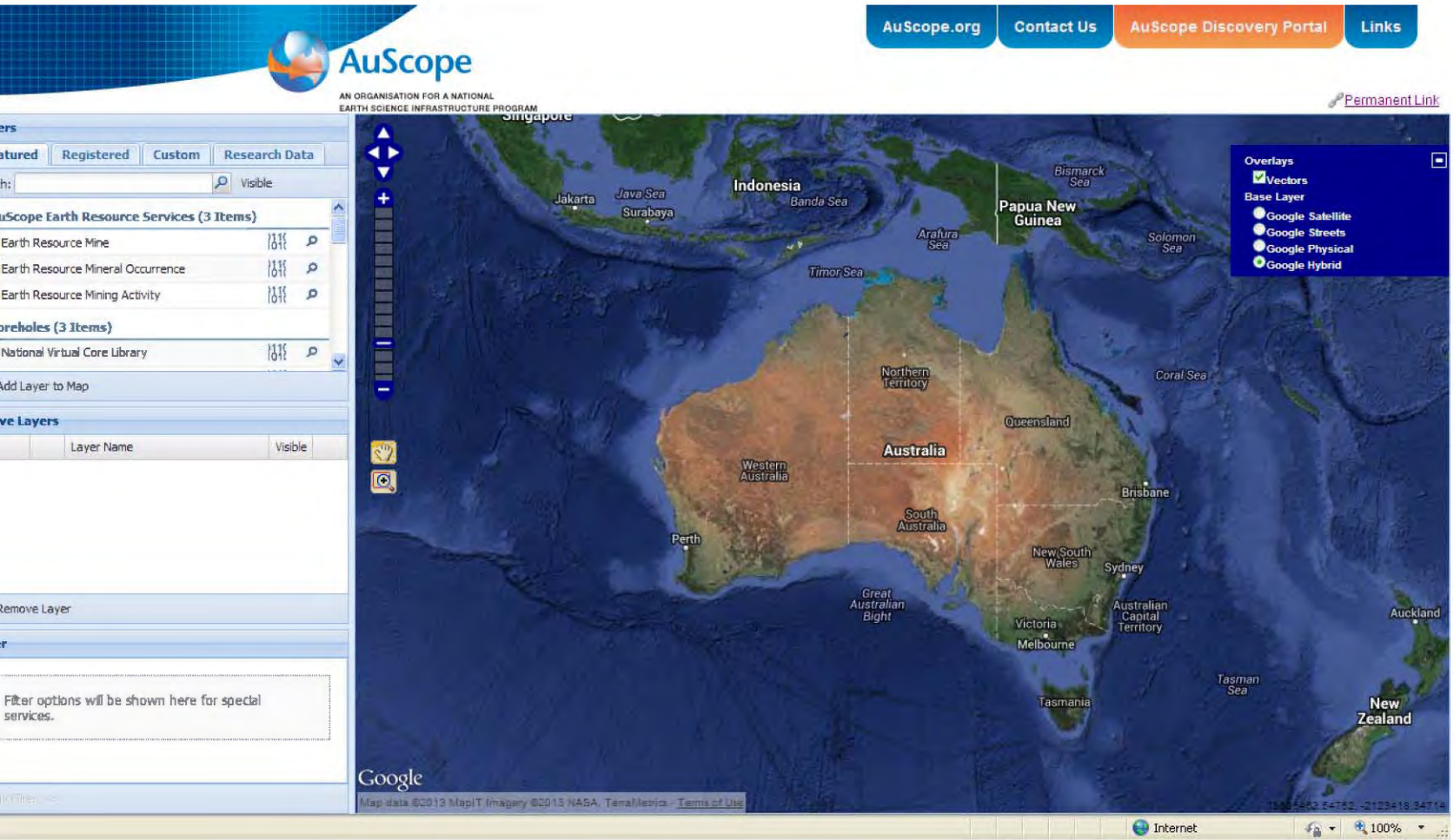
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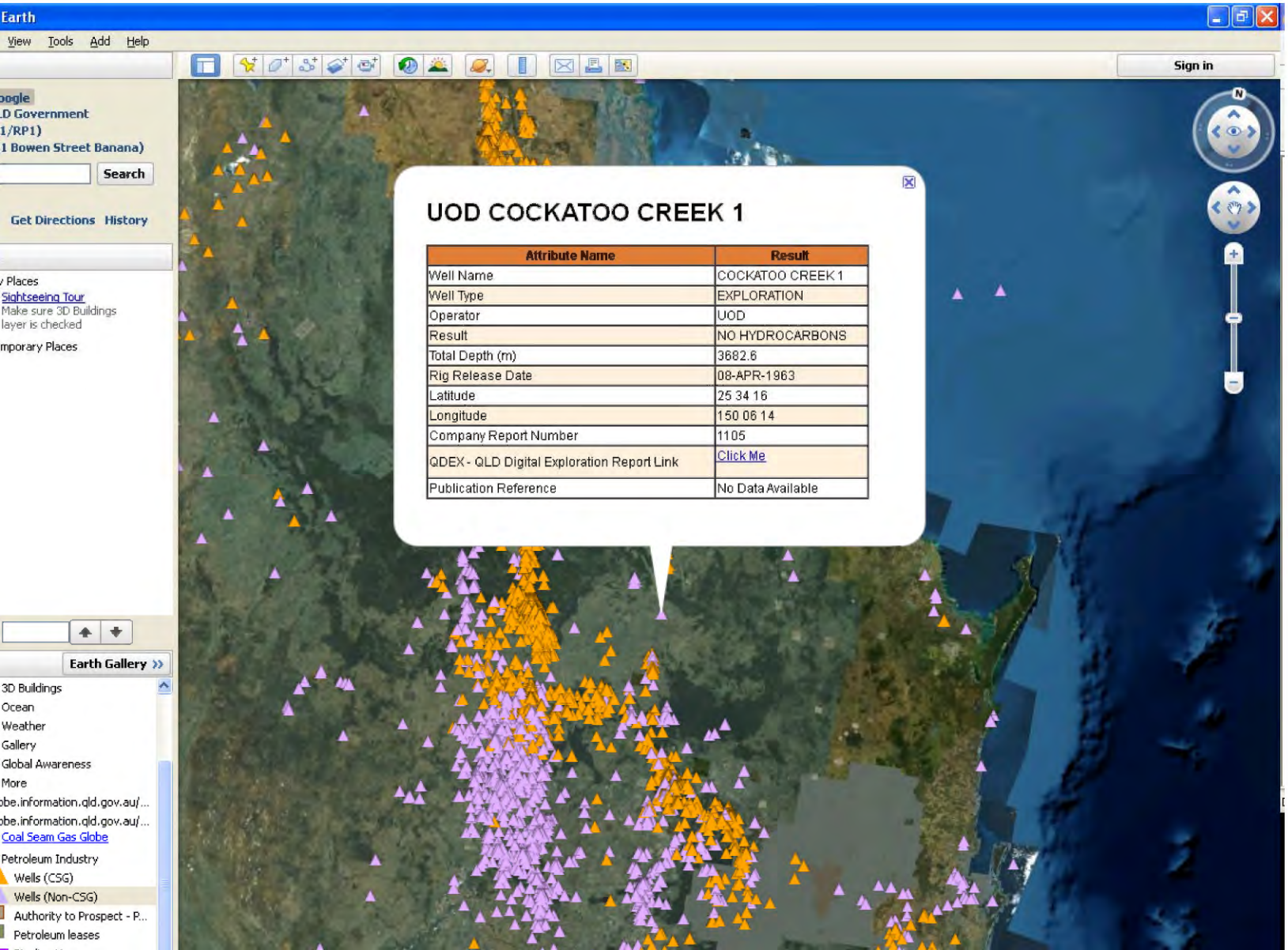
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Attribute Name | Result
Well Name | COCKATOO CREEK 1
Well Type | EXPLORATION
Operator | UOD
Result | NO HYDROCARBONS
Total Depth (m) | 3682.6
Rig Release Date | 08-APR-1963
Latitude | 25 34 16
Longitude | 150 06 14
Company Report Number | 1105
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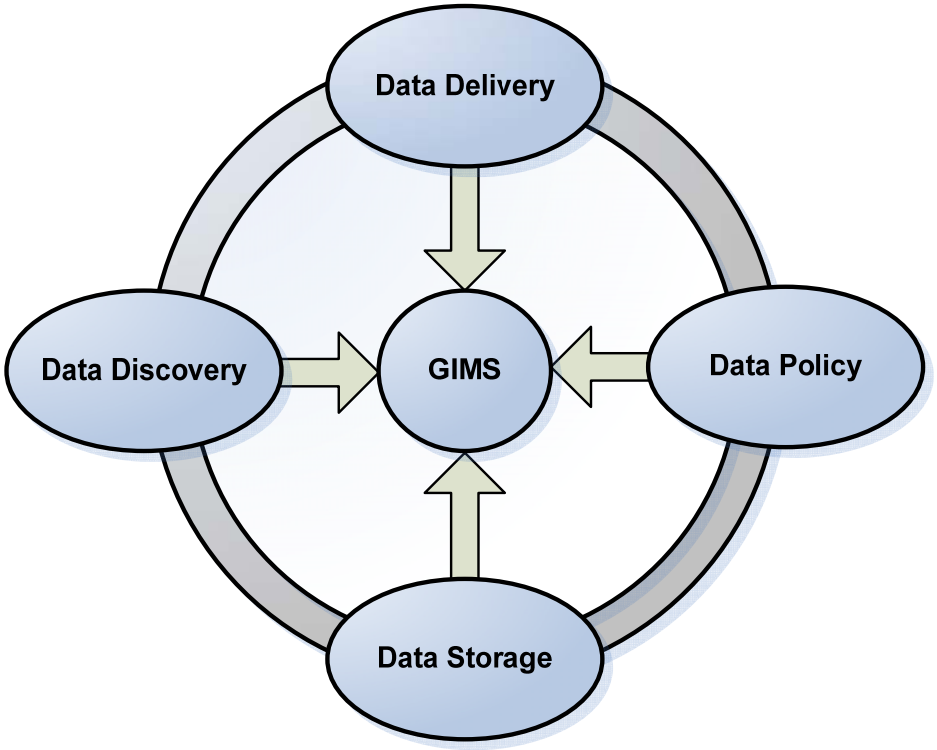
Strategic Direction

Data Delivery
Targeting system developments and enhancements to enable GSQ to support enhanced online delivery of its datasets.

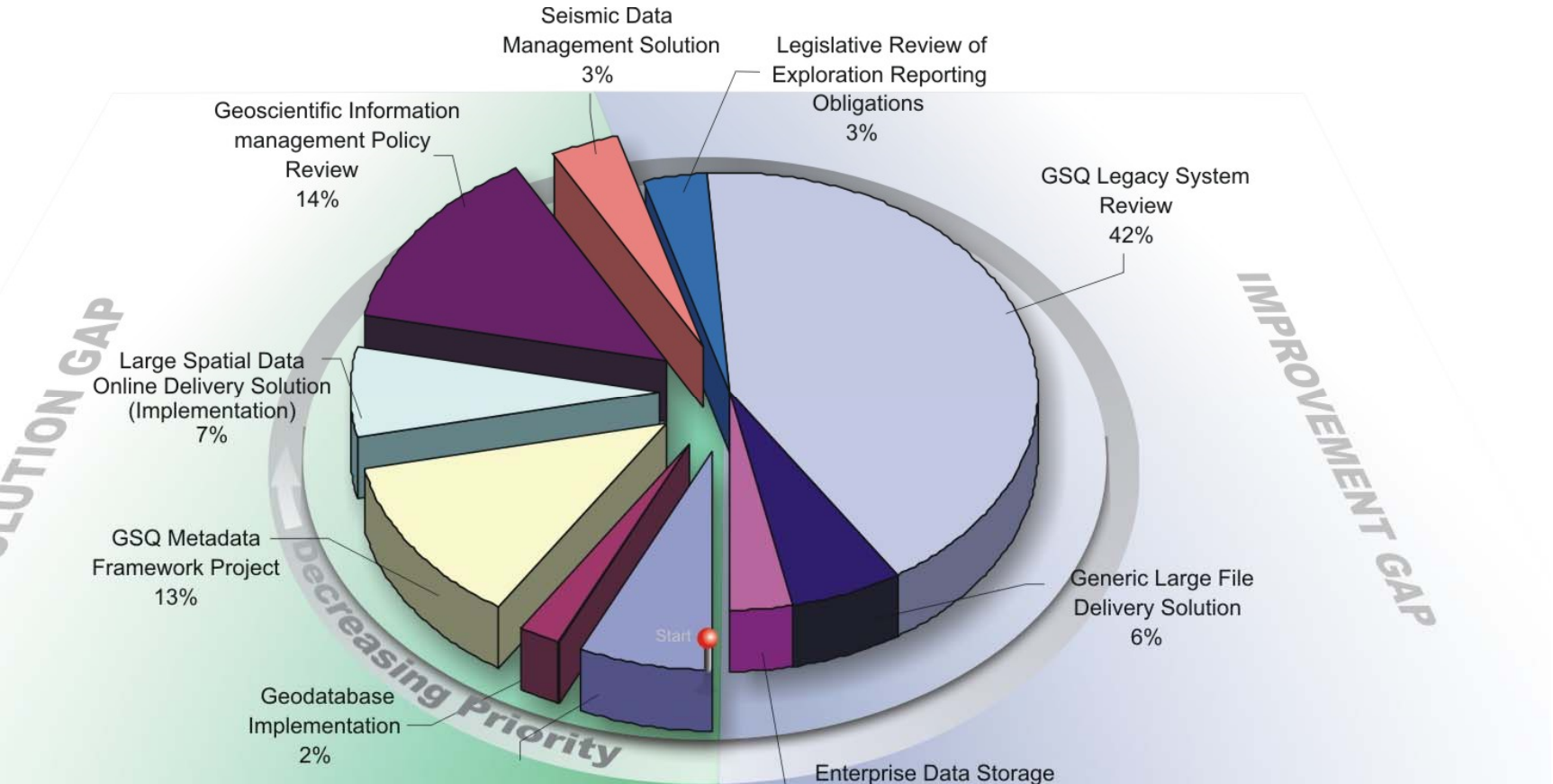
Data Discovery
Creating the metadata
stems and frameworks
to enable centralised
overy and accessibility
to GSQ's datasets.



Data Policy
Establishing the framework and developing the policies and processes to support best practice information management for geoscientific information assets.

Data Storage
Building the systems or enhancement to cater for centralised

Strategic Direction (Implementation)



Basement Geology of the Southern Thomson Orogen in Queensland

Dave Purdy, Pat Carr, Dominic Brown, Janelle Simpson (GSQ)
Rosemary Hegarty (GSNSW)
Michael Doublier (GA)

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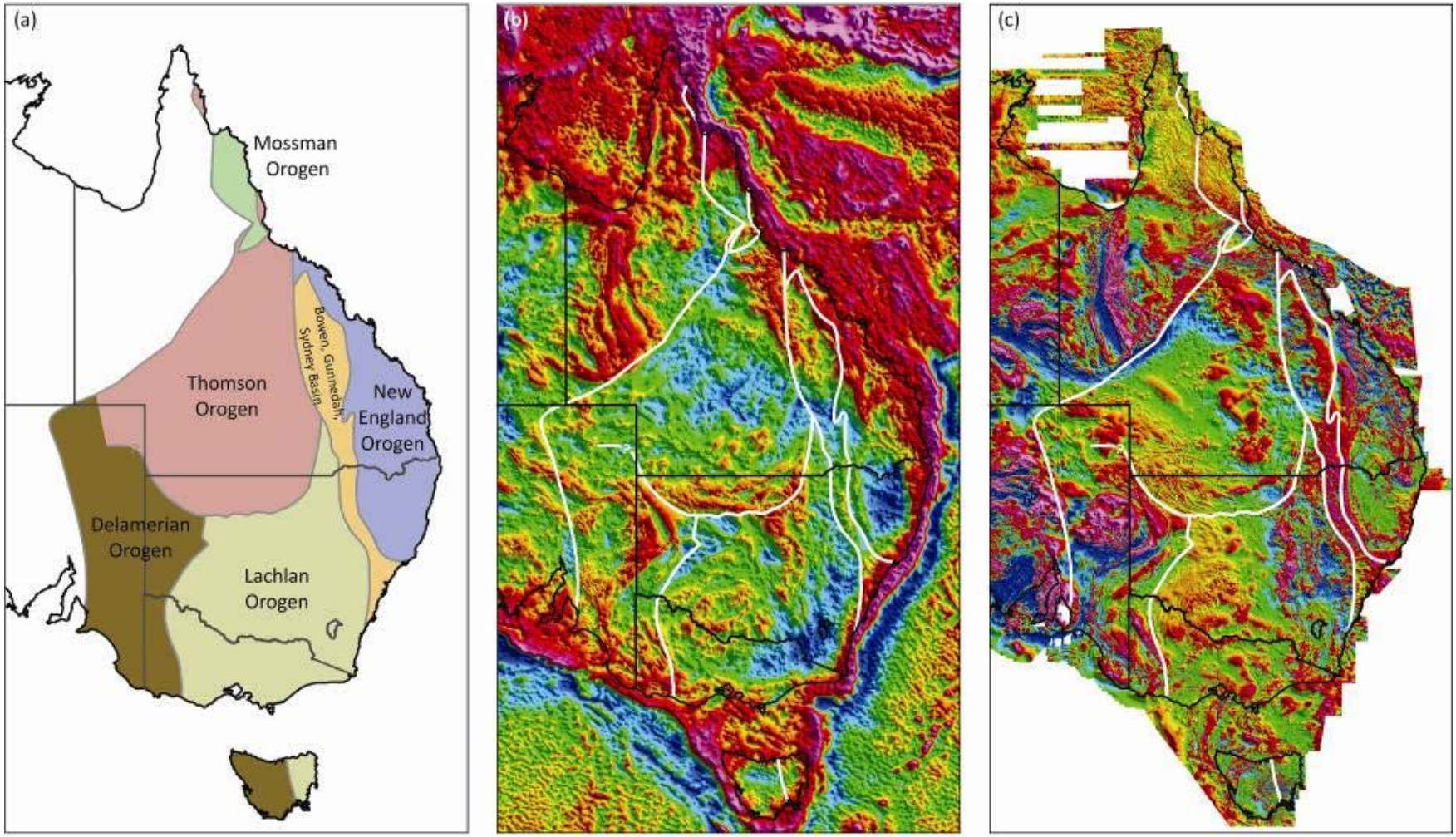

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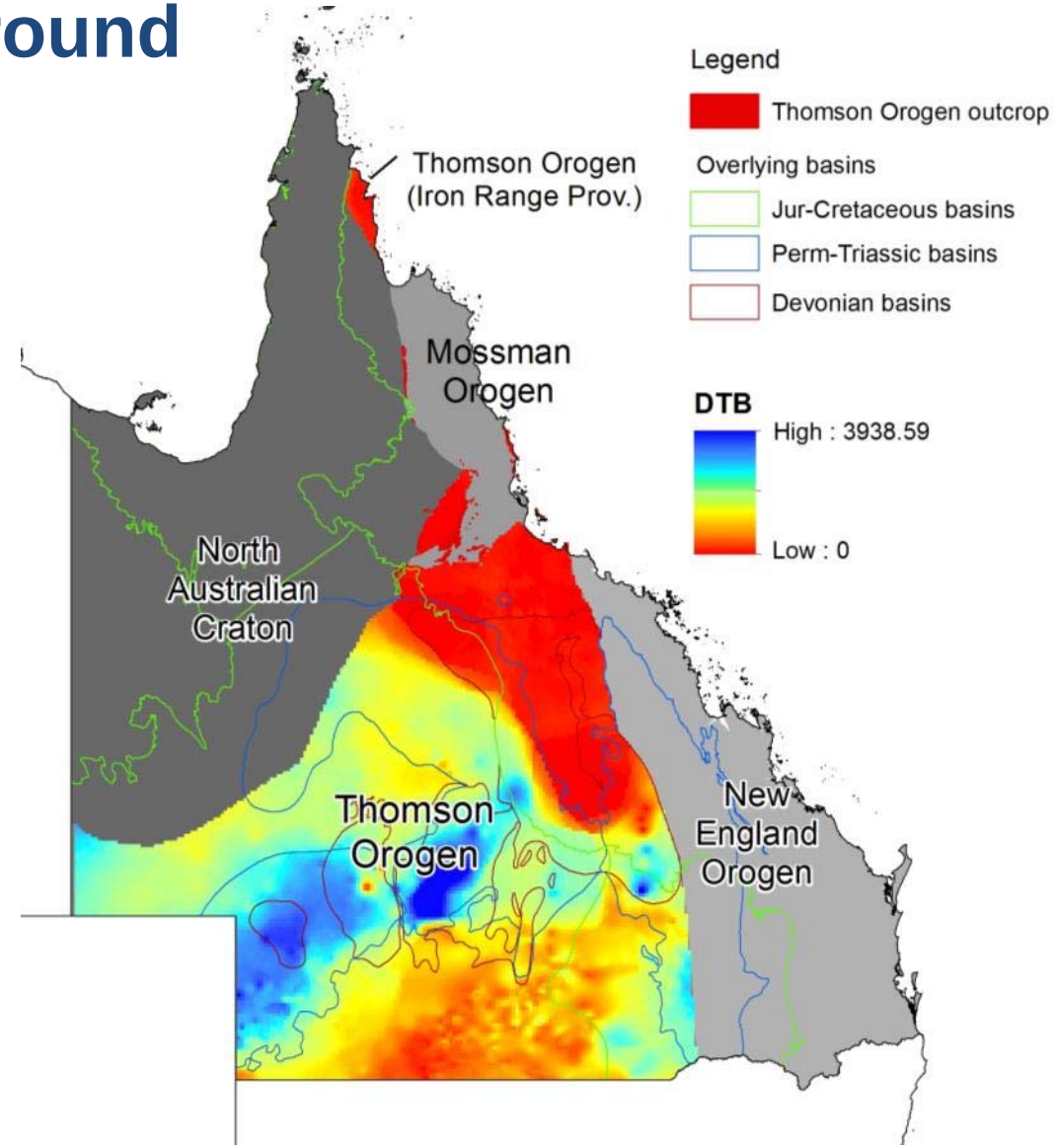
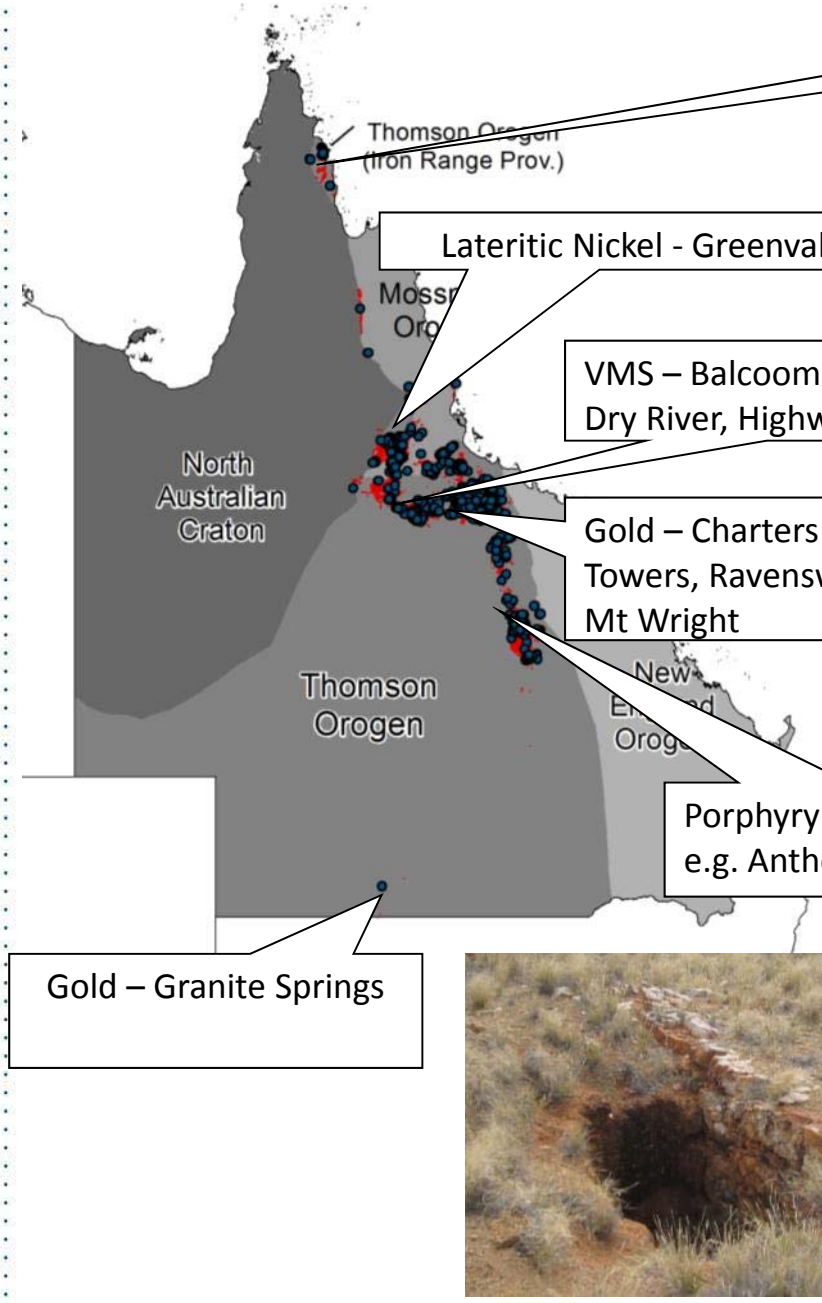




Iron Range

Lateritic Nickel - Greenvale

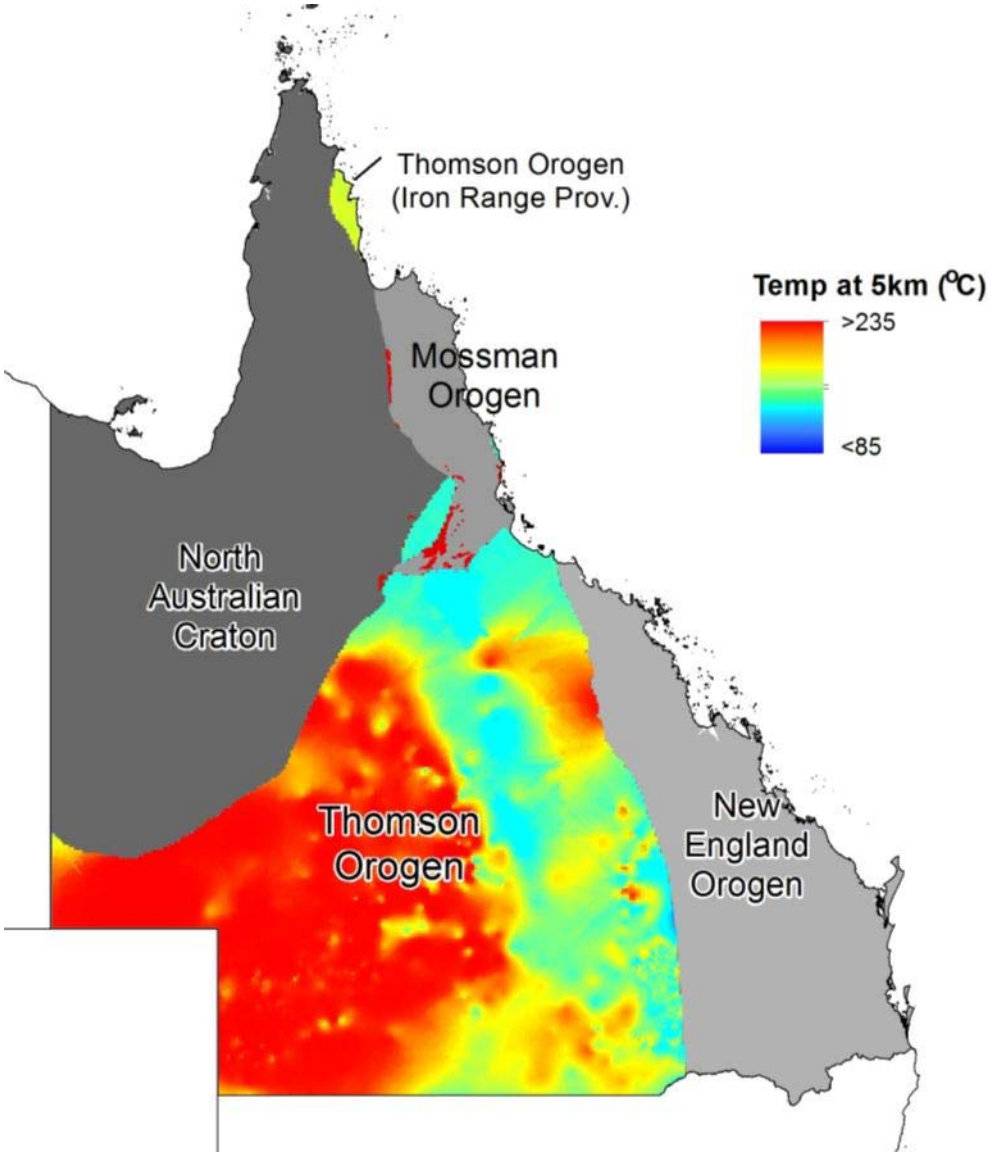
VMS – Balcooma, Thalanga, Dry River, Highway-Reward

Gold – Charters Towers, Ravenswood, Mt Wright

Porphyry – Anakie Inlier e.g. Anthony, Rosevale

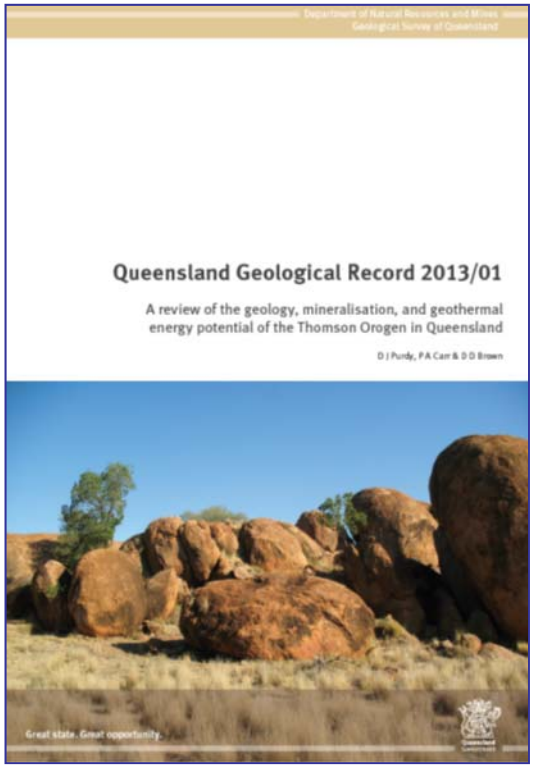
Gold – Granite Springs

Background

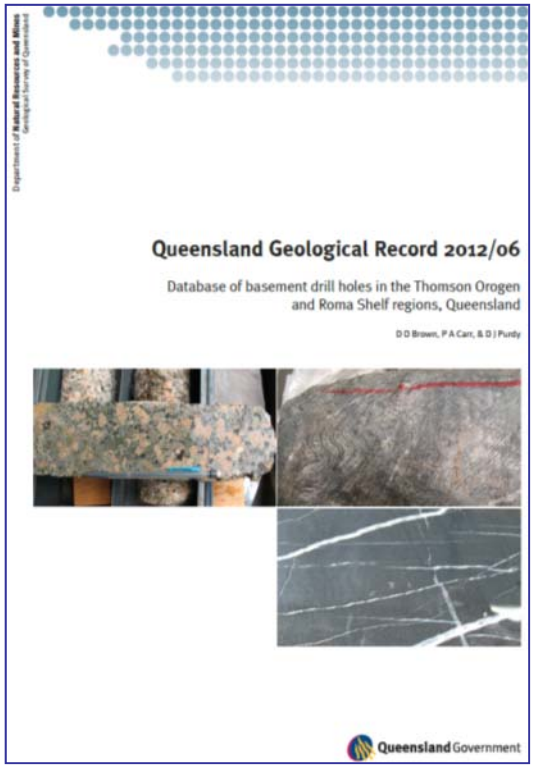


OzTemp (GA) - 2005

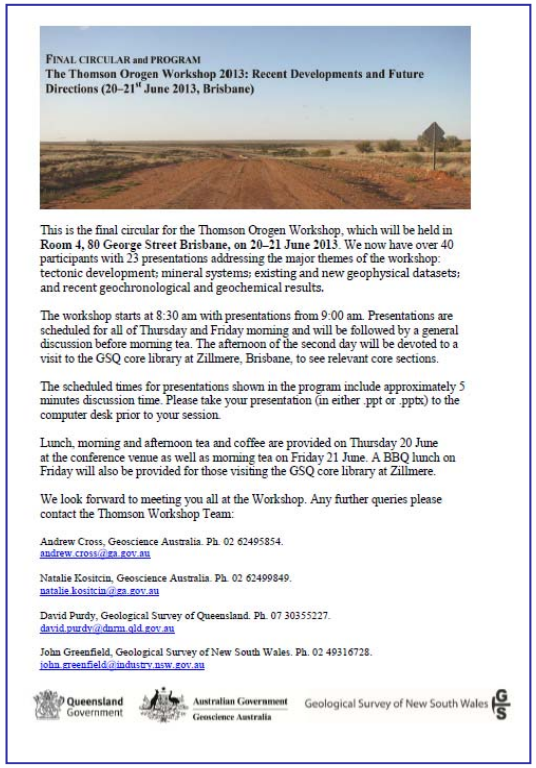
Outcomes



Review

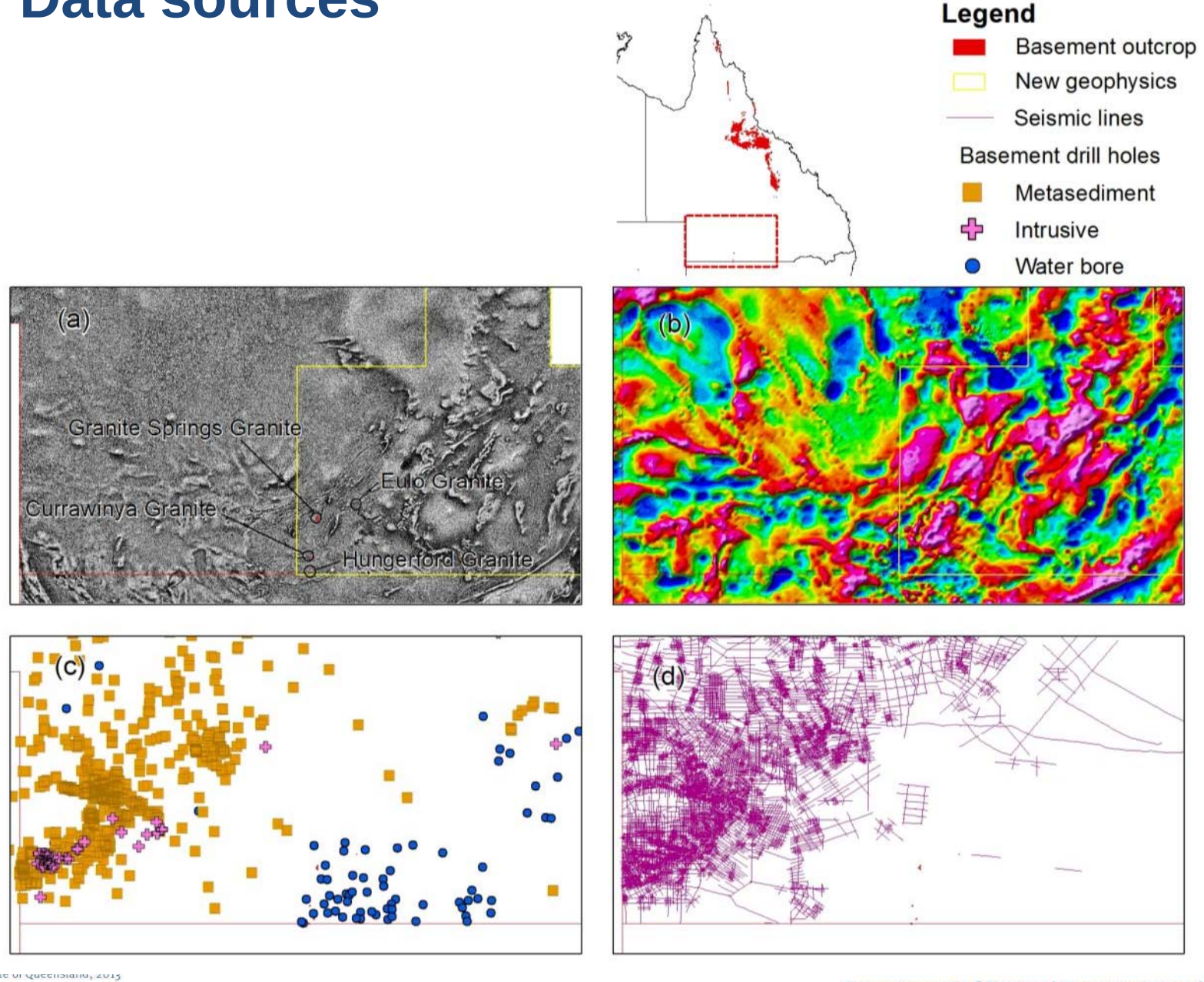


Drill hole database

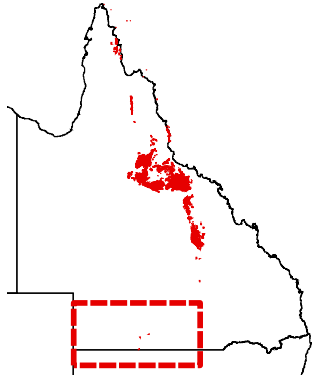


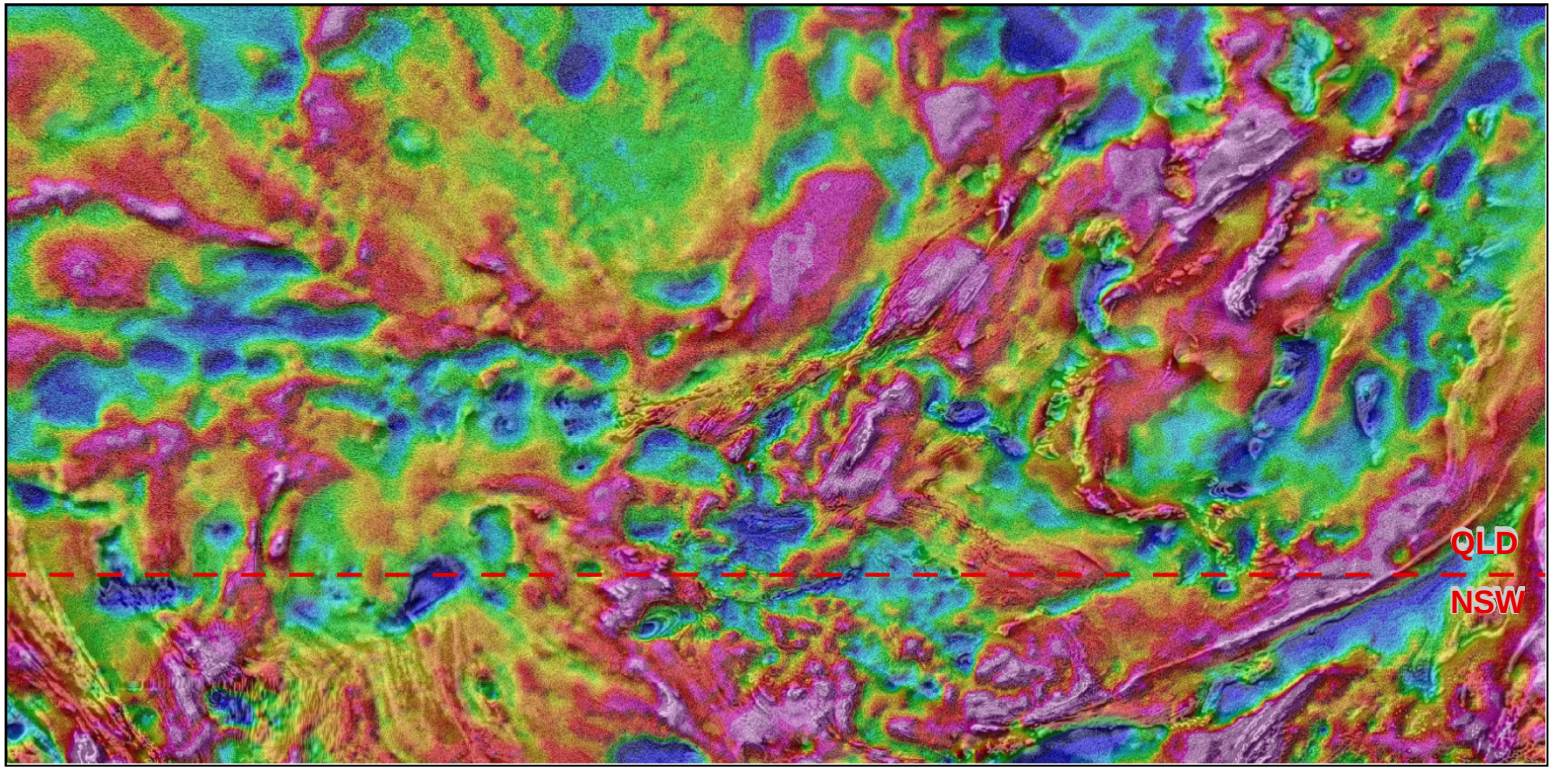
Workshop

Data sources



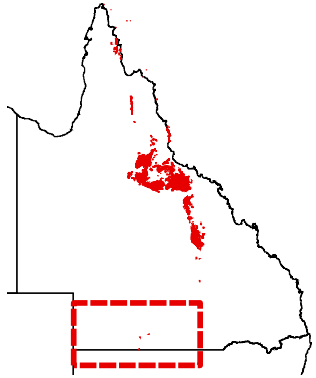
Interpretations

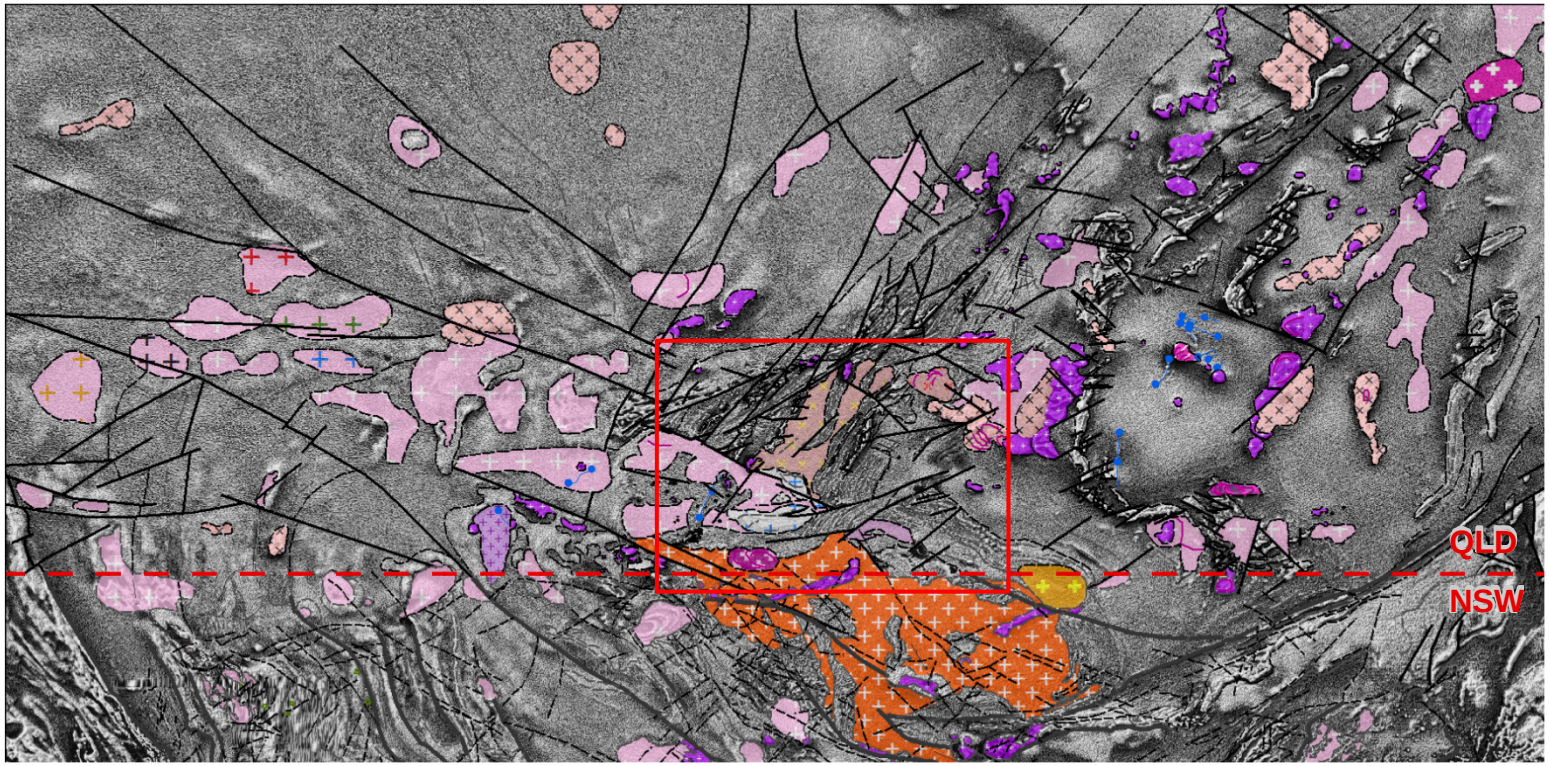


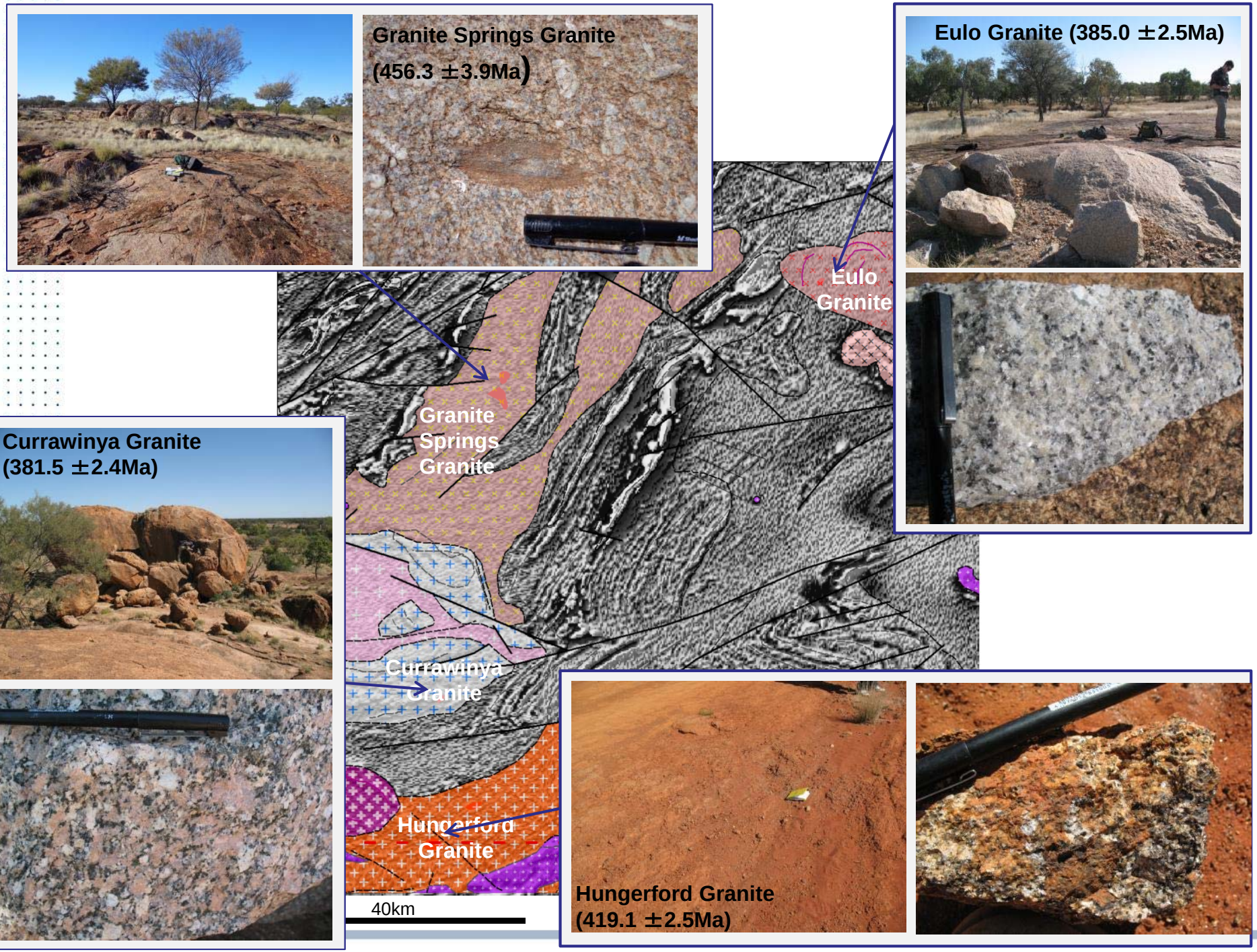


Interpretations

- Intrusive units

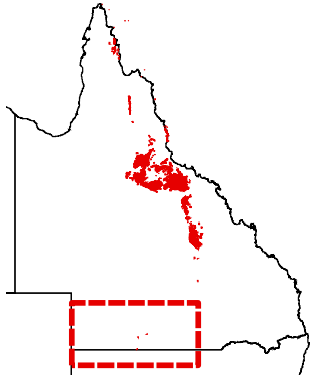


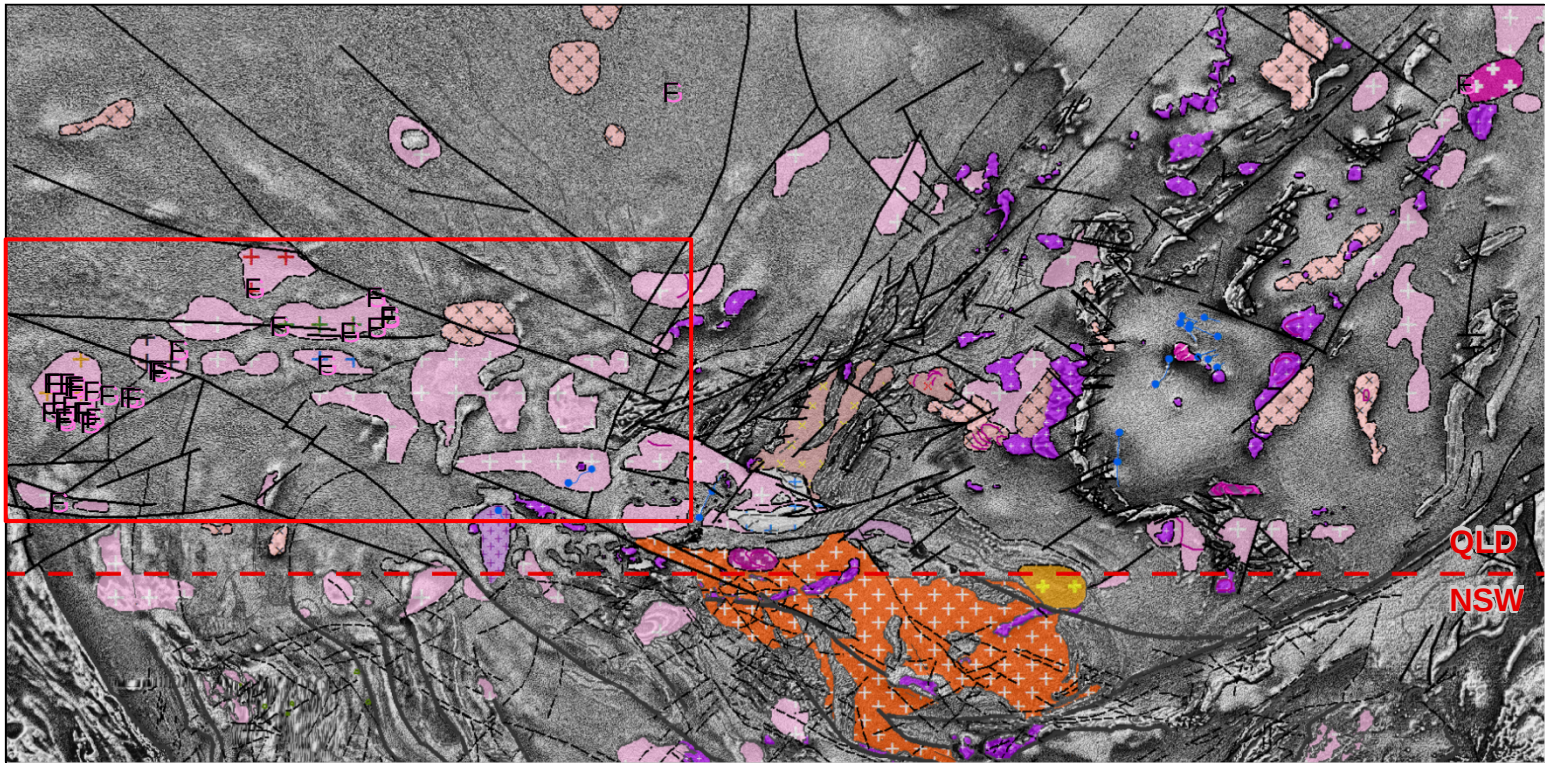



Granite Springs Granite
(456.3 ±3.9Ma)
Eulo Granite (385.0 ±2.5Ma)
Eulo Granite
Granite Springs Granite
Currawinya Granite
(381.5 ±2.4Ma)
Currawinya Granite
Hungerford Granite
40km
Hungerford Granite
(419.1 ±2.5Ma)

Interpretations

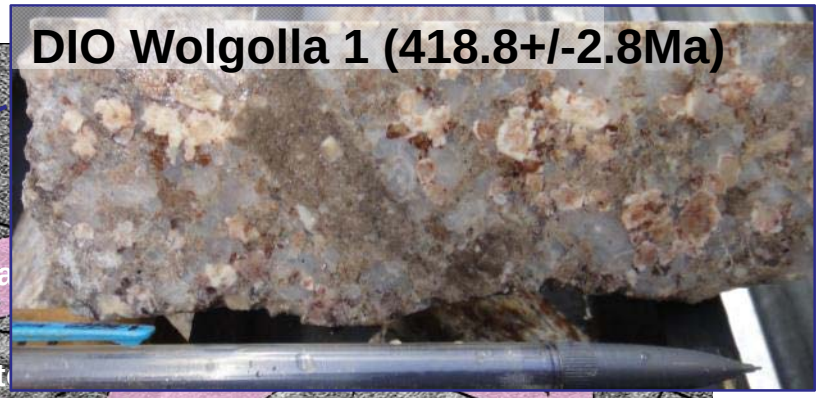
- Intrusive units - undercover





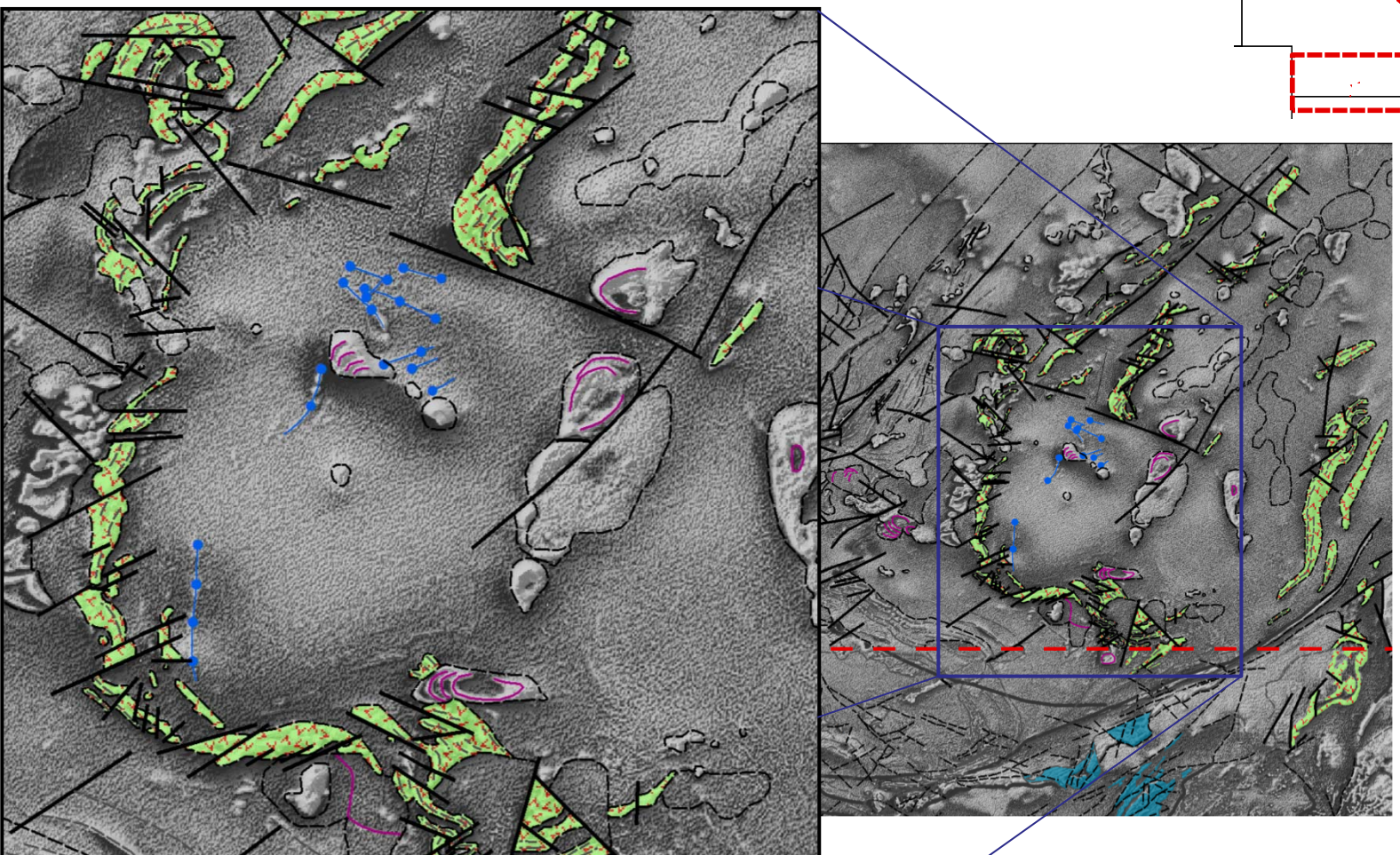
Interpretations

- Intrusive units - undercover



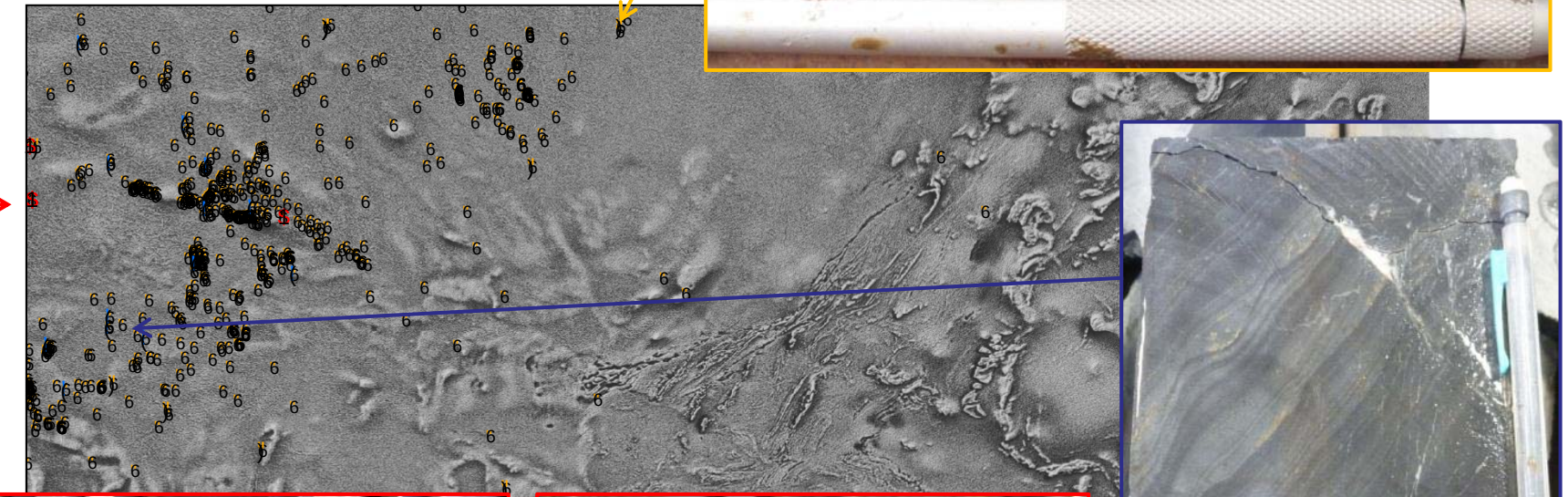
Interpretations

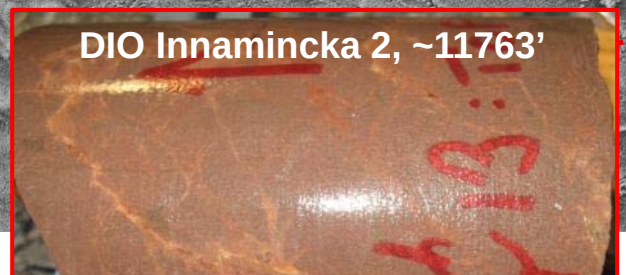
- Metavolcanic? units



Interpretations

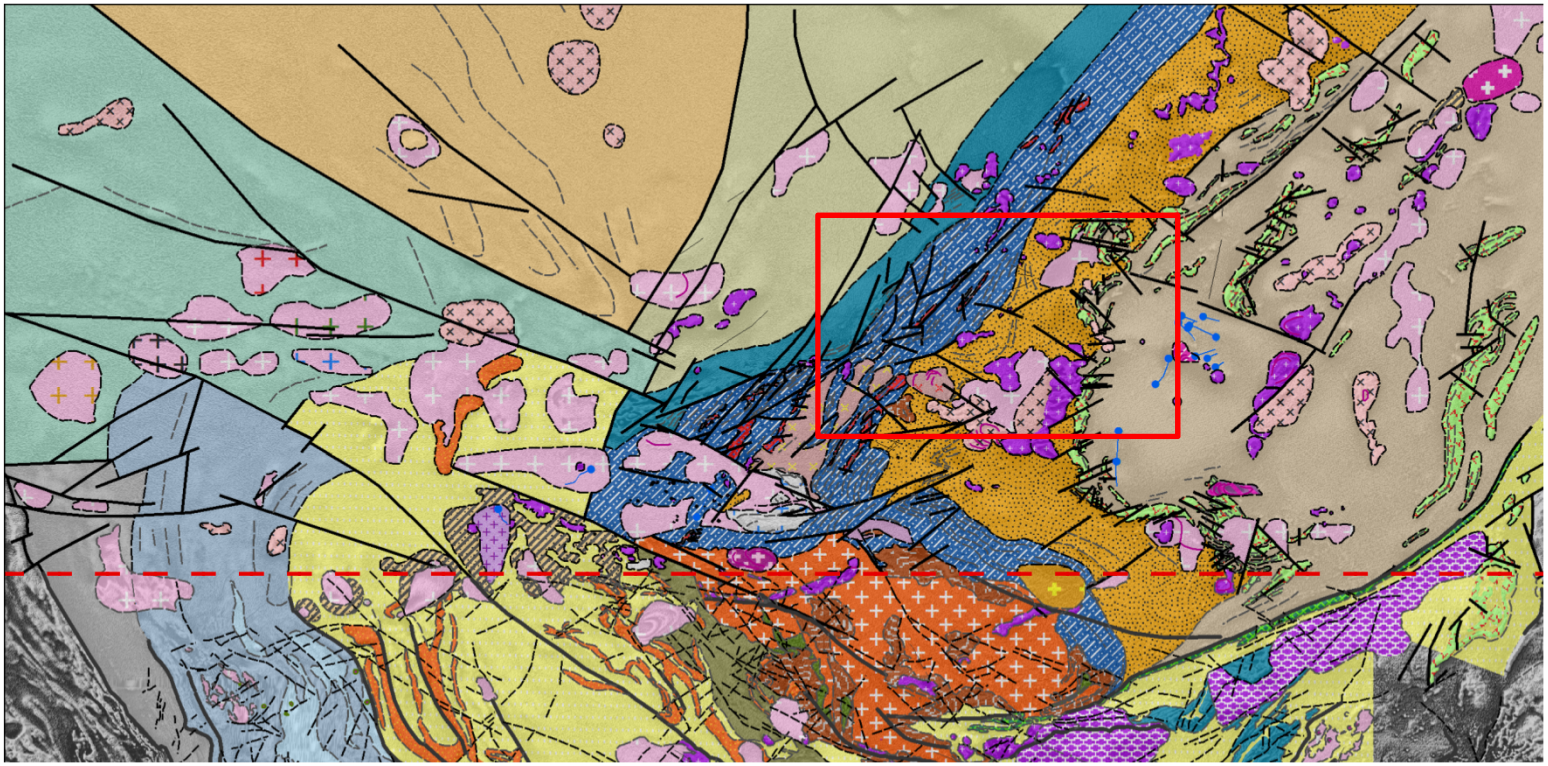
- Metasedimentary units





Interpretations

- Metasedimentary units

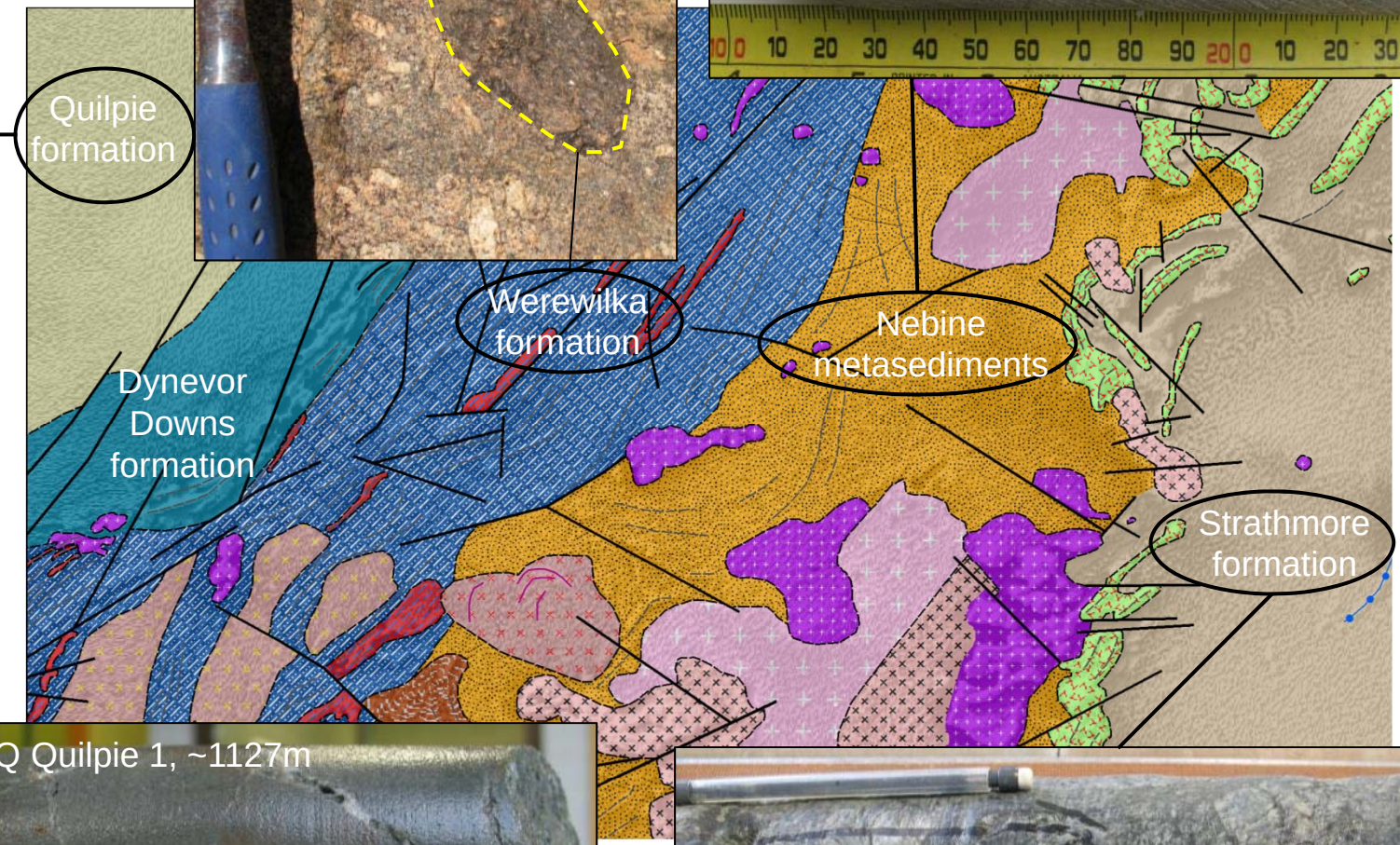


Interp

- Meta

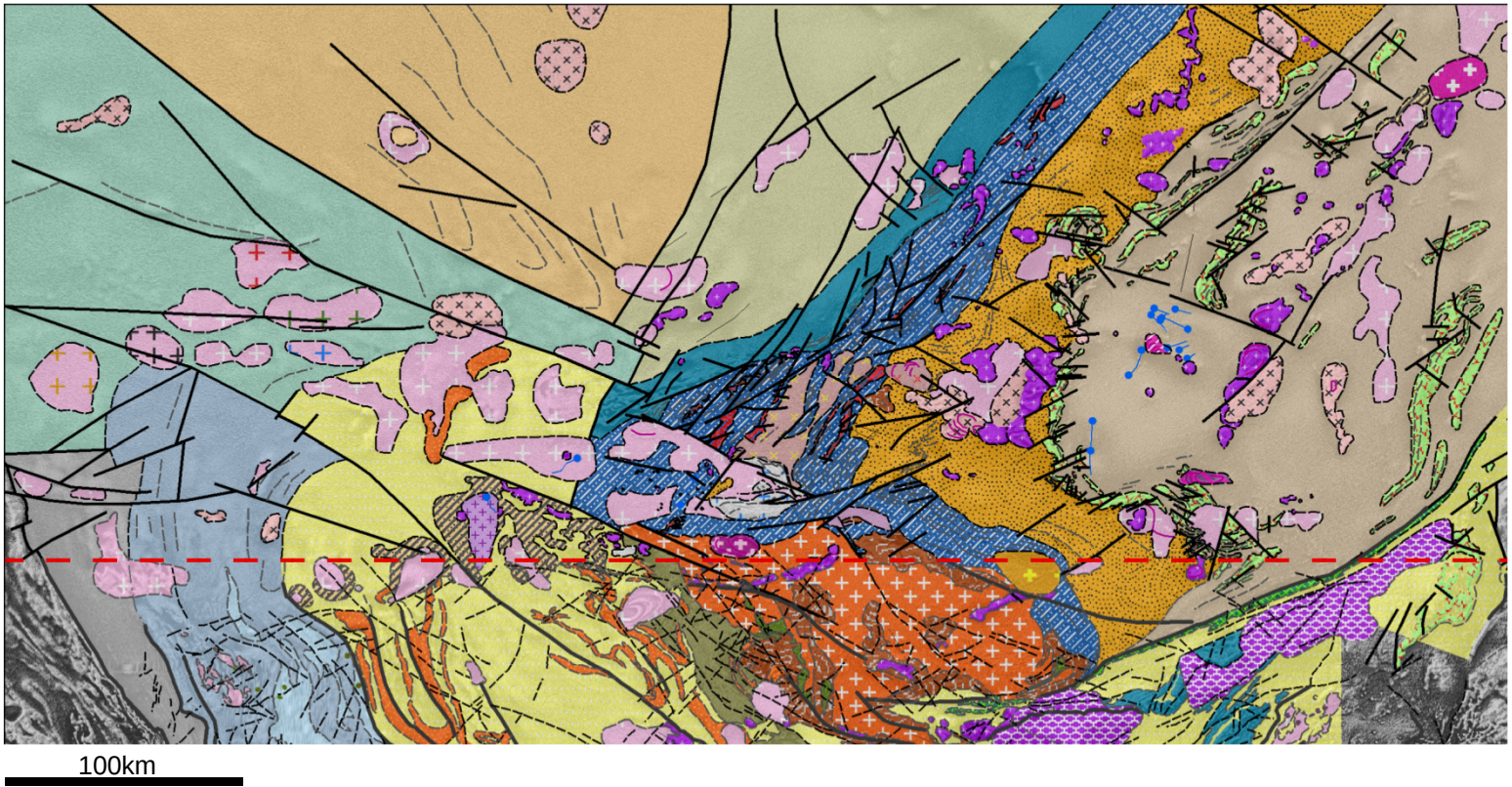

Xenolith Granite Springs
Granite outcrop


AOP Alba 1, ~2713’


Quilpie formation
Werewilka formation
Nebine metasediments
Dynevor Downs formation
Strathmore formation

Q Quilpie 1, ~1127m

Conclusions



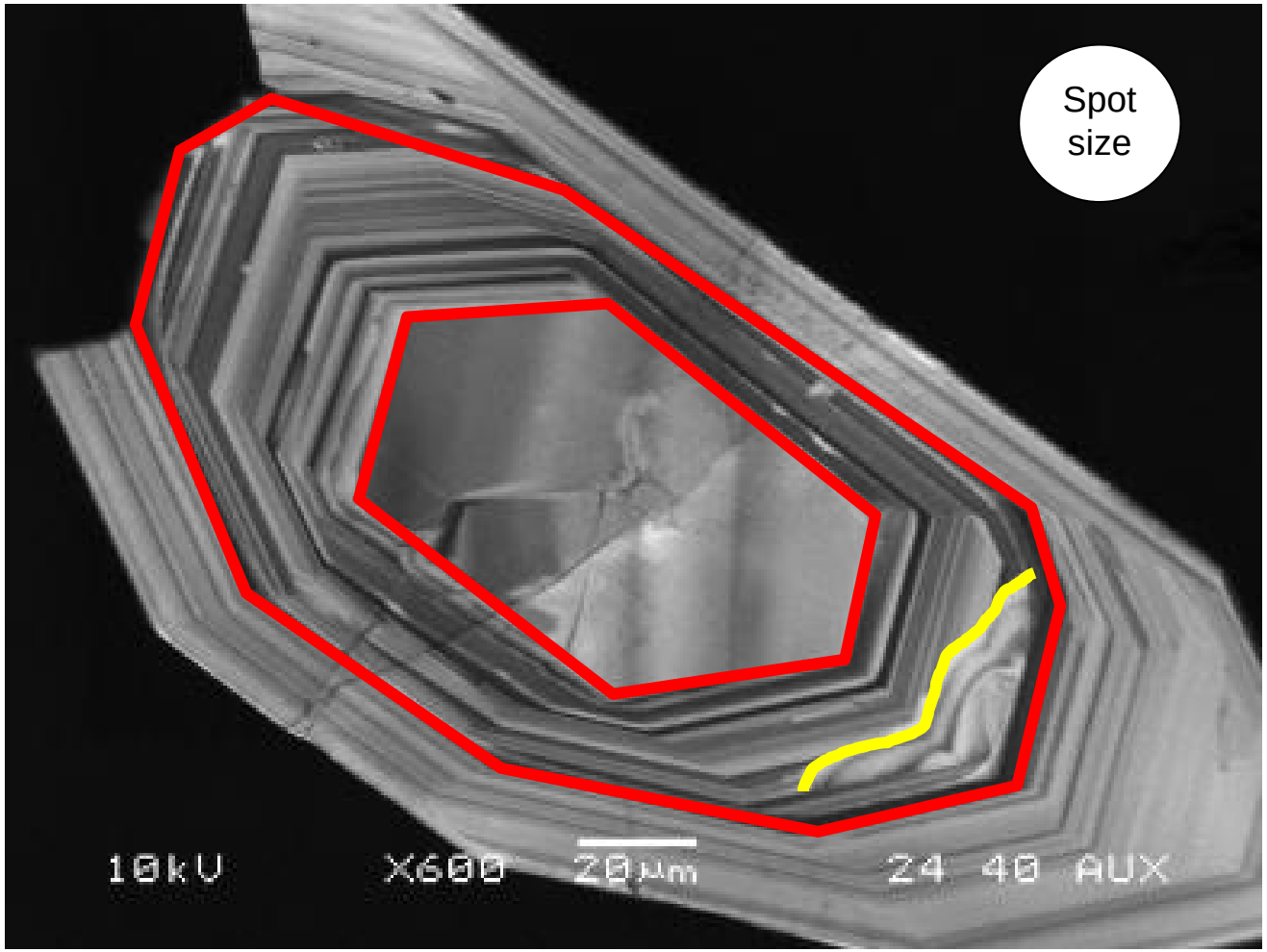
Tracking sediment sources of the Thomson Orogen and the implications for tectonic development of the Tasmanides

Patrick Carr, David Purdy and Dominic Brown - GSQ

Andrew Cross and Natalie Kositcin - GA

Australian Government
Geoscience Australia

What can zircons tell us?

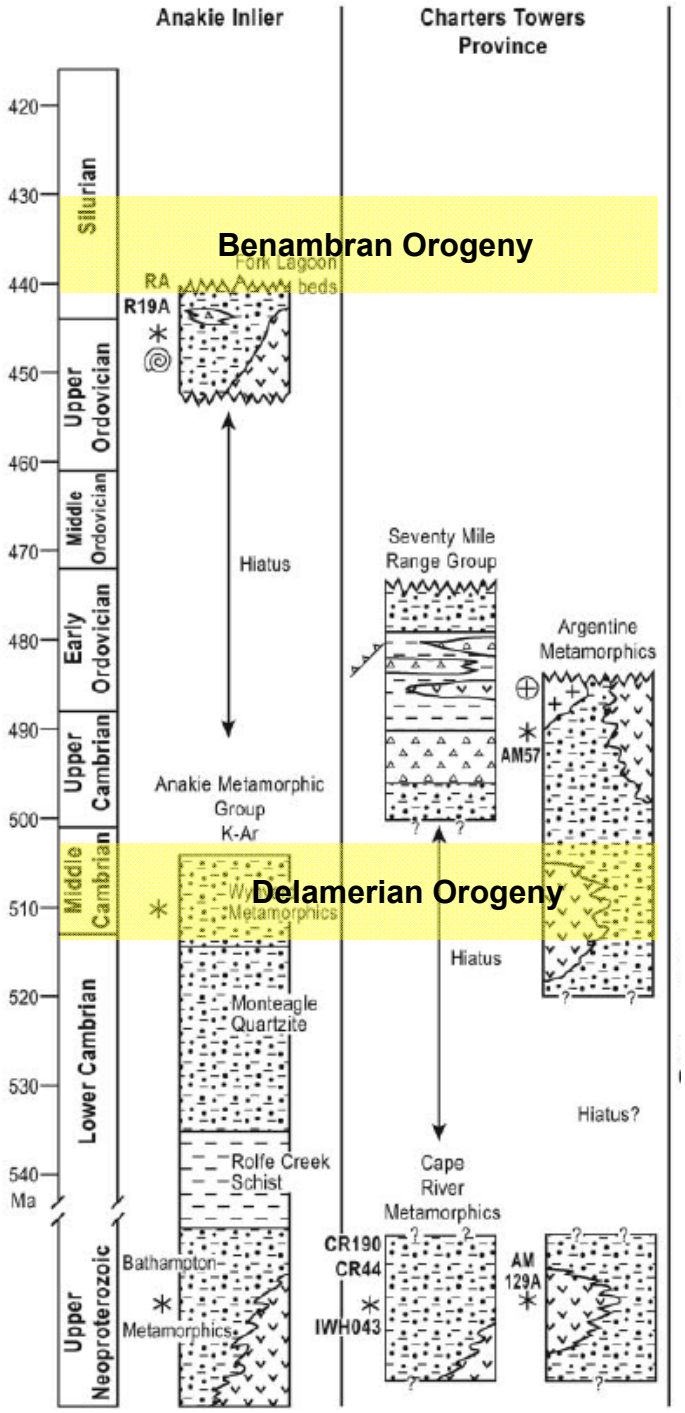


Thomson Orogen U-Pb detrital zircons

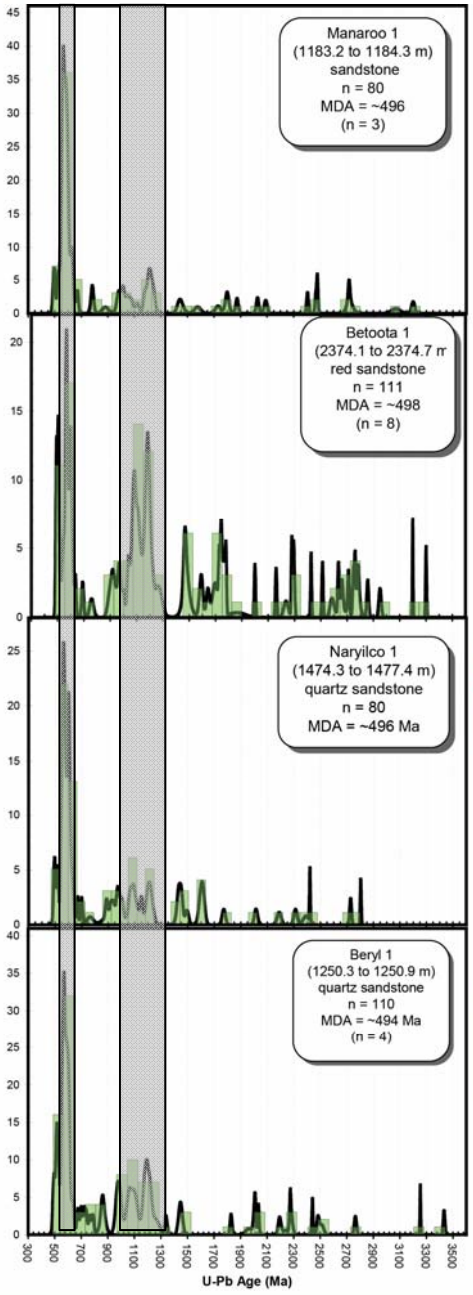
Fergusson et al. (2007) identified two principle successions based on their detrital zircon U-Pb signature.

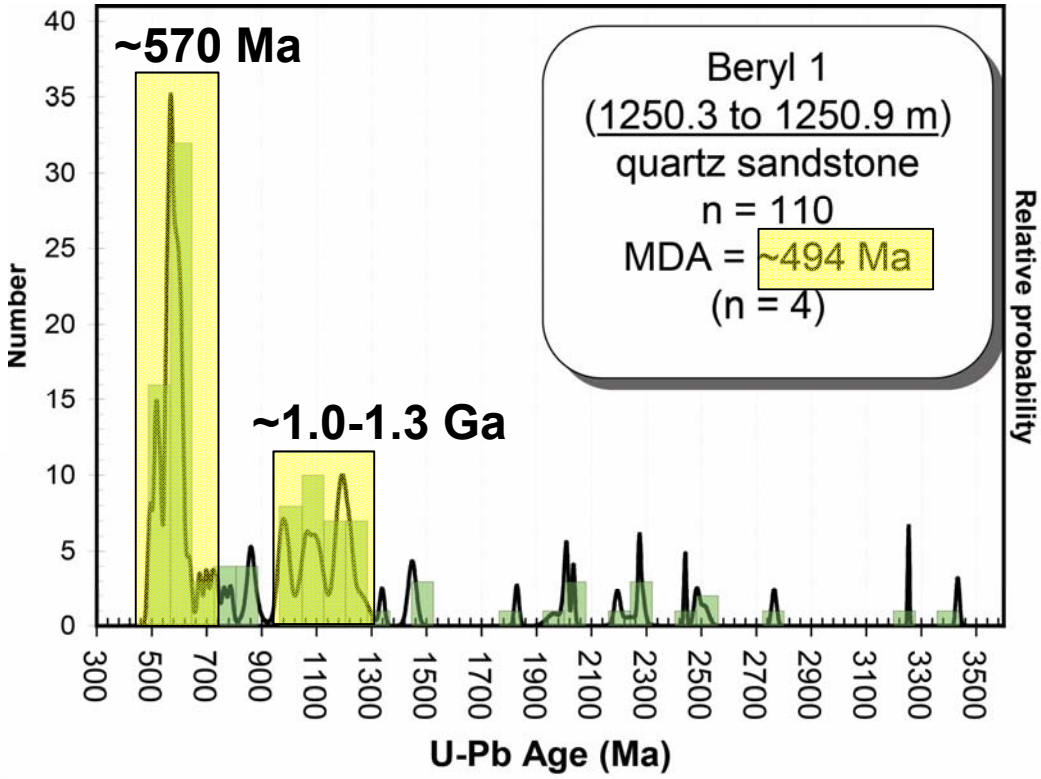
1. An older succession dominated by Grenvillian aged zircons (1300 to 1000 Ma) interpreted as a passive margin unit associated with rifting at ~600 Ma. (Older succession)

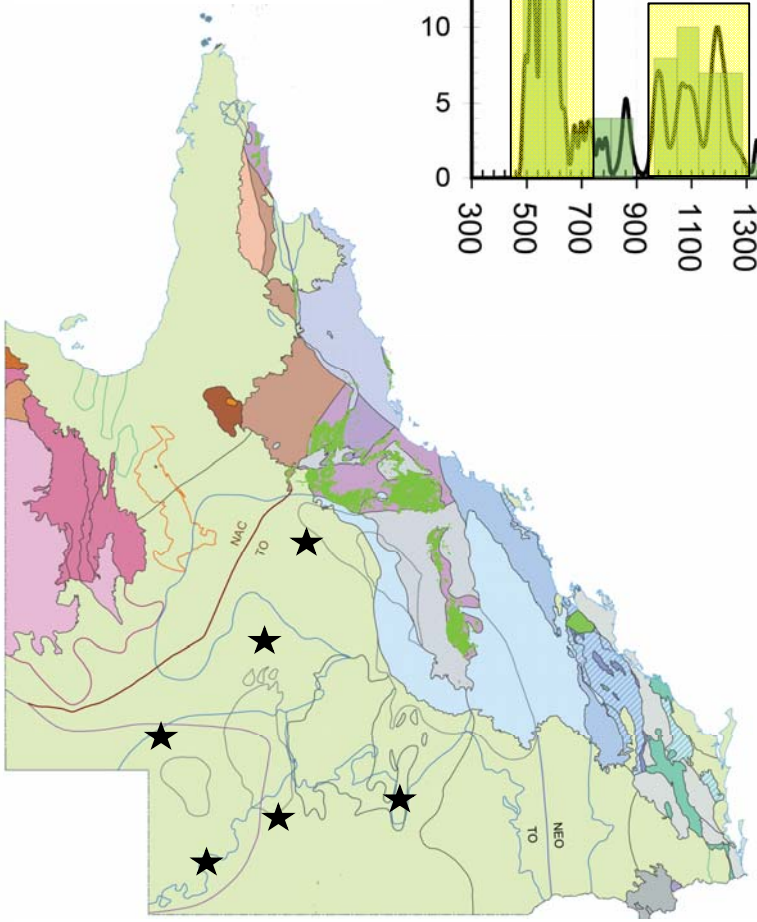
2. Younger, Early Palaeozoic succession with a distinctive 600 to 500 Ma detrital zircon signature, related to an active Gondwana margin. (Gondwana succession)



Pan-Gondwana succession



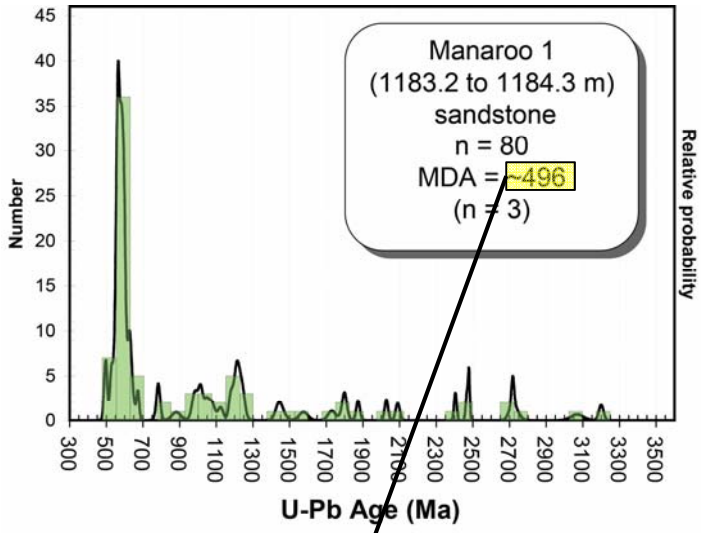




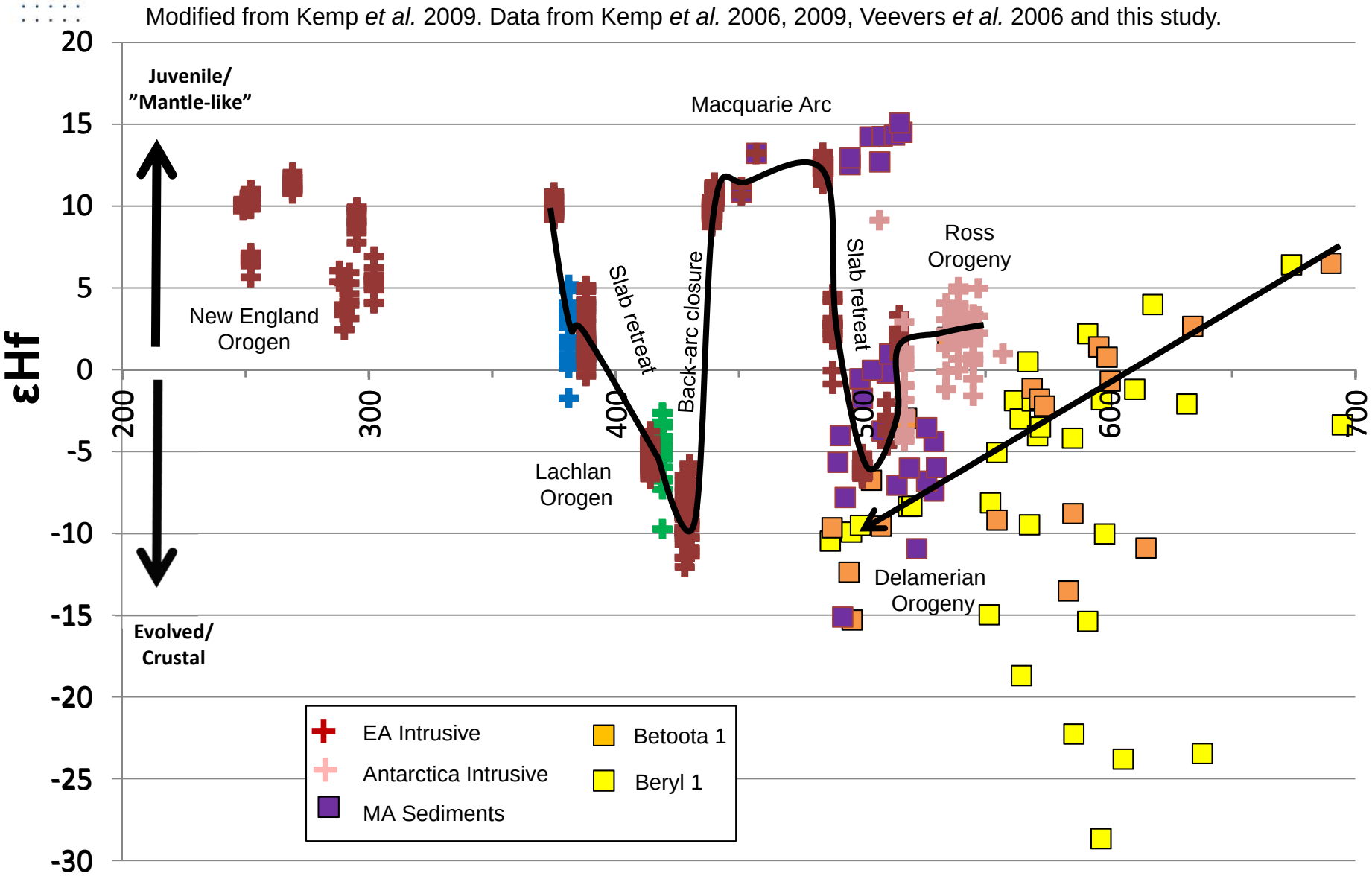
Minimum age constraint

472.9 ± 2.7
(Draper 2006)

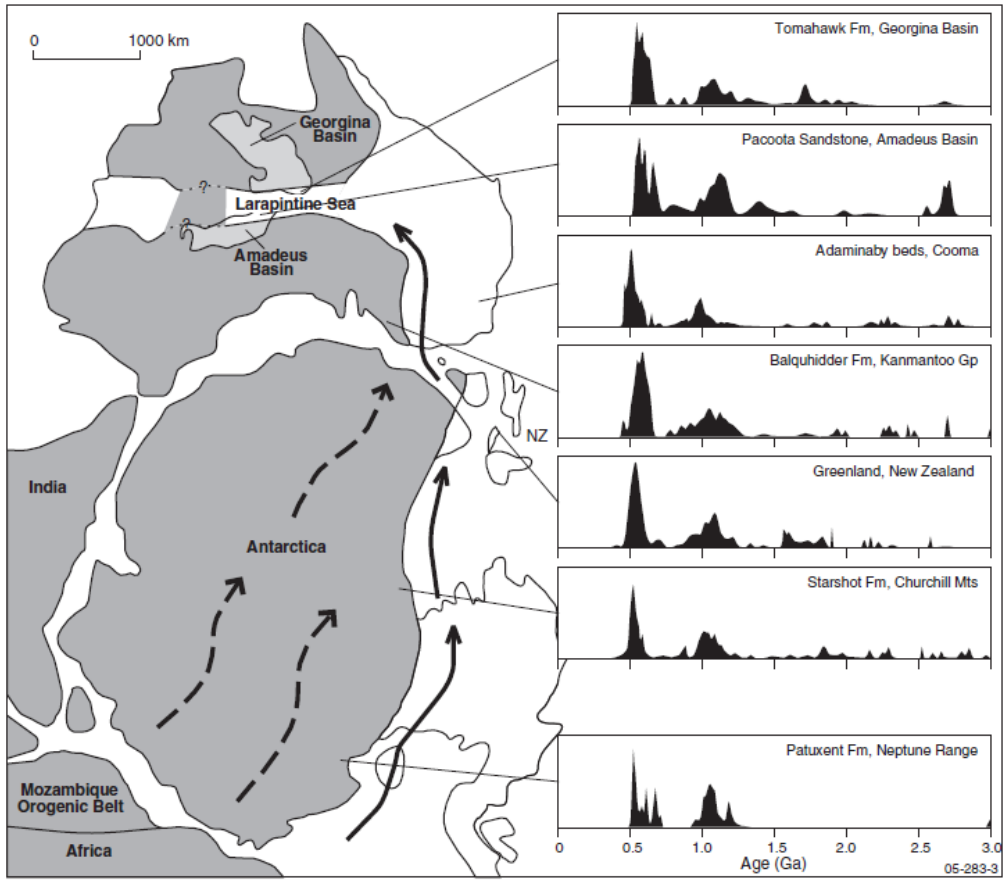
~25 million year period



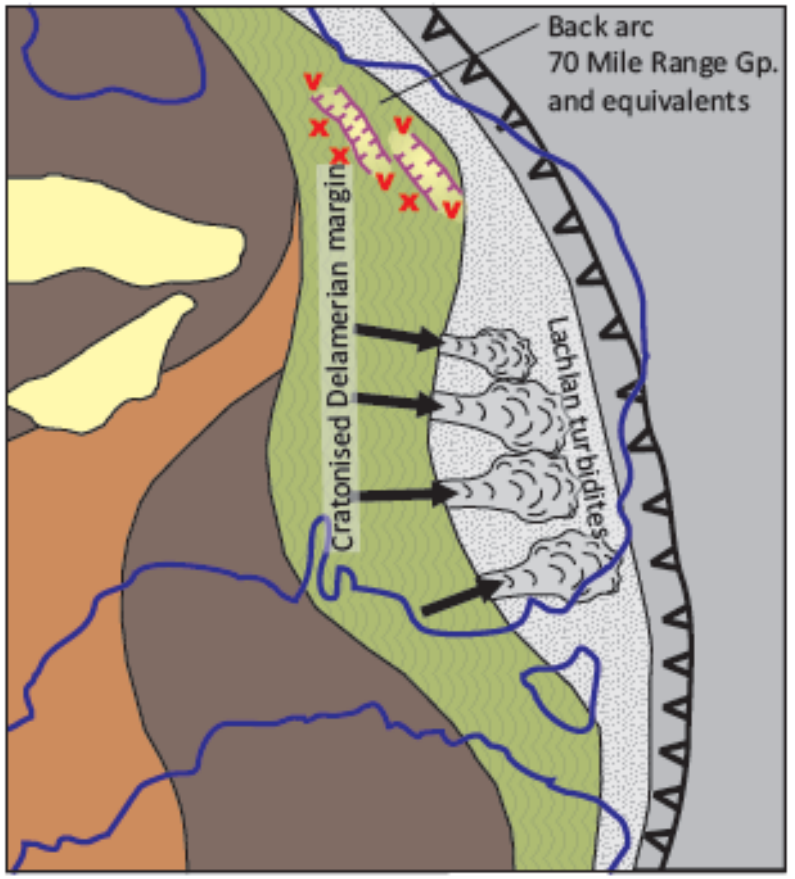
Eastern Gondwana Hf signatures



Provenance models: foreign vs local source

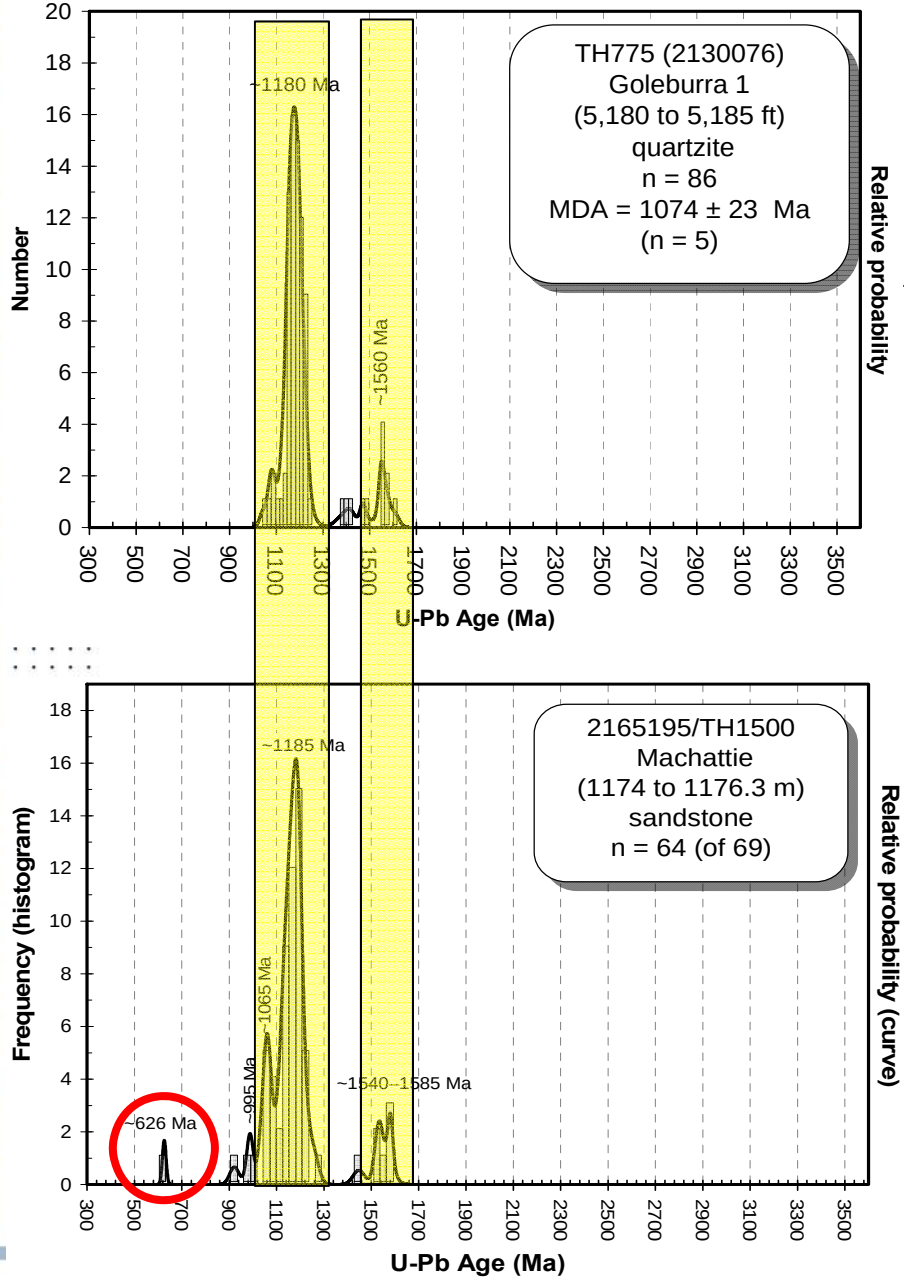


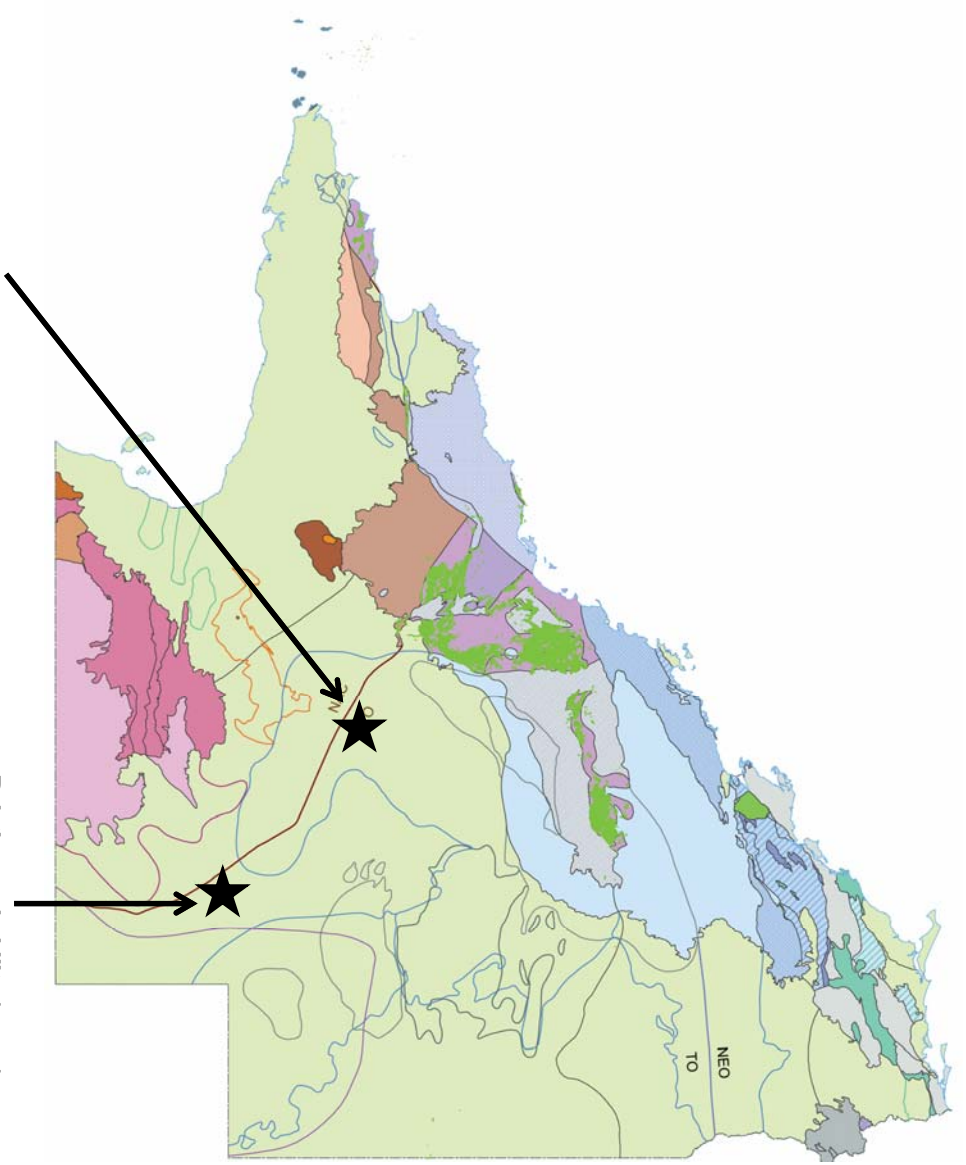
Maidment *et al.* 2007



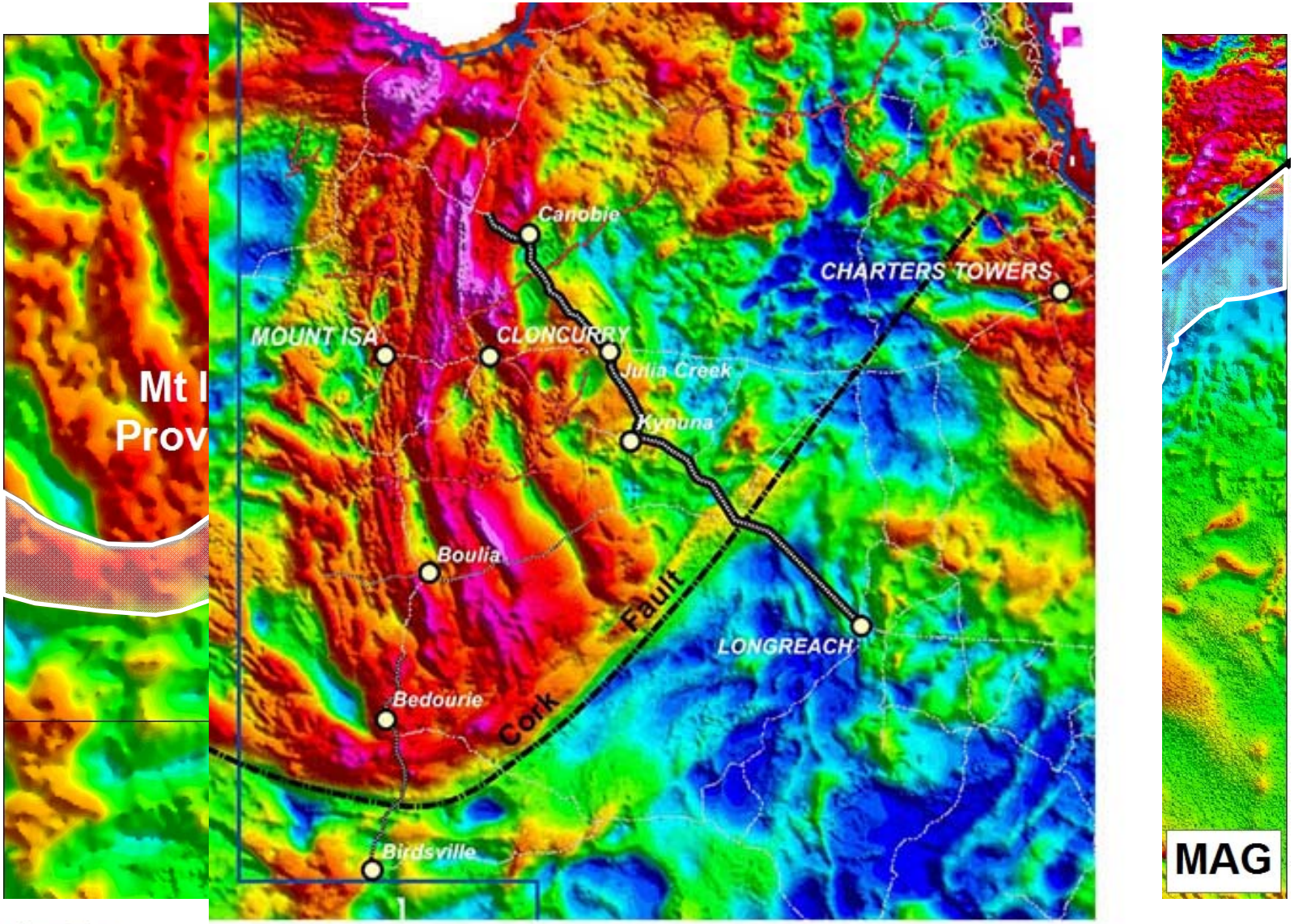
Fergusson *et al.* 2007

Older succession: Grenvillean age

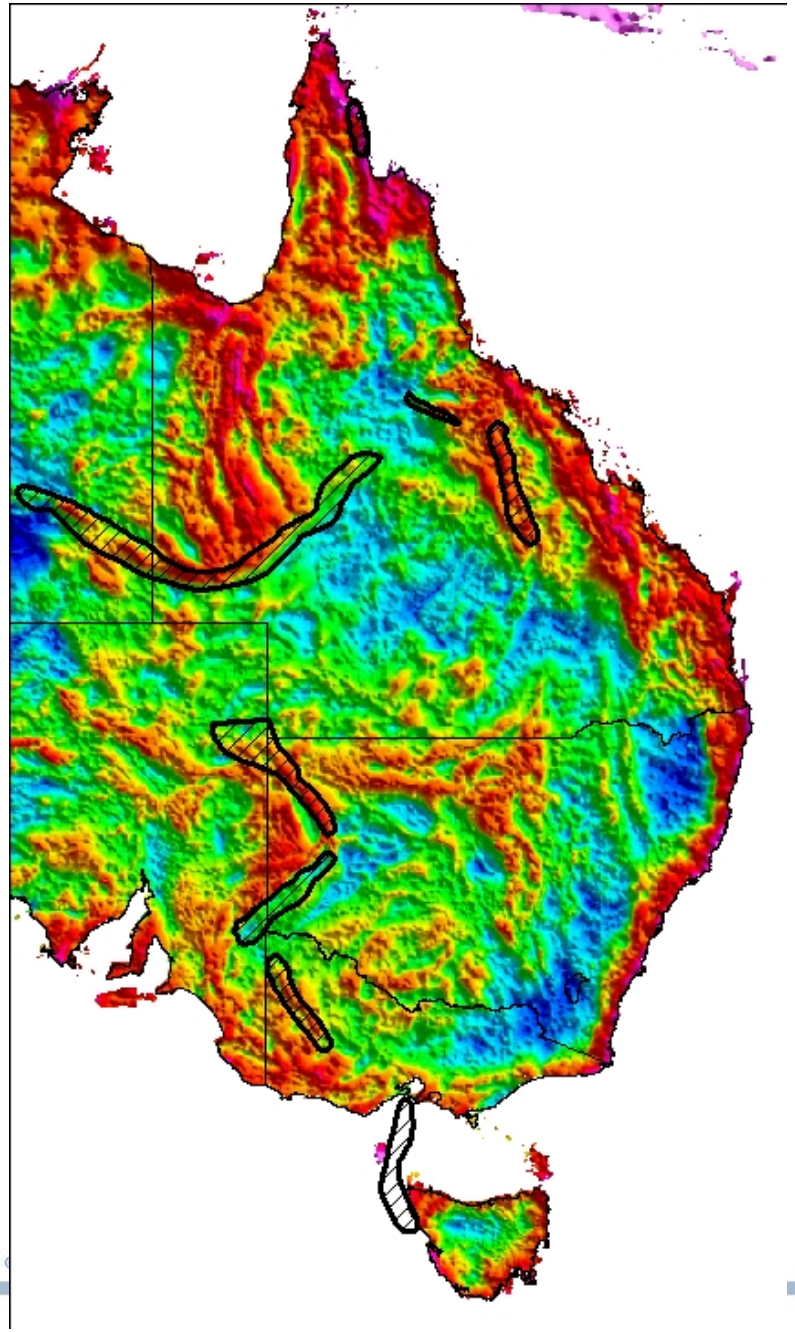


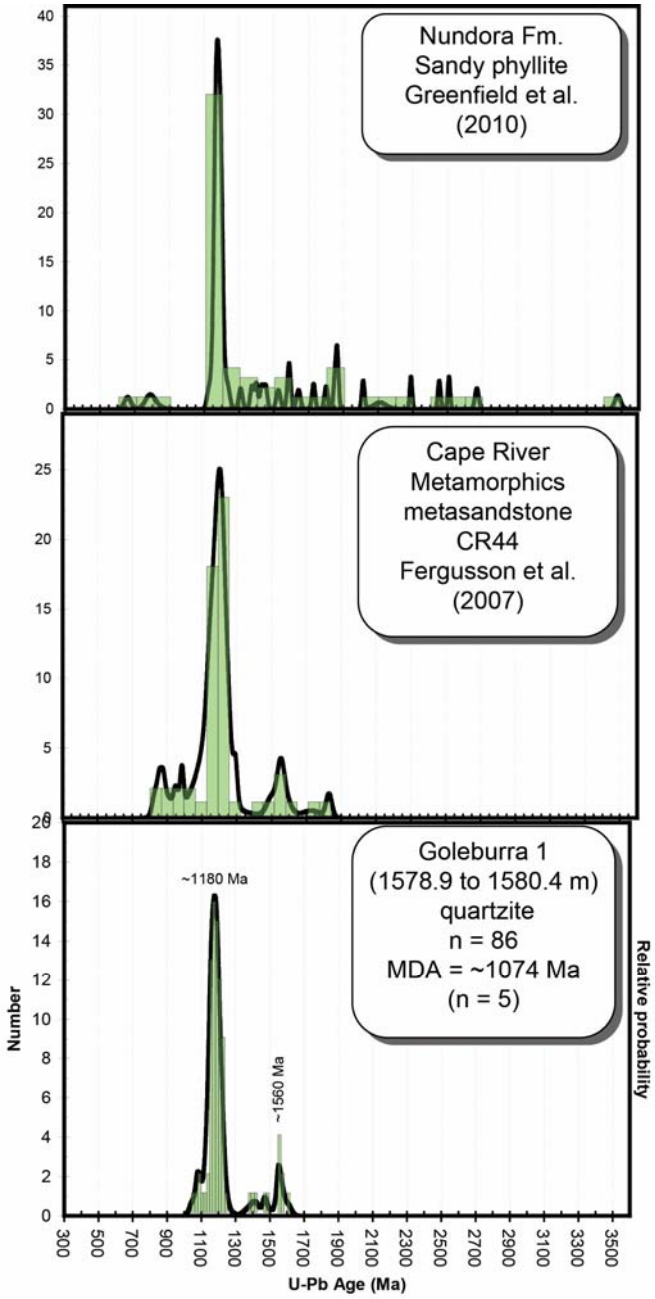


A new crustal domain?

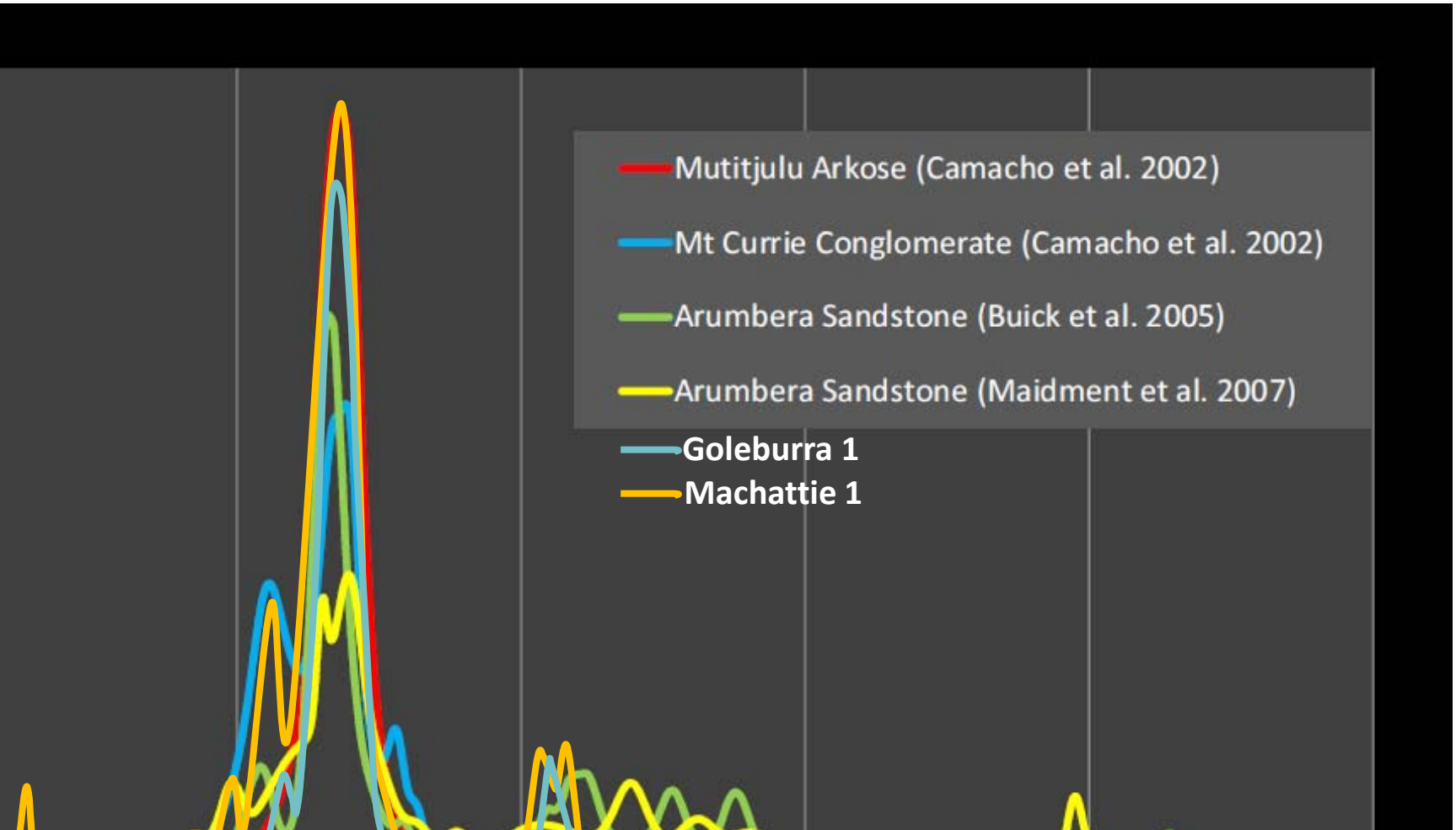


Comparable rocks in Eastern Australia

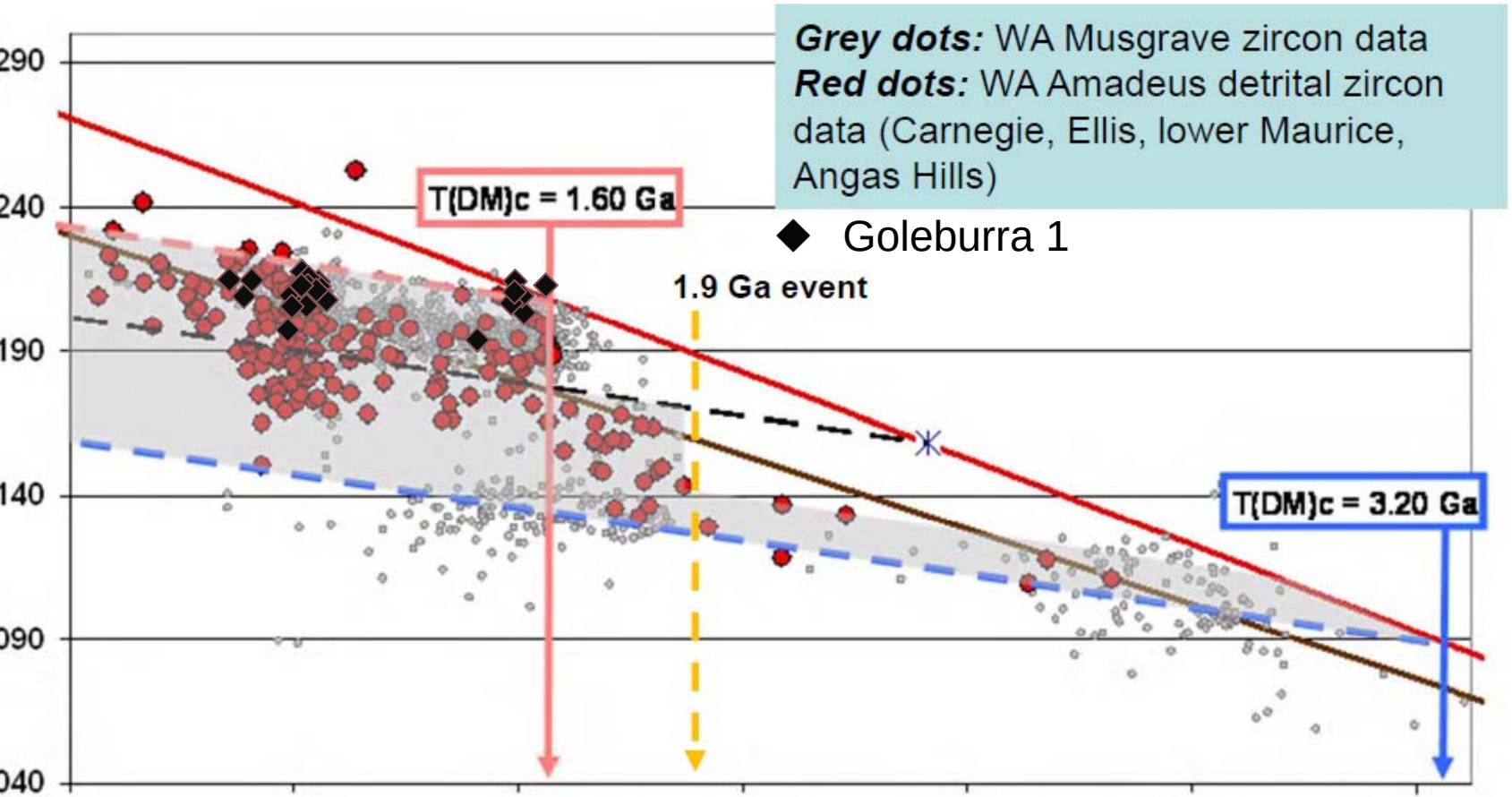




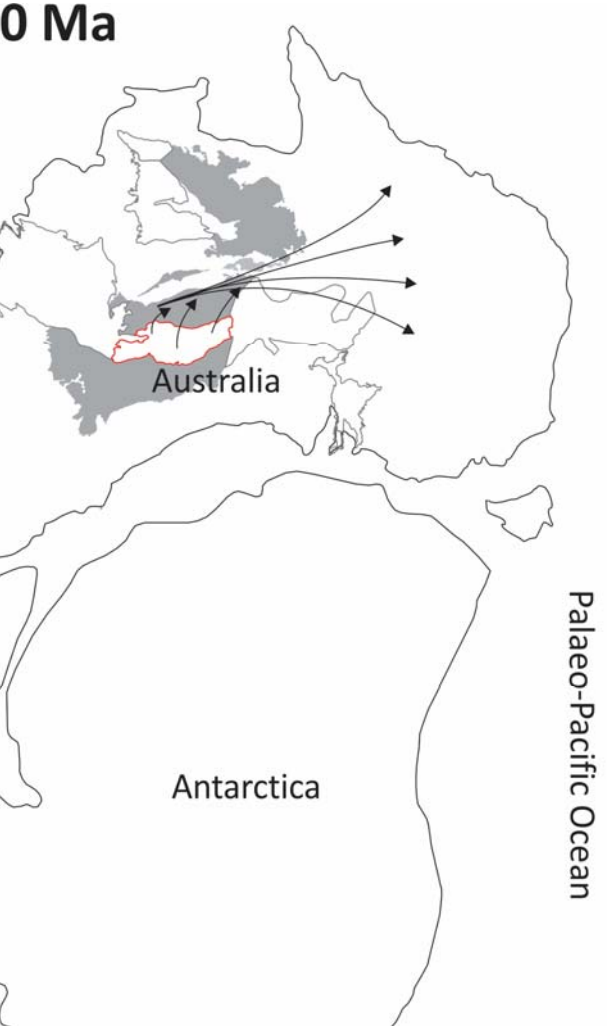
omparable rocks in Central Australia



Hf provenance

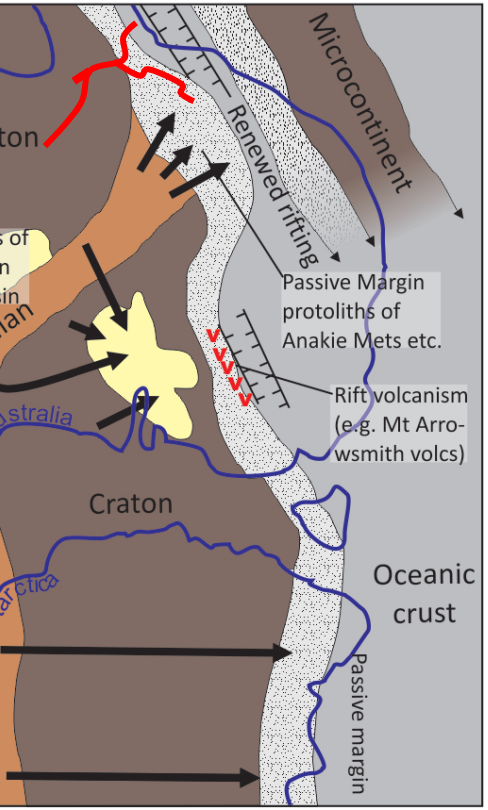


ovenance models: A



- Derived from uplift and erosion of the Musgrave Complex as a result of the 570–530 Ma Petermann Orogeny

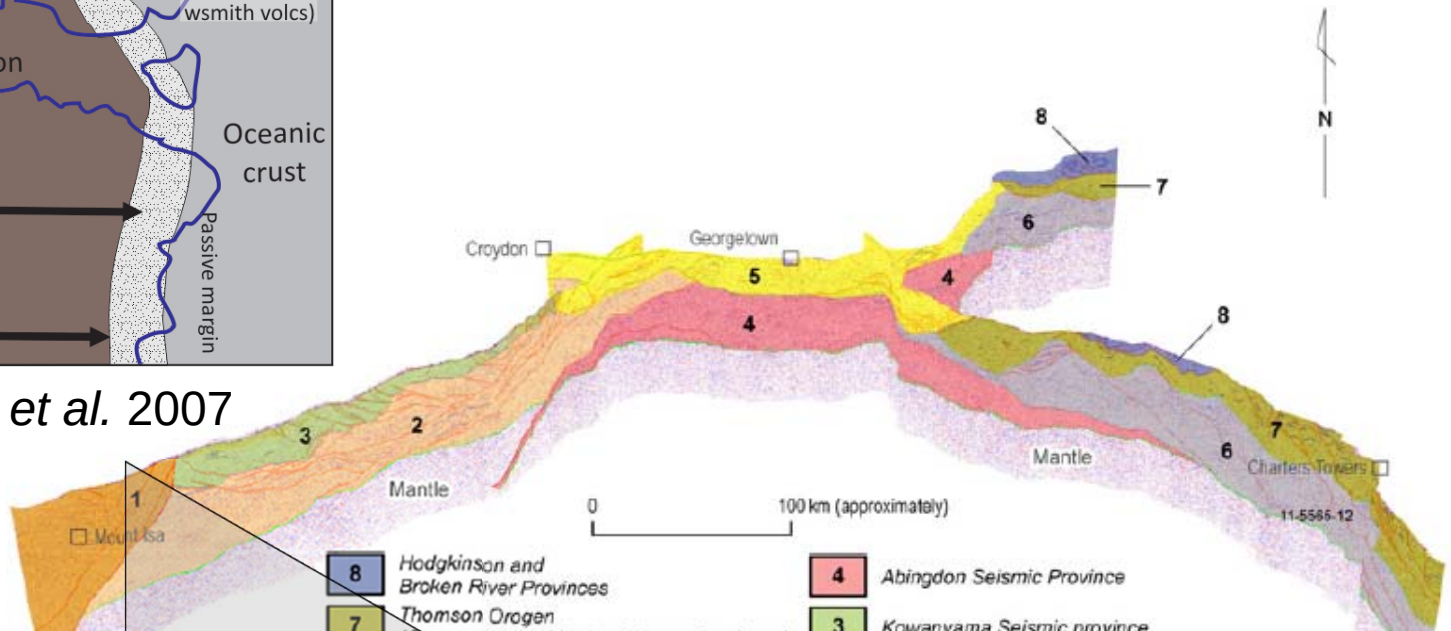
ovenance models: B



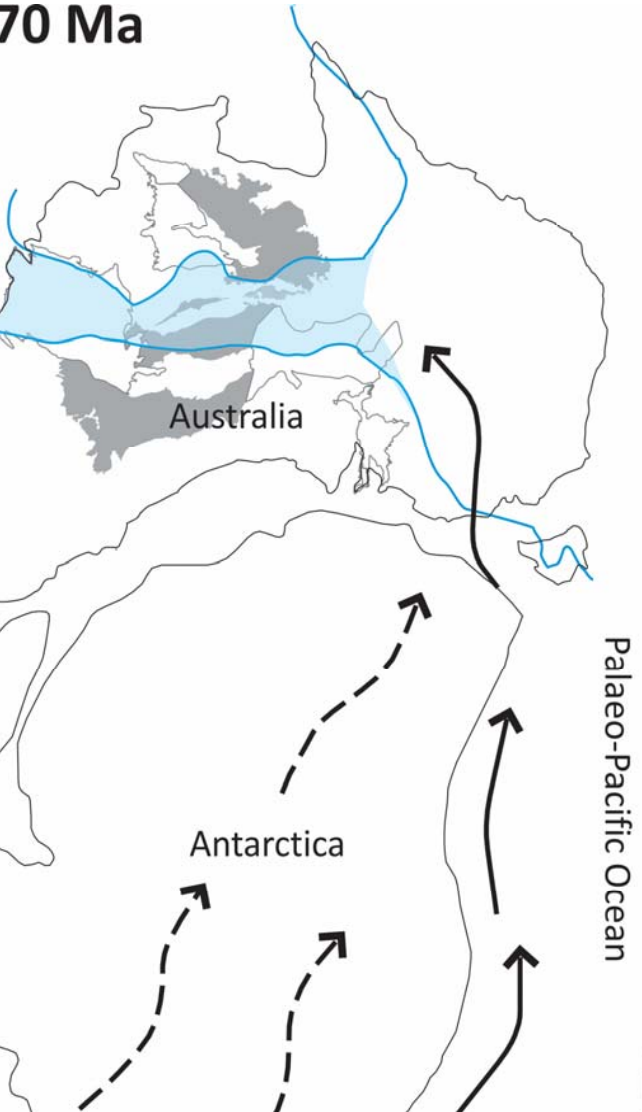
gusson *et al.* 2007

- Derived from an eastern extension of the Musgrave Complex in central Queensland beneath younger cover.

Korsch *et al.* 2012



Summary: sediment provenance



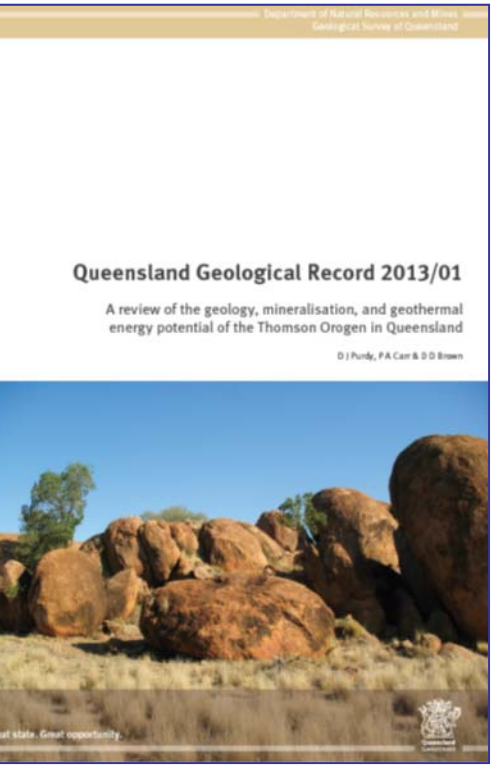
- Uplift and erosion of the Musgrave Inlier ~570–530 Ma – Petermann Orogeny.
- Easterly transportation of sediments into increasingly deeper waters.

- Deformation and minor magmatism of the Delamerian Orogeny and associated Ross Orogeny.

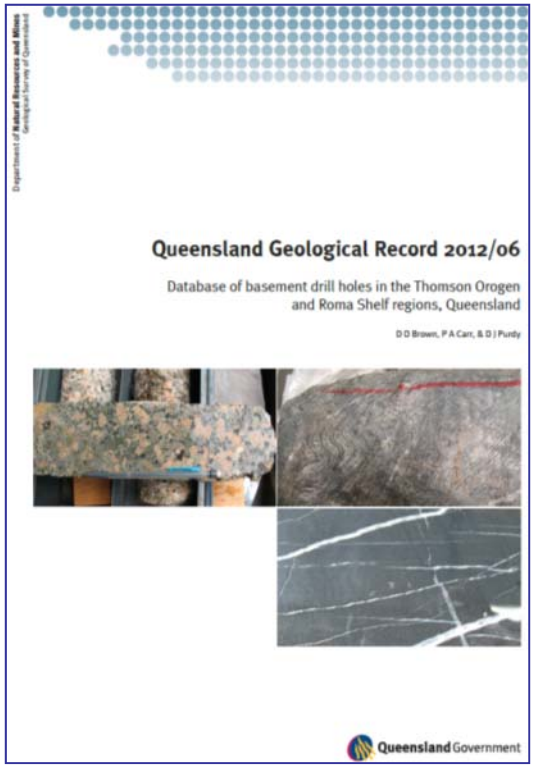
- Development of huge long-shore/fluvial, north directed sediment transport system.

- East-west opening of Larapinta Sea.

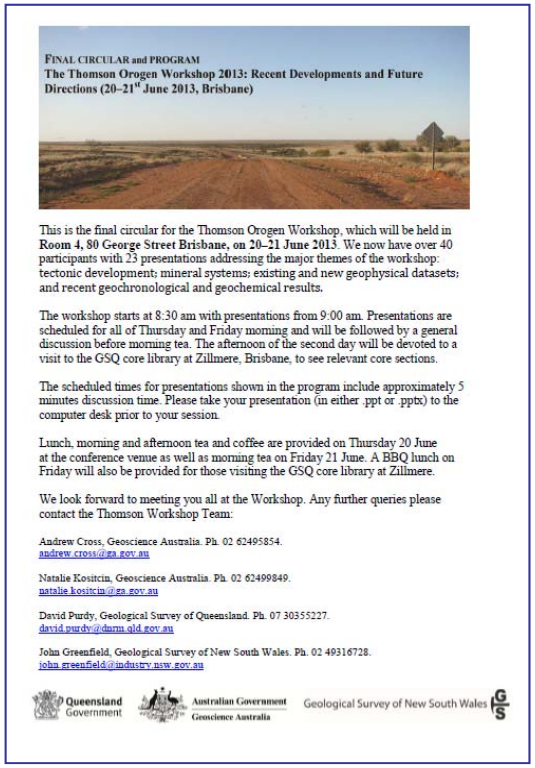
Products



Review



Drill hole database



Workshop

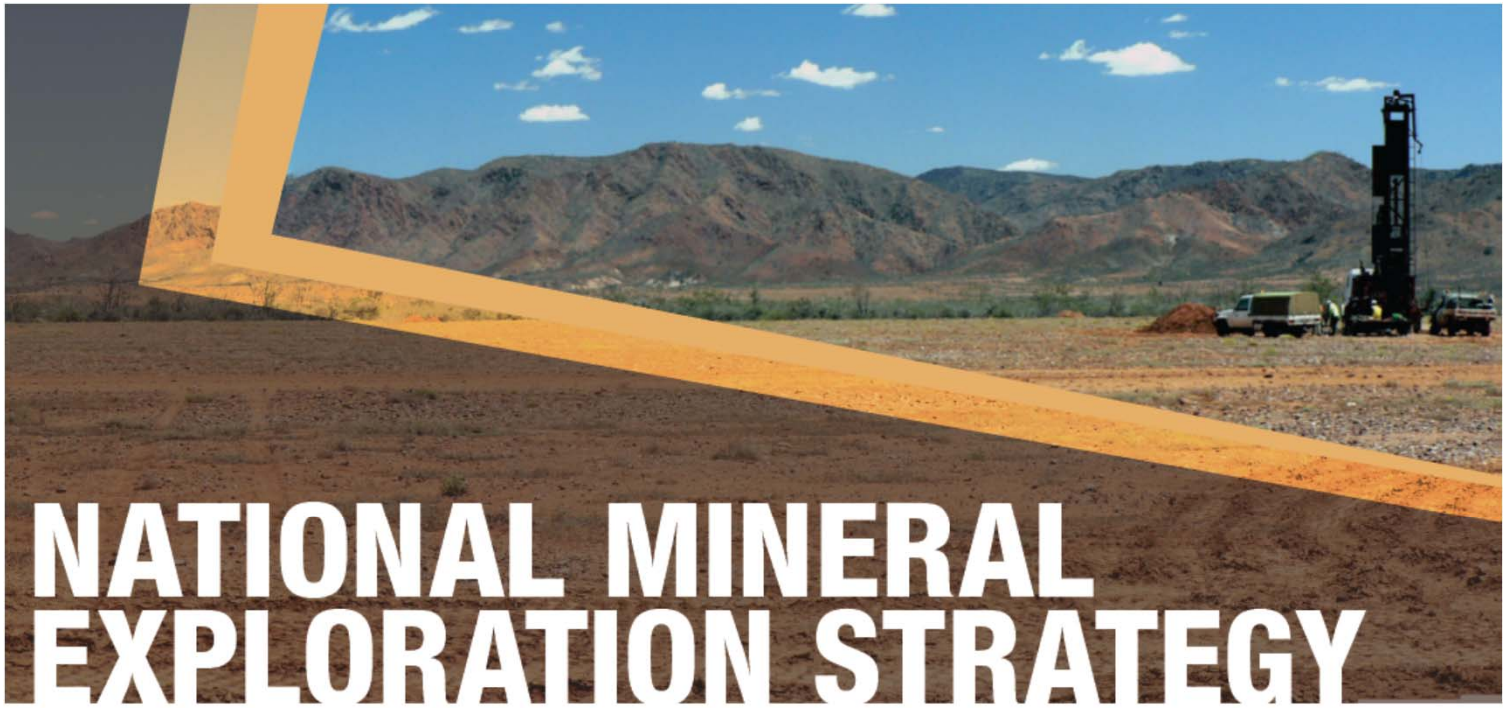
Australian Government
Geoscience Australia

Unlocking the Southern Thomson's hidden mineral resource potential

Richard Blewett

Group Leader: Regional Geology & Mineral Systems

Standing Council Energy & Resources (SCER)
National Mineral Exploration Strategy (2012)



VISION:

Unlocking Australia's hidden resource potential.

MISSION:

To address greenfield exploration challenges, stimulate new discoveries, ensure continuity of the pipeline of mineral resource investments, and the longevity of Australia's mineral resources industry.

Three elements to National Mineral Exploration Strategy

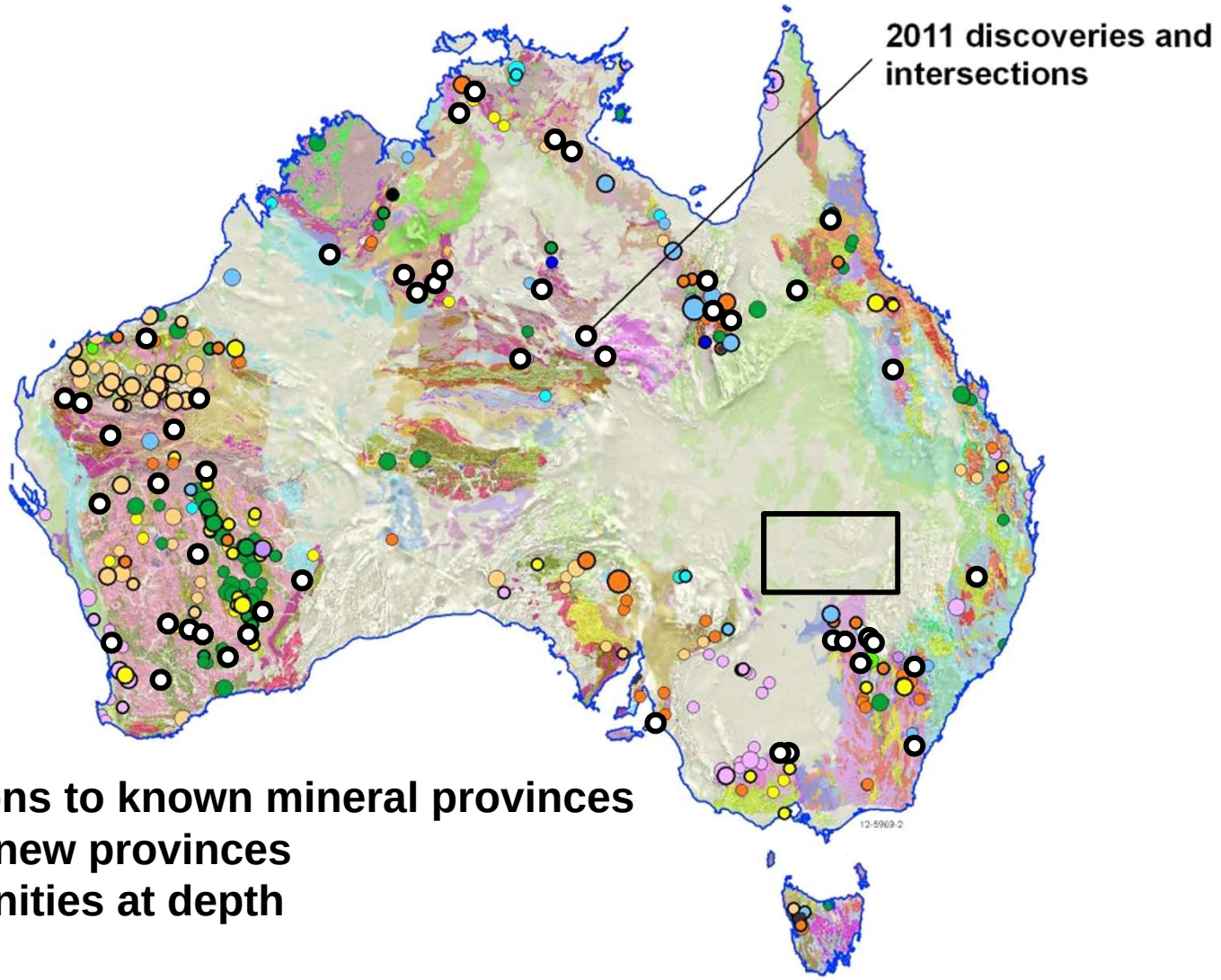
THE THREE ELEMENTS OF THE NATIONAL MINERAL EXPLORATION STRATEGY ARE:

PRE-COMPETITIVE
GEOSCIENCE INFORMATION

MINERAL EXPLORATION
INVESTMENT ATTRACTION PLAN

NATIONAL GEOSCIENCE
RESEARCH INITIATIVE

Australia’s cover opportunity



1. Extensions to known mineral provinces
2. Entirely new provinces
3. Opportunities at depth

Regional-scale pre-competitive: Greenfields Drilling

Considerations for area selection:

- Mineral systems potential
- Relatively poorly known geology
- Greenfields – make a material difference
- Potential to collaborate (co-invest)
- Suitable access and infrastructure

Some drilling parameters:

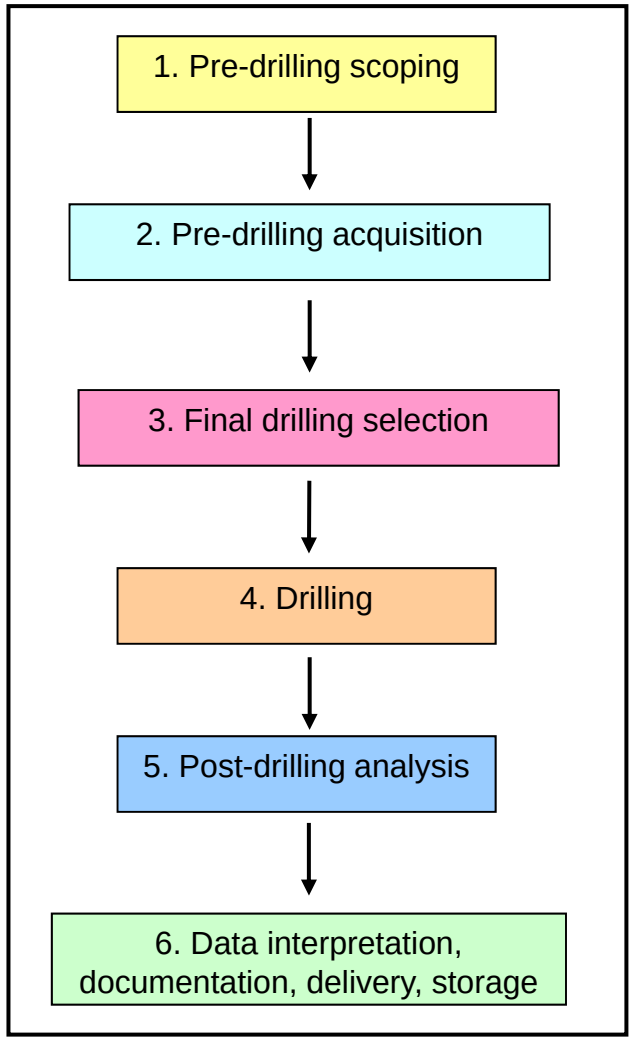
- Depth to target limit at ~500 m.
- Number of holes budget dependent

Southern Thomson Orogen: Collaborative agreement

- Three-way project of 3-year duration (2013–16)

- **Aims**
  - better understand geological character & mineral potential by acquiring and interpreting multi-disciplinary geophysical, geochemical and geological data.
- **Impact**
  - to provide the mineral exploration industry with pre-competitive data, information and knowledge that reduces risk and encourages investment in the region.

Regional-scale pre-competitive: Greenfields Drilling



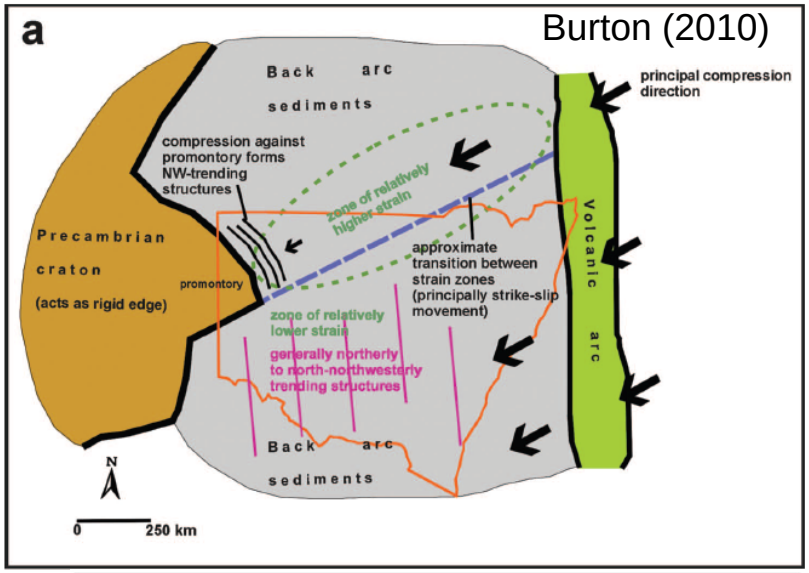
Drilling project workflow:

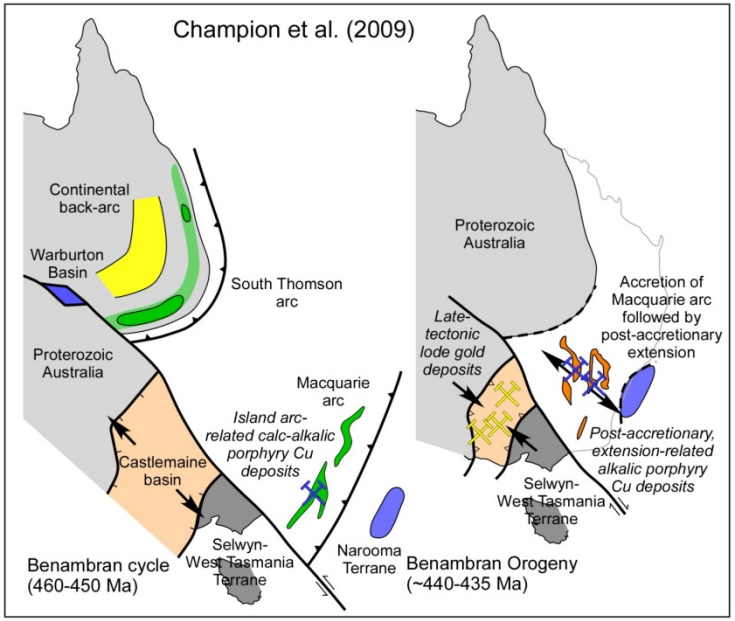
- **apply Stavely drilling learning**
- **to test geological interpretations**
- **'stratigraphic' holes**
- **hit the core with everything**

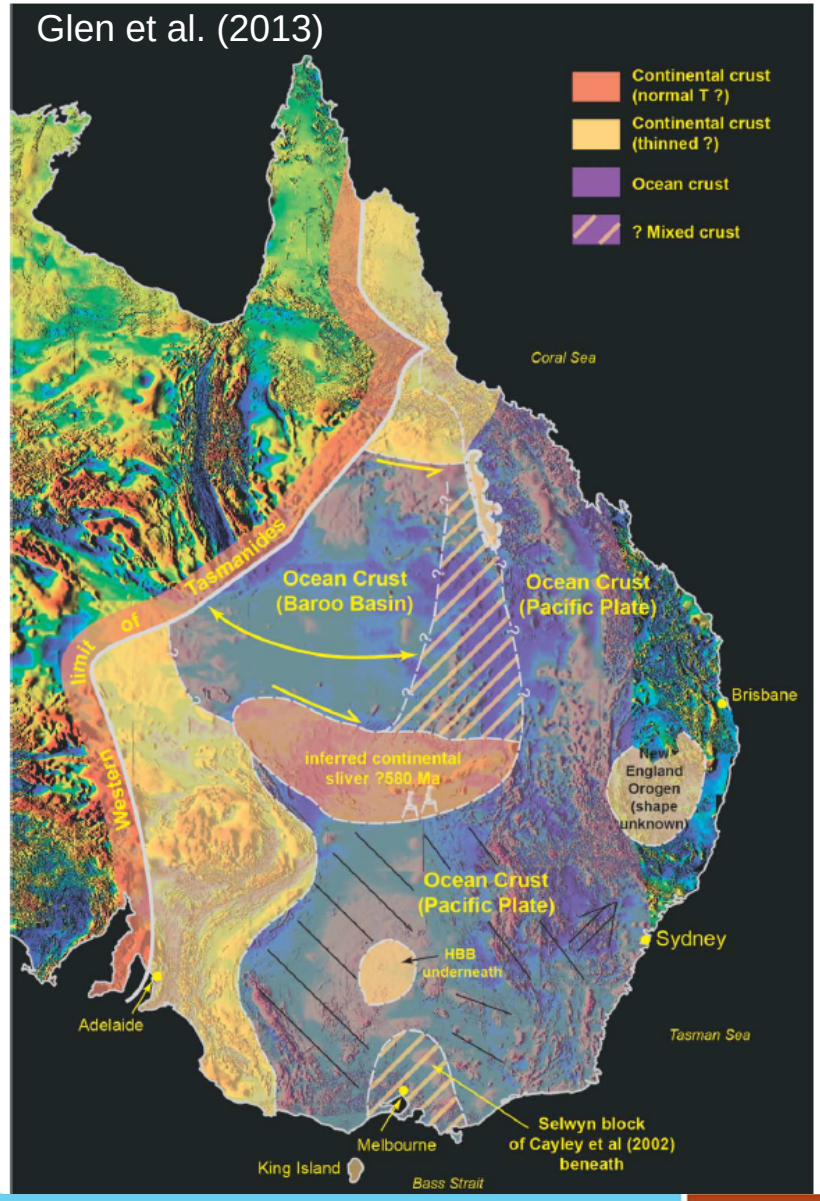
?

DEEP EXPLORATION TECHNOLOGIES CRC
Uncovering the future

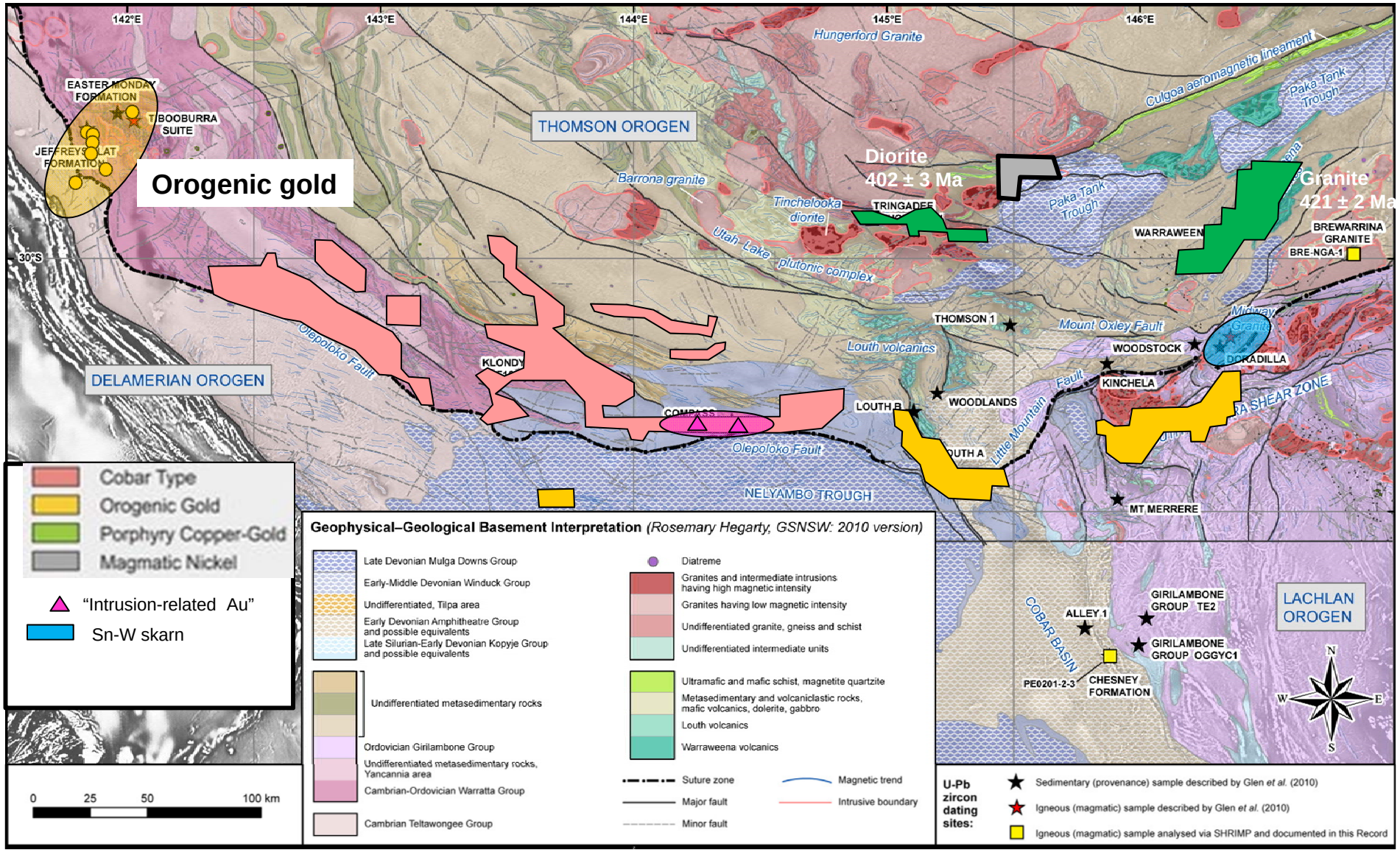
1) Origin of the orogen: back-arc within Lachlan, or other setting?







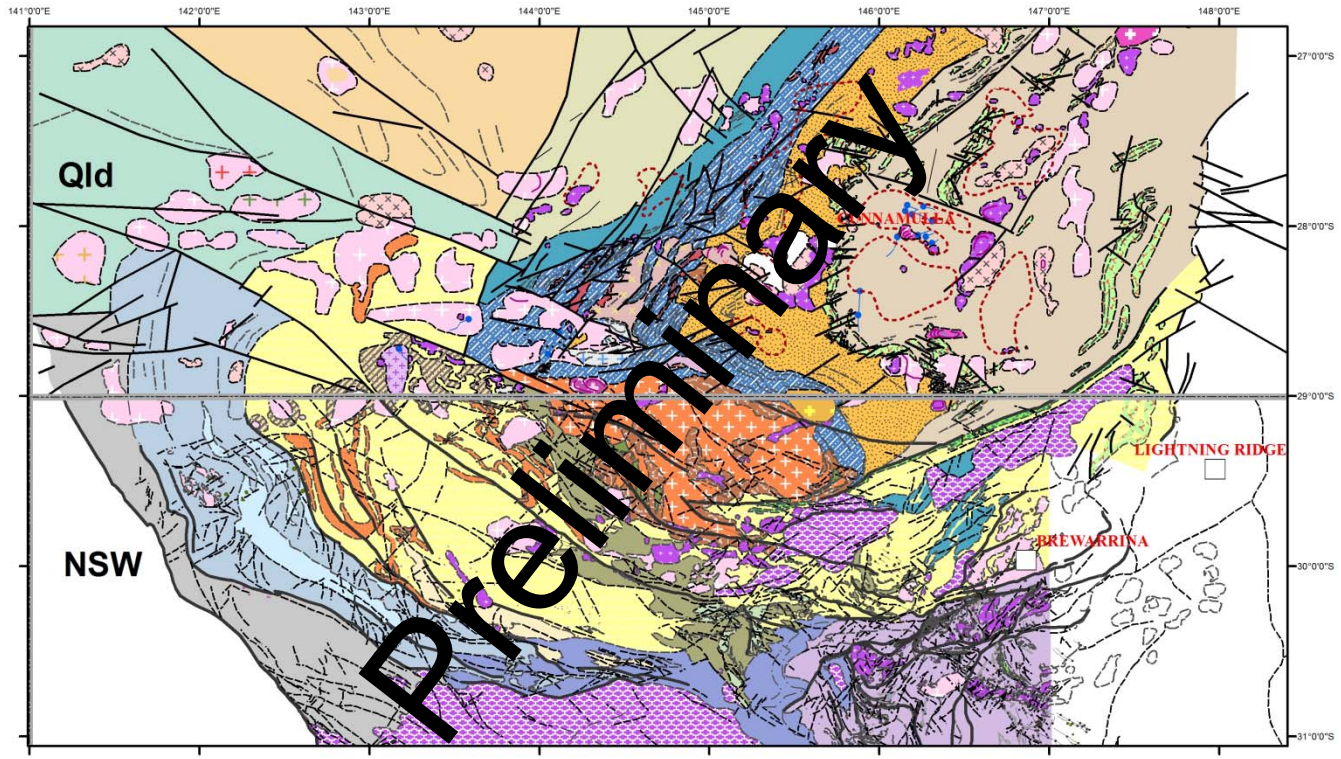
1) Synthesis: mineral systems and Southern Thomson (NSW) basement interp (Hegarty, 2010)



nthesis: mineral systems and Southern Thomson (NSW)

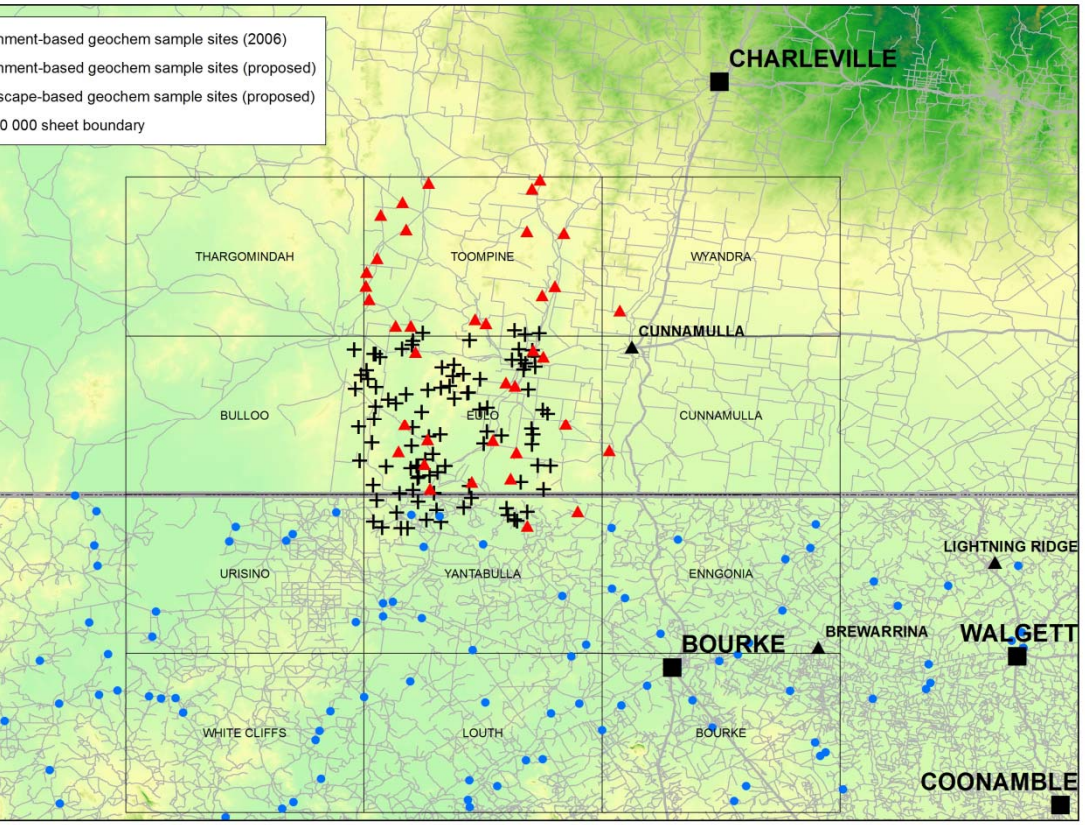
- Sampling of existing drill hole material for geochem & geochron

Solid Geology synthesis – seamless map and GIS



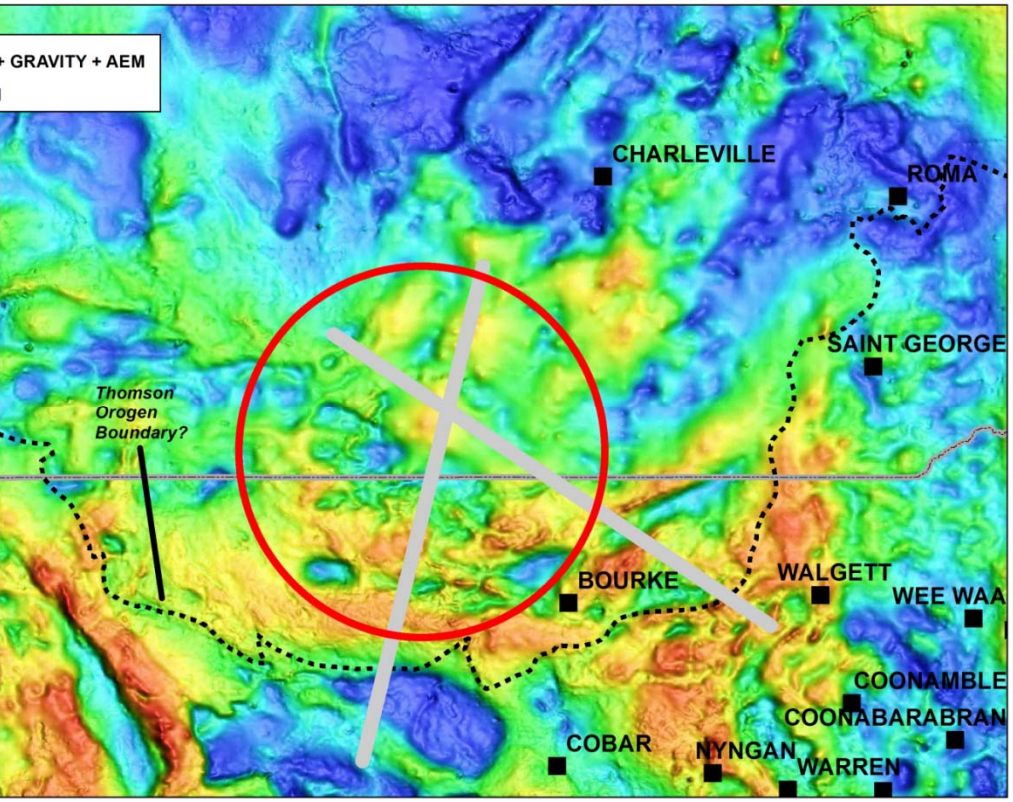
- Solid geology (after Dave Purdy GSQ & Rosemary Hegarty (GSNSW)
- Will be basis for 3D map (model) construction

Multi-element surface geochemistry

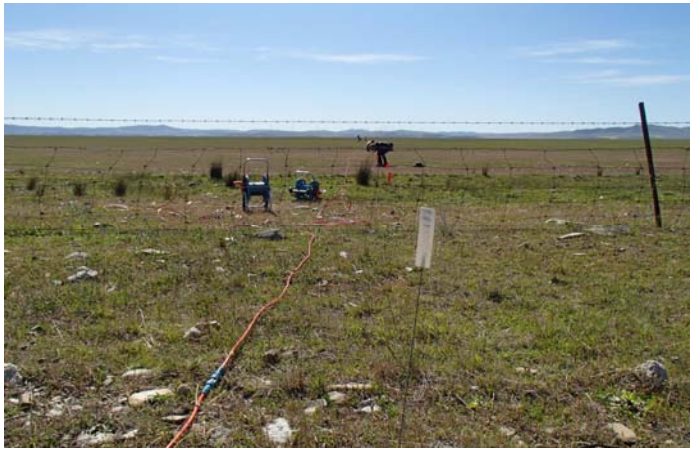


Regional-scale geophysical acquisition programme

- X km of MT and gravity lines (333 m spaced)
- X km flight line AEM (5 km spaced)



Pre-drilling local-scale geophysics acquisition

Reduce drilling risk and aid extrapolation from drill hole detail into regional datasets

Latest advances in drilling to be ployed

Conclusions

- Project stage 5 (Analysis) and stage 6 (delivery) still to be scoped
- Geochemistry and mineral systems has commenced
- Synthesis and solid geology well progressed
- Regional geophysical acquisition planned, commencement date early 2014
- Assessment and drill site selection later in 2014
- Drilling in 2015 following local-scale geophysics
- Build on knowledge of Stavely Drilling Project (esp for DET CRC work)
- Delivery in 2016

Australian Government
Geoscience Australia

Unlocking the Southern Thomson's hidden mineral resource potential

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CAPE YORK MINERAL RESOURCE ASSESSMENT
- Progress report

Digging Deeper 11

4 December 2013, 111 George Street Brisbane

Joseph Tang, Dominic Brown, David Purdy & Patrick Carr

Geological Survey of Queensland, Department of Natural Resources and Mines

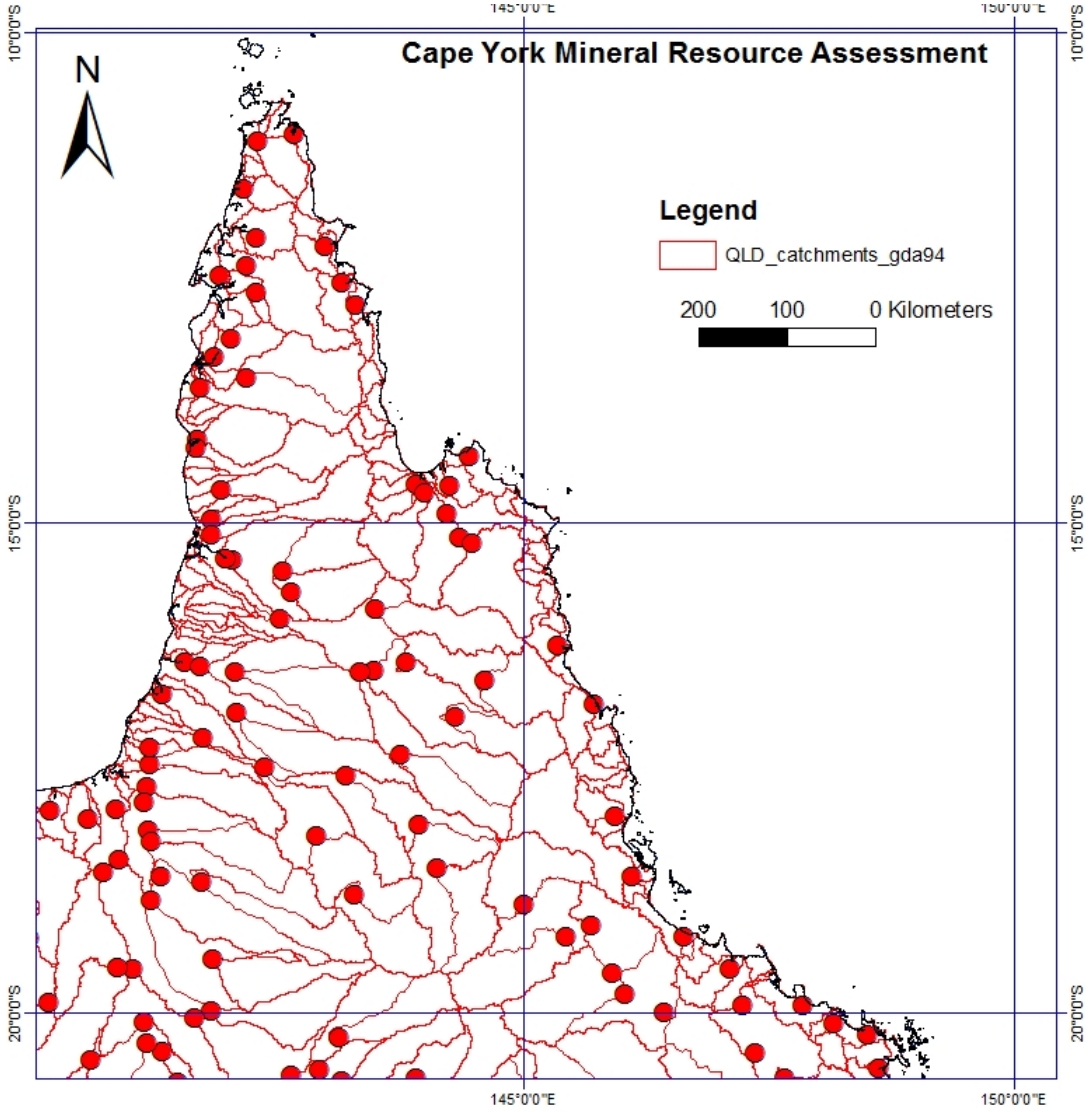
Talk outline

- Background
- National Geochemical Survey of Australia (NGSA) results
- Specific objectives
- Field programs
- Summary

Background

- Cape York Mineral Resource Assessment (CYMRA) project is to evaluate the mineral resource potential of the region under the Future Resource Initiatives using new and existing geochemical and geological data
- The project is a follow-up program to sample subcatchments within larger anomalous catchments identified from the National Geochemical Survey of Australia or NGSA project (2006-2010)
- Statistical analysis of the Cape York data identified **23** major river catchments (>5500 sq km) as geochemically anomalous for rare earth, tungsten, tin, uranium, antimony, bismuth and arsenic (Tang & Brown, 2010)
- Aims to create new opportunities in Cape York

NGSA program



Drainage system of the Cape York Region

Large catchment cells (>5000 sq km) to demarcate the major drainage systems in Cape York

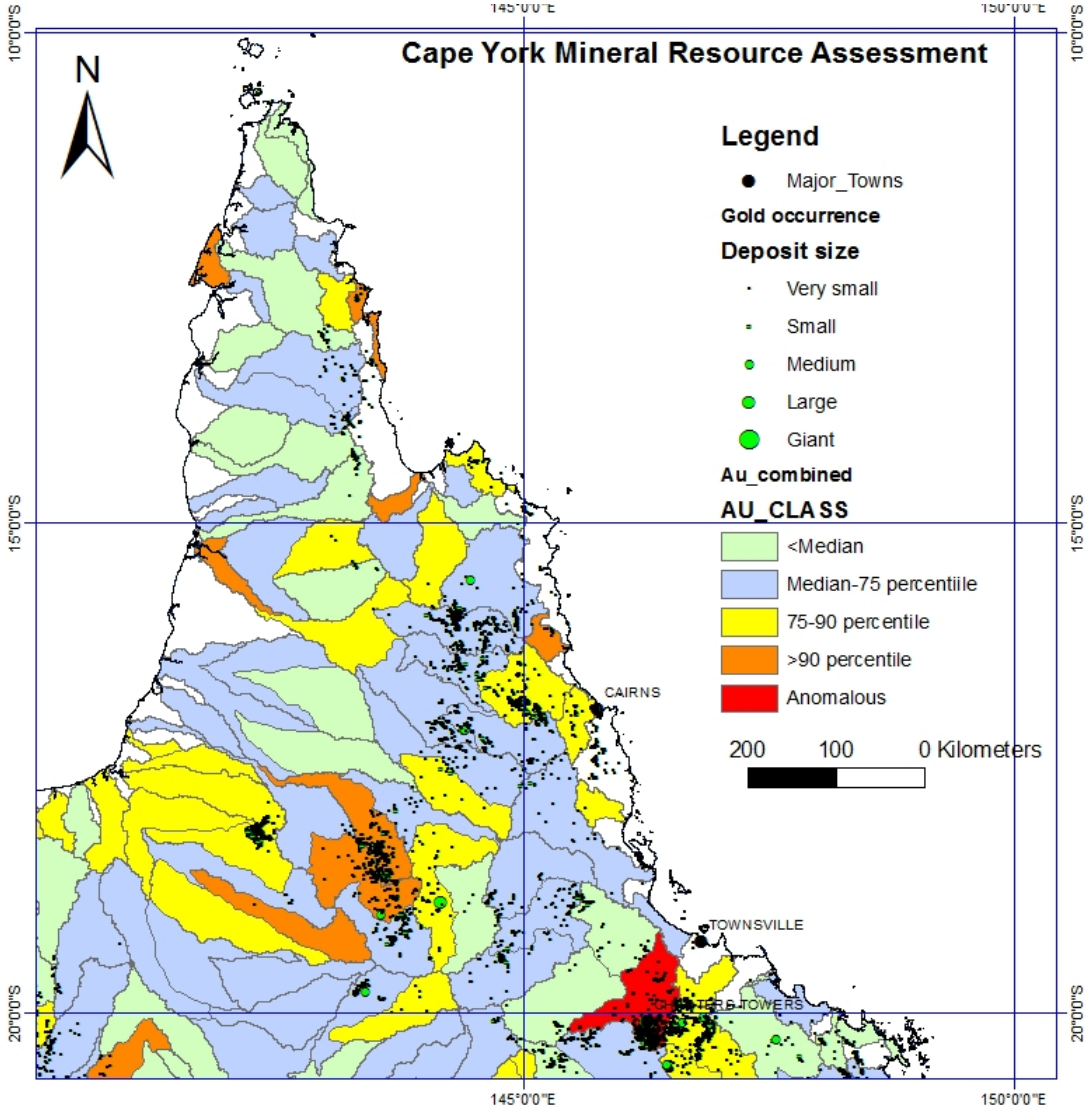
NGSA target sample sites for large catchment cells in the Cape York region

Anomalous catchments

Element	Anomalous Catchment in the Cape York Region
Aluminium	Pine River, Kendall River, Saltwater Creek
Antimony	Walsh River
Arsenic	**Mitchell River**, Cape Melville, Normanby River, Walsh River,
Barium	**Einasleigh River**, Smithburne River,
Beryllium	**Mitchell River**, Einasleigh River, Lynd River, Saltwater Creek, Tully River, Walker Creek, Watson River
Bismuth	Herbert River, Kendall River, Lynd River, Mitchell River, Saltwater Creek, Tully River, Walsh River
Cobalt	Watson River
Lead	Carron River, Gilbert River, Saltwater Creek, Tully River, Walsh River
Lithium	Daintree River, Kendall River, Pine River
Molybdenum	Ducie River, Jackson River, Kendall River, Pine River
Selenium	Jackson River
Tantalum	Mitchell River, Herbert River, Lynd River
Tin	**Mitchell River**, Herbert River, Lynd River, Walsh River
Tungsten	**Mitchell River**, Barron River, Crosbie Creek, Lynd River, Normanby River, Pascoe River, Staaten River, Walsh River
Uranium	Lynd River, Saltwater Creek, Tully River
Total REE	**Lynd River**, Carron River, Mitchell River, Palmer River, Tully River, Walker Creek, Watson River

Note: Red and bold highlights strong anomalies along major sections of the river.

NGSA results (single element)



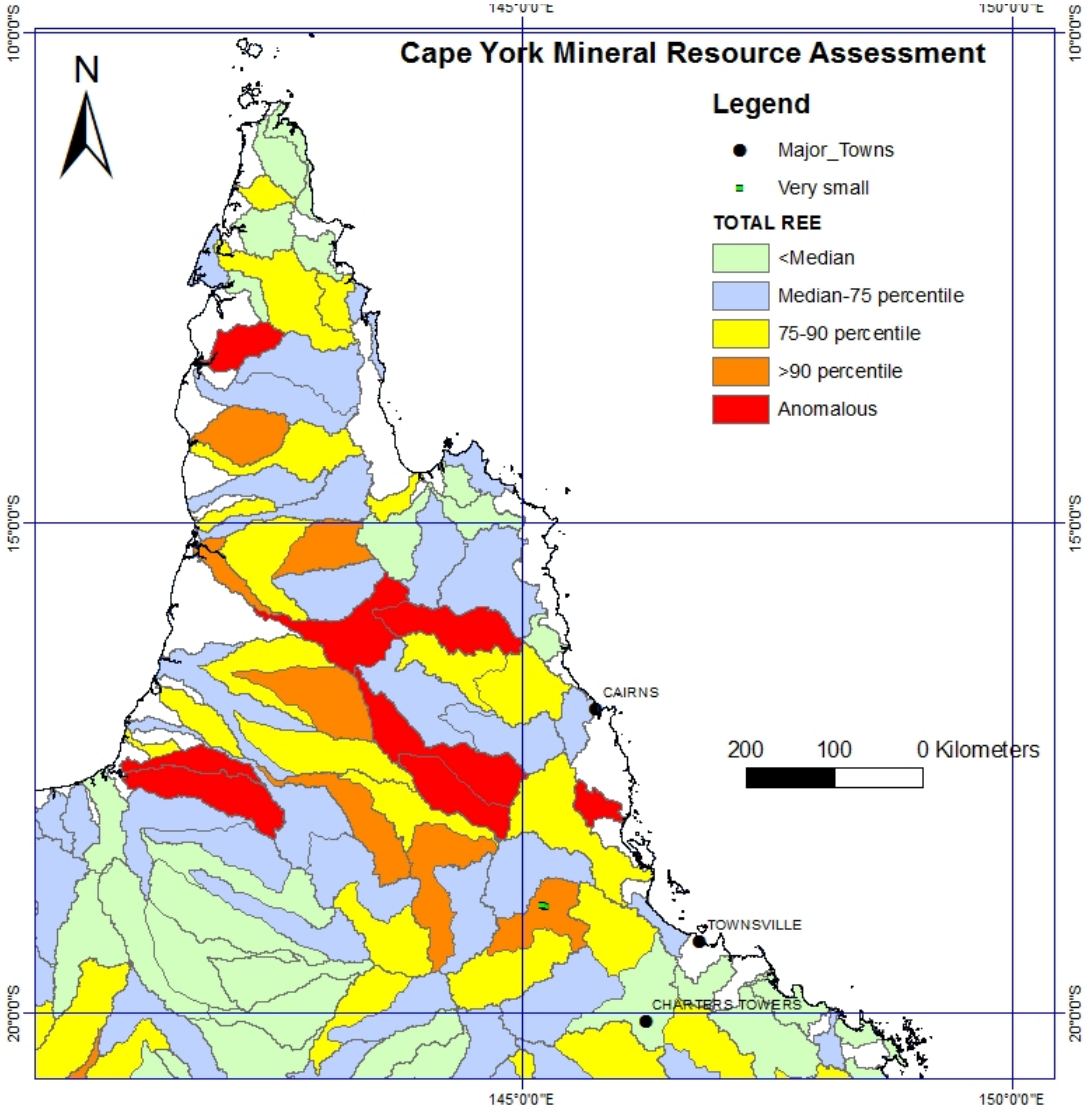
Cu result shows no obvious anomalies

Pb result shows anomalies in southern Cape York-Walsh, Gilbert and Norman River

Zn result shows no significant anomaly

Au result shows no anomaly but elevated in the southern Cape York

NGSA results (Group of elements)

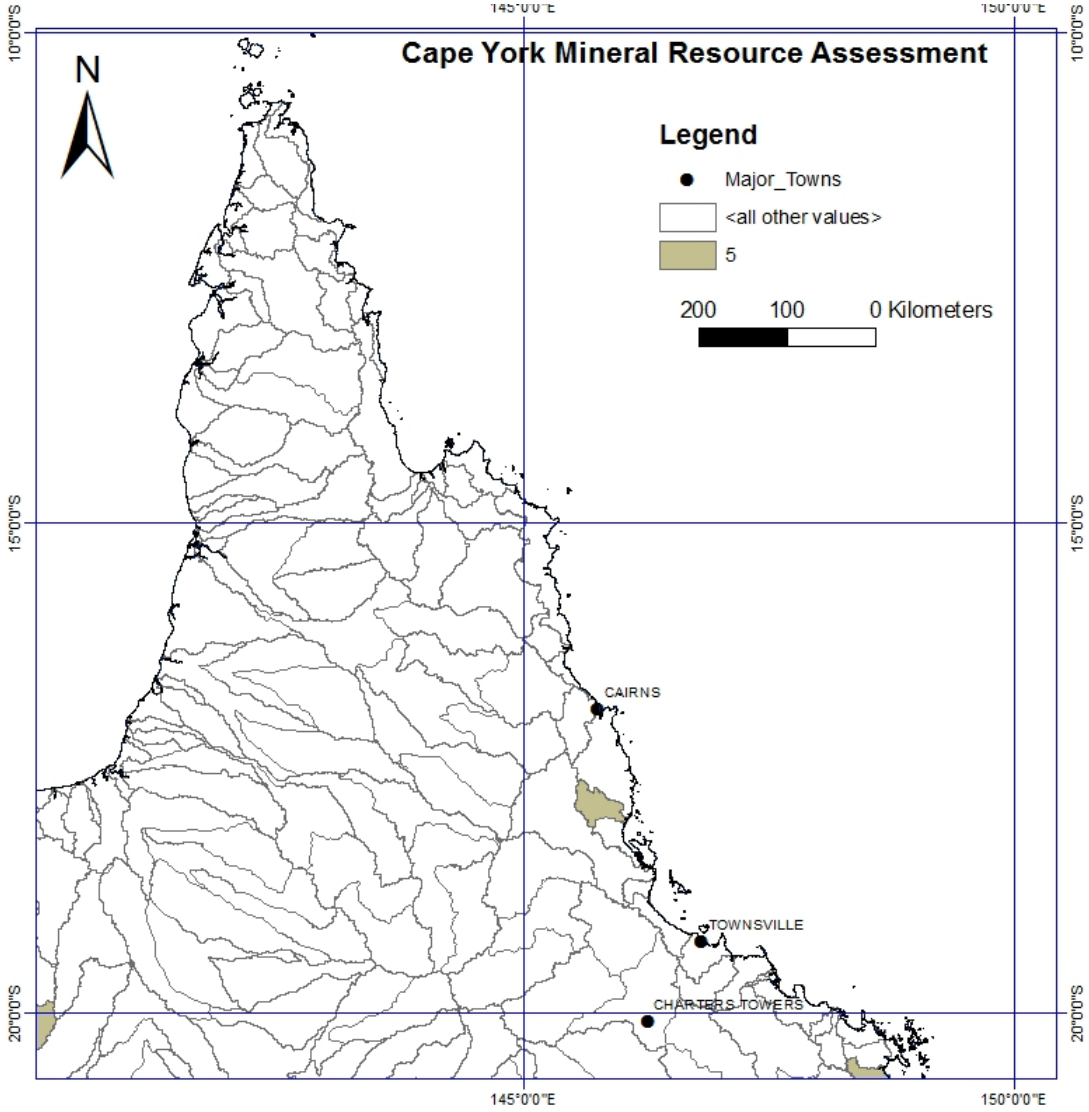


Combined light REE result shows widespread anomaly

Combined heavy REE result also shows widespread anomaly

Total REE result shows anomalies along Watson, Palmer, Mitchell, Lynd, Tully, Walker and Carron River

NGSA results (Mineral system approach)



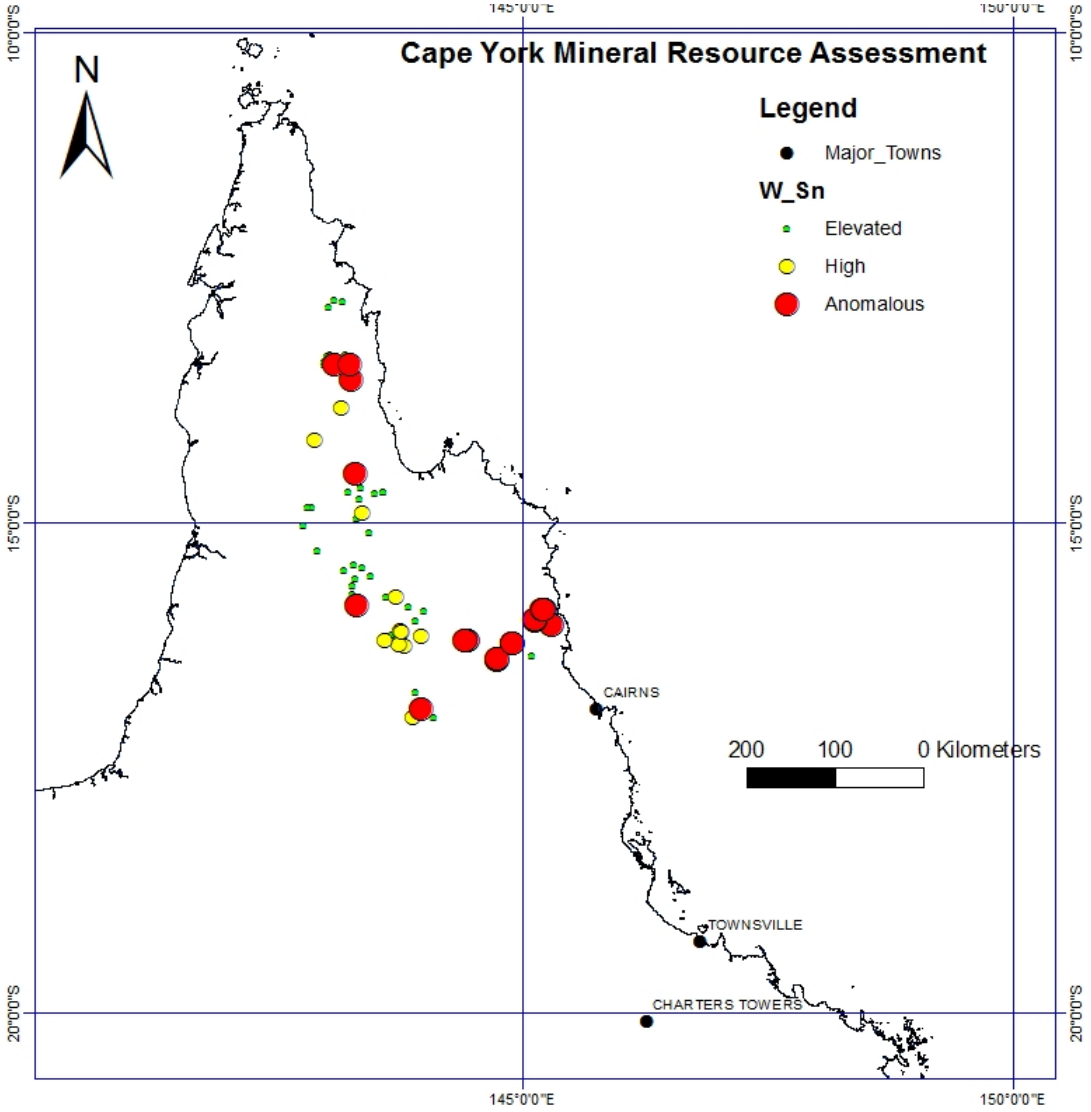
Hydrothermal system: **K-Li-Na-Cs-Rb-Ba-Sr-B-P-U-Hg-As-F-S-Sb-Se-Te-Ti** ± Be-Al-Ca-Mg

High field strength system: **U-Th-Bi-La-Ce-Pr-Nd-Sm-Eu-Gd-Tb-Dy-Ho-Er-Tm-Yb-Lu-Pm-Y-Sc**

Light ion lithophiles system: **K-Cs-Li-Na-Rb-Ba-Sr**

Base metals: **Cu-Pb-Zn**

Other data



Stream sediment samples from the Queensland Exploration Geochemistry and Drill hole Database

Statistical appraisal of REE geochemistry in the Cape York region

Statistical appraisal of Sb-Mo-Bi-As geochemistry

Statistical appraisal of W-Sn geochemistry

Cape York Mineral Resource Assessment

Cape York MRA Field programs

- Phase 1: Geochemical sampling program
  - Stage 1: Northern Cape York (completed in November 2013)
  - Stage 2: Southern Cape York (will commence in April 2014)
  - Possible Stage 3 for infilling and follow-up sampling (June 2014)

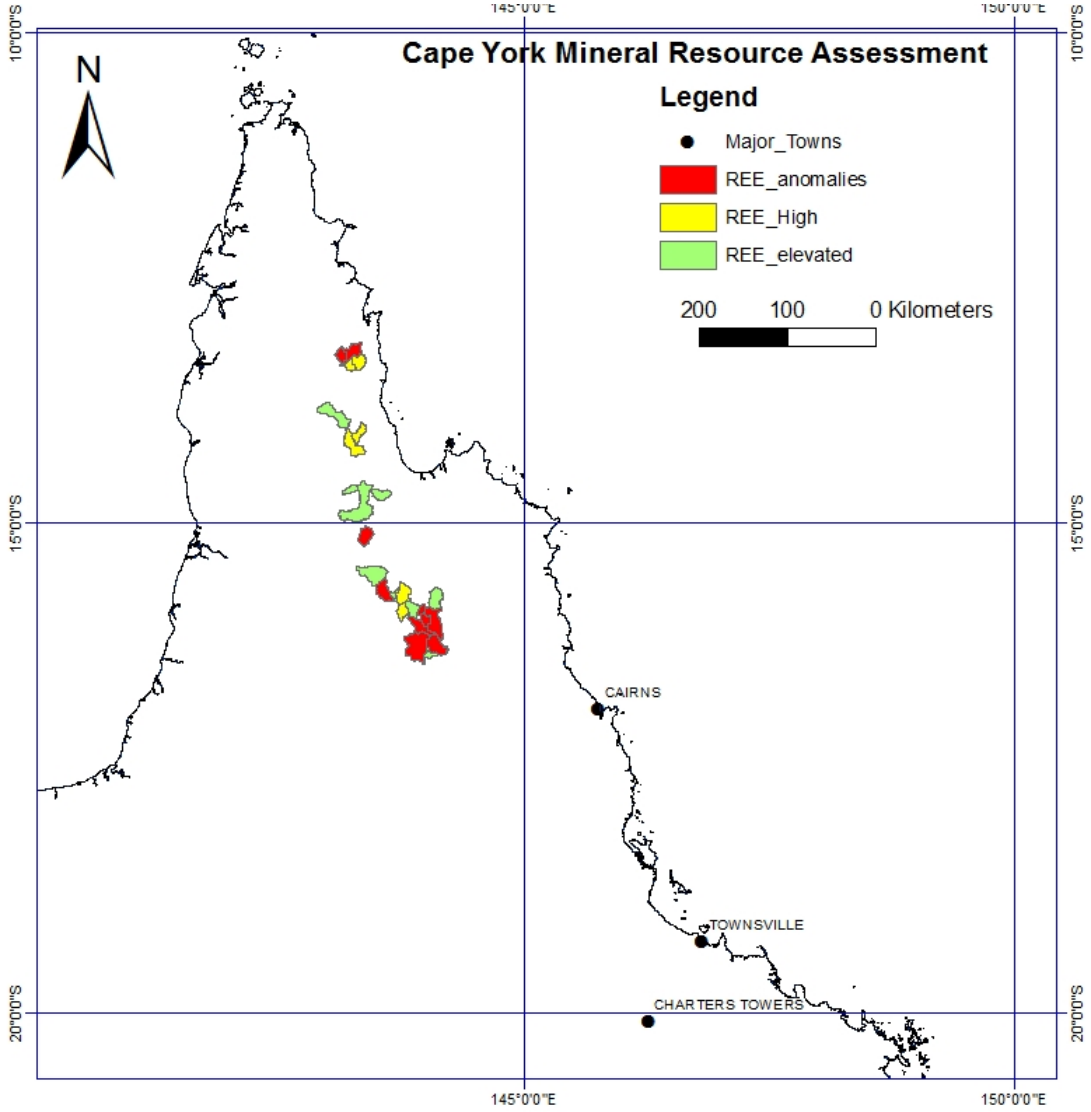
- Phase 2: Mapping programs (2014-2016)
  - Map areas identified as geochemically anomalous
  - Mapping of the Coen and Cape Weymouth 1:250k map area
  - Mineral occurrence mapping
  - New interpretation of geology using new geological and geochronological data, and geophysical data acquired by GSQ through previous initiatives
  - Mapping quarry rock material for future development

Cape York geochemical sampling

- Sample 208 subcatchments at sampling density of 1 sample per 500 square kilometres
- Collect overbank deposits at or close to the subcatchment outlets
- Sediments are sampled from 0-10 cm and from 60-90 cm using methodology established for the NGSA
- Analyse 68 elements to extract maximum geochemical information using internally consistent, state-of-the-art techniques
- Follow-up sampling and mapping by GSQ to establish the cause of geochemical anomalism and to assess resource potential of the region




Subcatchment scale sampling

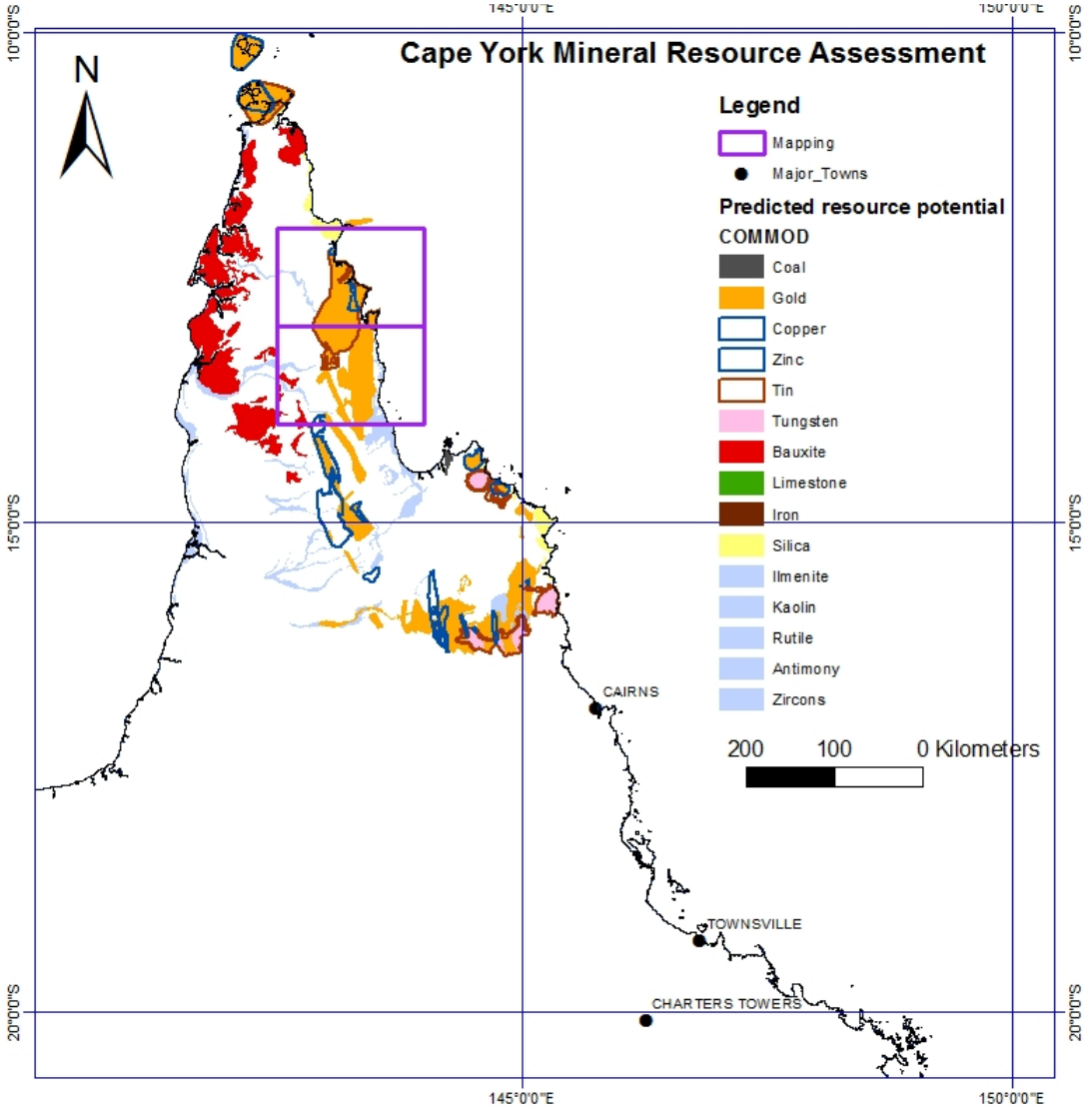


Geology of Cape York region
NGSA sampling is based on 1 sample per 5000 sq km catchment

CYMRA sampling density of 1 sample per 500 sq km based on the Australian Nested Subcatchments (ANCS-C), GEODATA 9 Second Digital Elevation Model (DEM-9s) v.2

Example of CYMRA outcome using subcatchments

CYMRA field program



208 subcatchment target sites

Phase 1 Northern Cape York region sampling program has been completed in November 2013

Phase 2 Southern Cape York sampling program is planned for May-June 2014

Mapping phase and follow-up sampling commences after July 2014 to June 2016. Resource potentials from CYPLUS report (1996)

Summary

- The Cape York mineral resource assessment project aims to re-evaluate the mineral resource potential of the Cape York region
- Geochemical sampling phase aims to sample 208 subcatchments using an internally consistent methodology in accordance with procedures set up for the NGSA project
- The new geochemical data will be used to appraise the mineral potentials, will revitalise mineral exploration interests leading to the possible discovery of strategic rare-earth mineral resources
- The mapping initiative will improve understanding of the geological history of this part of the North Australian Craton and northern Thomson Orogen
- Mines, mineral occurrences and potential quarry rock materials for Cape York will also be mapped and this information is vital for the future development plans of the region

Acknowledgements

APPRECIATION

- Appreciation to Christopher Hansen, Stanley Briggs and Dudley Fulton for organising the trip logistics and field assistance
- Appreciation to property owners, land councils, shire councils and traditional owners for permissions and advice

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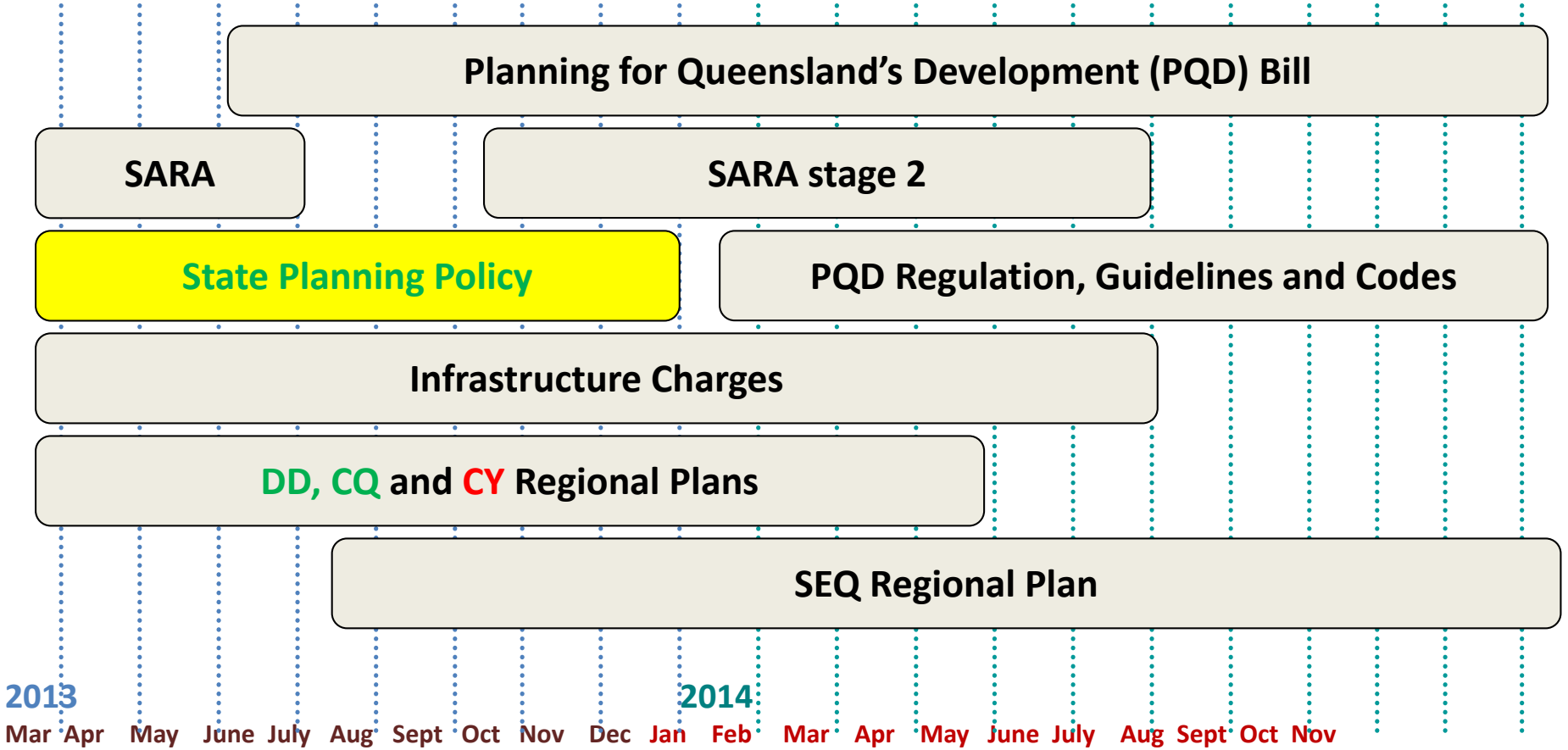
- LECH, M.E., CARITAT, P. DE & MCPHERSON, A.A. 2007: National Geochemical Survey of Australia: Field Manual. *Geoscience Australia Record*, **2007/08**. Available at: https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=65234
- HUTCHINSON, M.F., STEIN, J.L. & STEIN, J.A. 2000: *Derivation of nested catchments and subcatchments for the Australian continent*. Centre for Resource and Environmental Studies, Australian National University, Canberra. http://cres.anu.edu.au/outputs/programs.html
- TANG, J.E.H & BROWN, D.D., 2011: Queensland Mineral Prospectivity Atlas, National Geochemical Survey of Australia. *Queensland Geological Record*, **2011/08**, GSQ Sales.

Planning Reform and the Geological Survey of Queensland

Maintaining access to resources and prospective areas

Planning reform context…

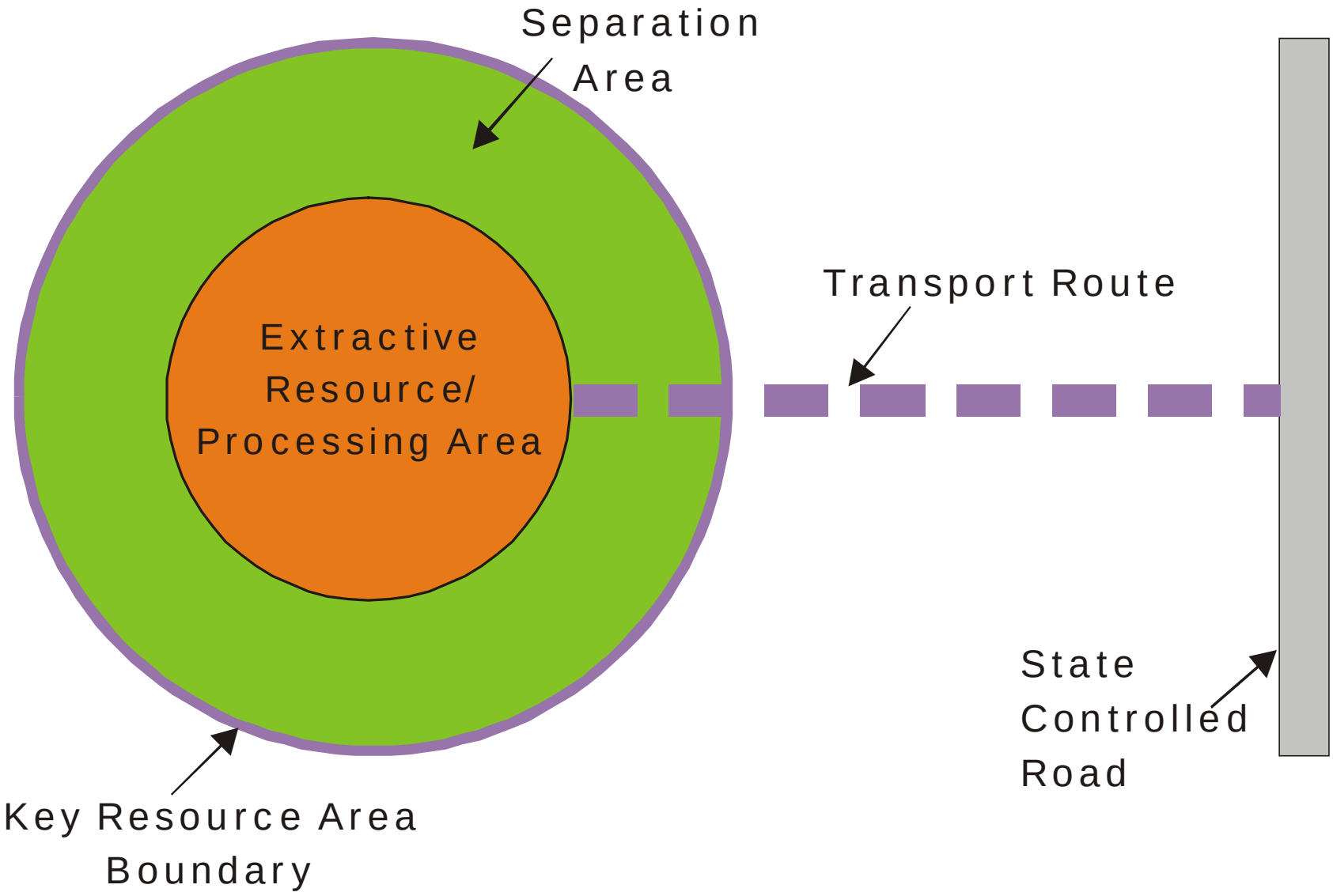


Single State Planning Policy

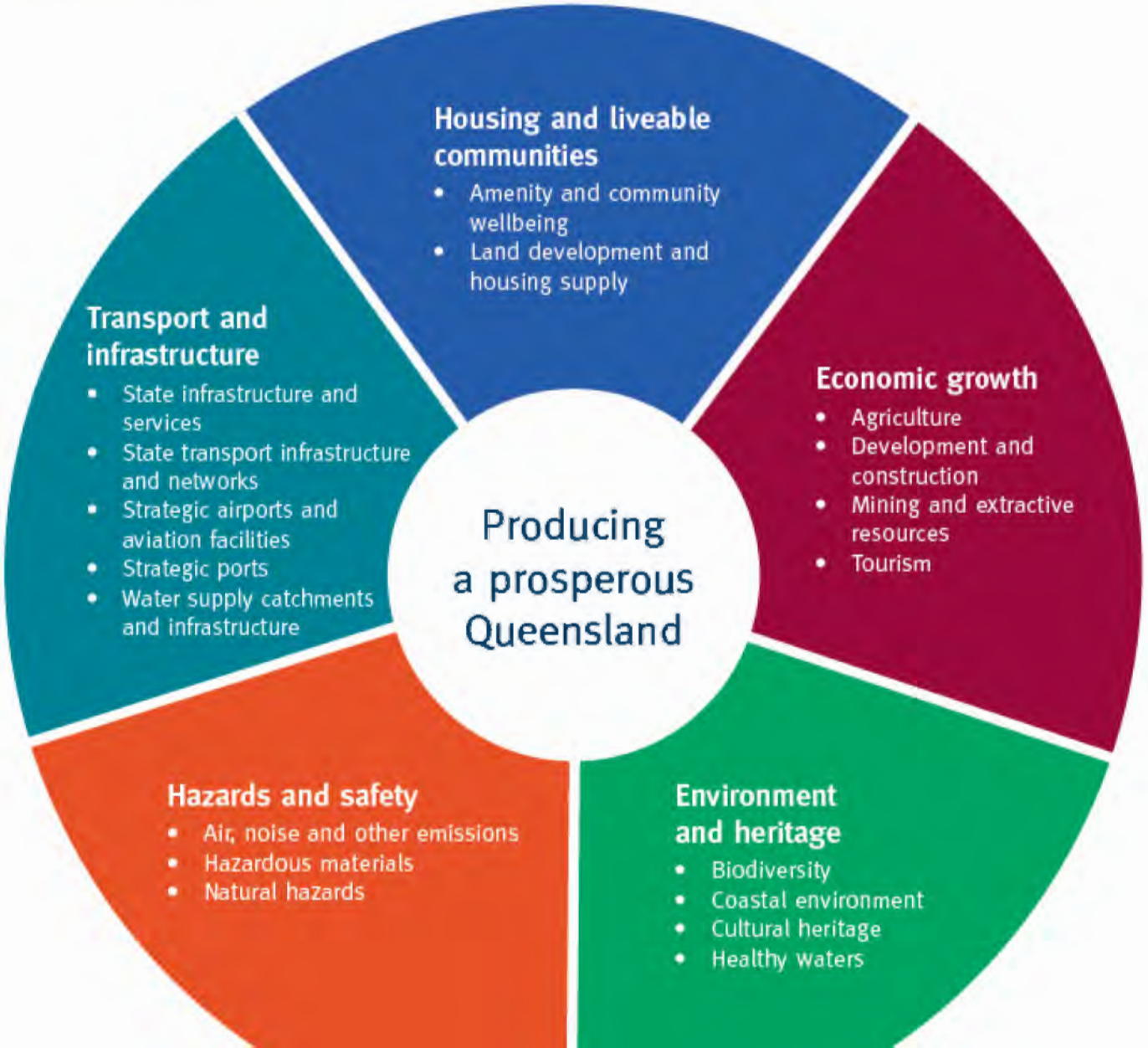
- Sets out State interests and policy that local governments must consider when making planning schemes or development decisions
- Regional plans set the regional context for expression of State Interests in the SPP, such as protection of extractive and mineral resources

Five Themes

- The Economic Growth Theme includes Mining and Extractive Resources; applying the Key Resource Area concept.
- Other themes "roll up" most previous SPPs in one document – some themes may 'compete' with the M&E component


Separation
Area
Extractive
Resource/
Processing Area
Transport Route
State
Controlled
Road
Key Resource Area
Boundary

Part C identifies the state interests relevant to the SPP and with respect to the following themes:



Regional Plans

Darling Downs and central Queensland

- Developed through regional panels of Council Mayors, chaired by planning Minister the Deputy Premier
- Designed to resolve general conflicts between resources sector and agriculture
- Core issue is identification of Priority agricultural areas and Strategic cropping areas

Cape York Regional Plan

public consultation until 25 March 2014

- New Regional Plan to achieve balance between economic and environmental drivers
- Replaces Wild Rivers
- Identification of Strategic Environmental Areas, General Use Areas and National Parks

CQ and DD Components

- Priority Agricultural Areas
- Priority Living Areas
- Priority Agricultural Land Use Areas

- PAAs to be protected from inappropriate resource activities
- PLAs to be managed to avoid impacts on townships

Cape York Components

- Strategic Environmental Areas.
- Priority Living Areas
- Priority Agricultural Areas
- General Use Areas
- SEAs to allow only uses compatible with ecological values
- PLAs and PAAs similar to other RPs
- General Use Areas for all activities subject to environmental compliance

Regional Planning on the Radar

- Western Rivers
- To protect iconic channel country
- To ensure water yields are protected

- South-east Queensland
- To balance urban needs with rural, and preserve inter-urban breaks

Resource and Prospectivity outlines

- Regional Plans can be updated every ten years
- -however- development in most regions will accelerate
- Once a site is identified and used for another land use - reversal is difficult for economic and often social reasons

Resolution of potential conflicts

- Regional plans and planning schemes will provide regional context for resolution of competing State interests
- Decisions on land use will be guided by the SPP, Regional Plans and planning schemes

Planning Schemes

applying the local context

- State interests, legislative requirements and advice so planning schemes operate to protect and facilitate access to resources.
- Mapping and codes are reviewed to ensure access to resources is protected from incompatible development

Role of GSQ

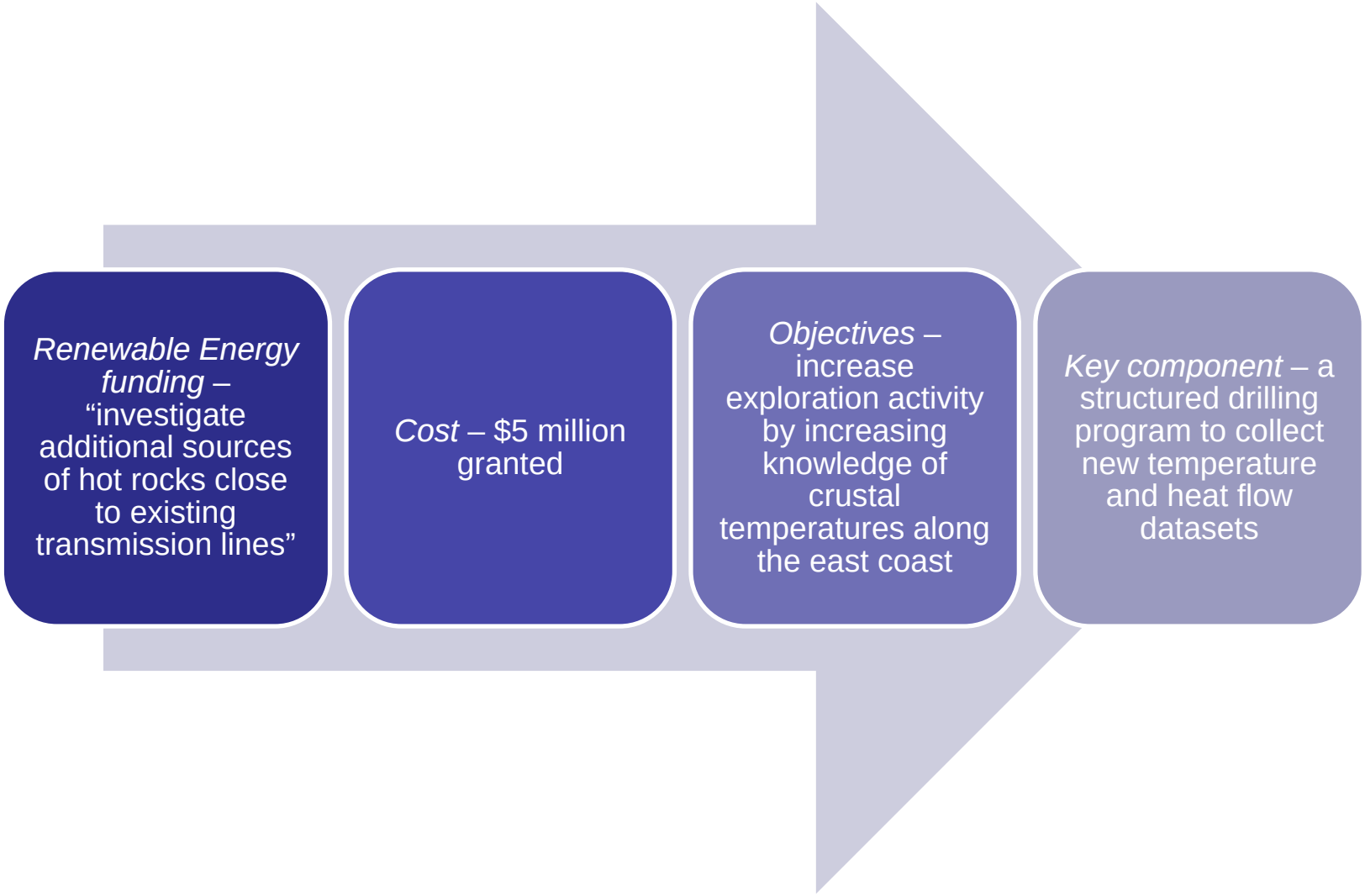
- Develops spatial information on resource extent and desirable ‘separation area’ and transport routes
- Prepares spatial information showing extent of prospective areas
- Advice to planners on potential impact of constraints on exploration and mining

Coastal Geothermal Energy Initiative (CGEI)

Sarah Sargent, Behnam Talebi and Lauren O'Connor
Geological Survey of Queensland

Digging Deeper 11
4th December 2013

Coastal Geothermal Energy Initiative (CGEI)



Scope of work

August 2009

Drill target selection

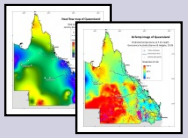
- 32 target assessments
- Land access
- Cultural heritage

Data collection

- Drilling
- Precision temperature logging
- Thermal conductivity analysis

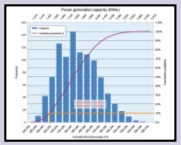
Modelling

- Heat flow
- Temperature to 5 km



Preliminary Geothermal resource assessment

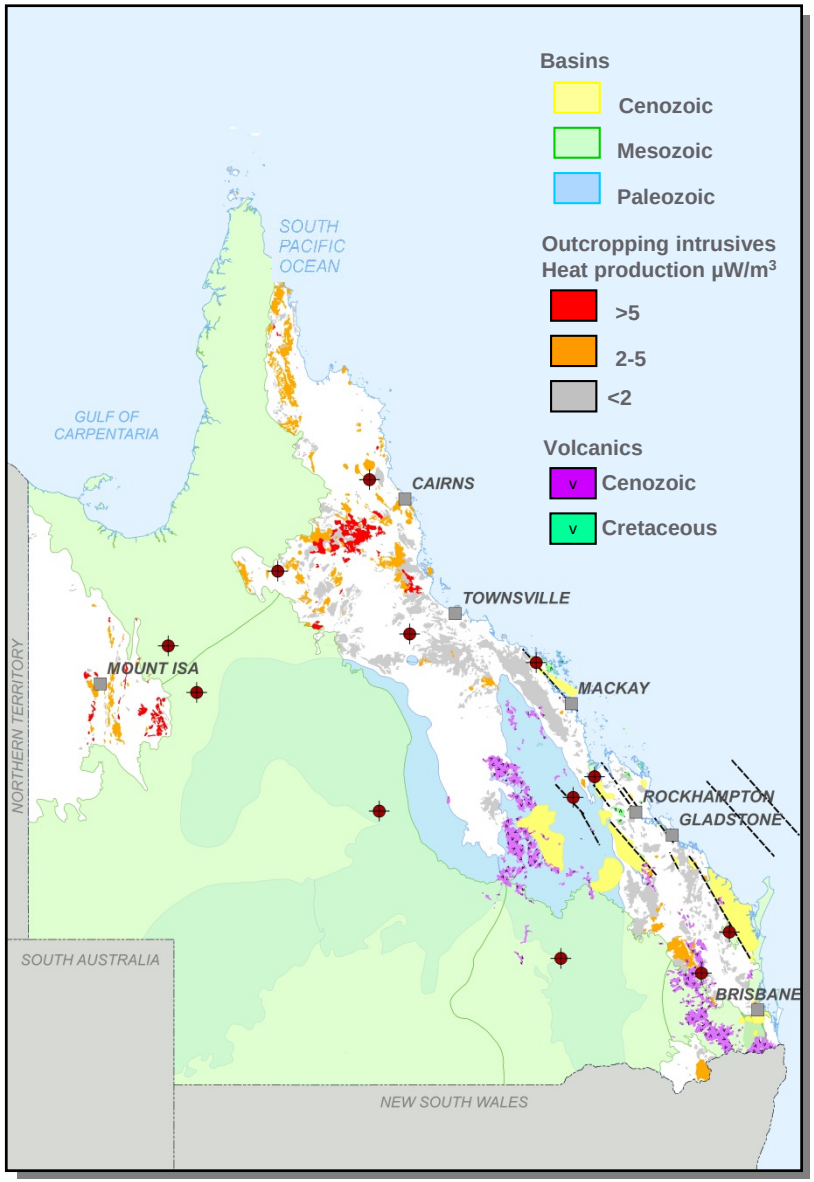
- Stored thermal energy in place
- Equivalent power generation
- Monte Carlo analysis



June 2013

Drill target selection

- Insulation
  - Sedimentary basins
  - Coal measures
- Heat sources
  - High heat producing intrusives (>5 µW/m^3)
  - Moderate heat producing intrusives (2-5 µW/m^3)
  - Cretaceous and Cenozoic volcanism
  - Cenozoic rifting
- Identifying potential heat sources under cover
  - Through gravity, magnetics, magnetotellurics
- Other constraints
  - Cultural Heritage, land owners, proximity to power lines



Data collection

Drilling

- 10 sites drilled, 1 abandoned, 1 not drilled
- 320-500 m
- PVC, steel cased

Thermal conductivity analysis

- under both *in situ* and saturated/dry conditions
- Hot Dry Rocks, Geoscience Australia

Temperature logging

- 10 sites, multiple logs
- Hot Dry Rocks, Geoscience Australia

Modelling: heat flow

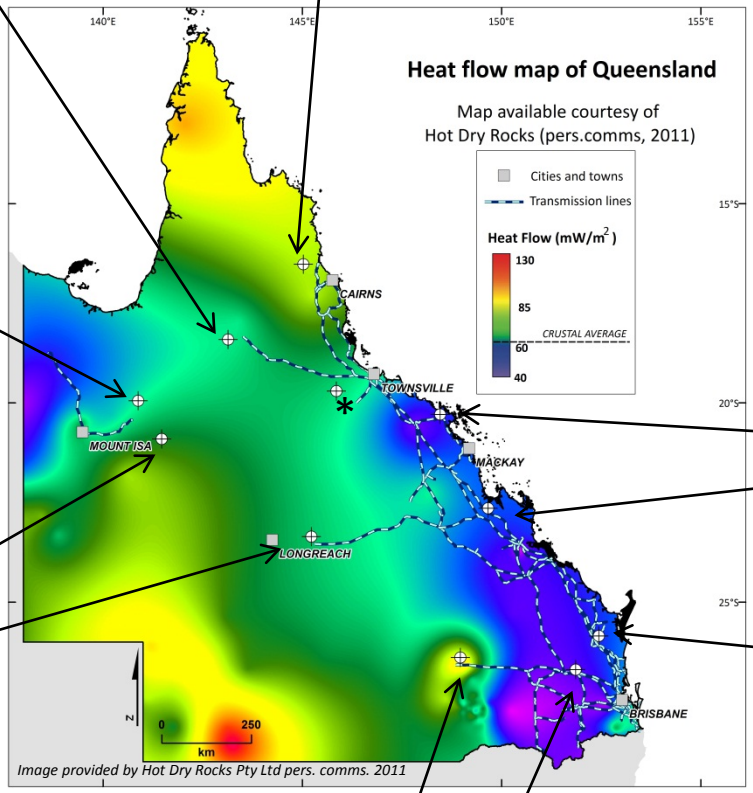
GSQ GEORGETOWN 8-9R
Georgetown inlier
48.5 ± 2.3mW/m²

GSQ MOSSMAN 2-3R
Hodgkinson Province
77.0 ± 0.9mW/m²

GSQ DOBBYN 2
Millungera Basin: North
107.5 ± 1.7mW/m²

GSQ JULIA CREEK 1
Millungera Basin: South
113.0 ± 2.3mW/m²

GSQ LONGREACH 2
Eromanga Basin (Barcaldine region)
63.0 ± 2.5mW/m²



* *Hole abandoned (no heat flow results available)*

GSQ BOWEN 1
Hillsborough Basin
71.0 ± 2.3 mW/m²

GSQ ST LAWRENCE 1
Styx Basin
64.5 ± 1.1 mW/m²

GSQ MARYBOROUGH 16
Nambour Basin
67.5 ± 2.9mW/m²

GSQ ROMA 9-10R
Surat Basin (Roma Shelf)
82.5 ± 2.5mW/m²

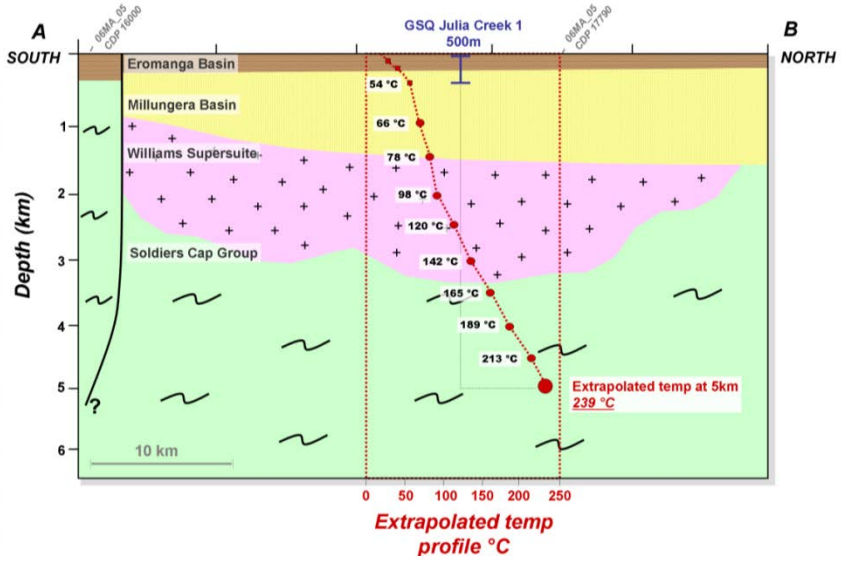
GSQ GYMPIE 7
Tarong Basin
37.5 ± 1.5mW/m²

Modelling: temperature estimation to 5 km

$$T_z = T_0 + q_0 \cdot \int_0^z \frac{d_z}{\lambda_z}$$

Where:

T_0 and T_z	represent the temperature at the top and bottom of the interval, respectively
λ	thermal conductivity
d	thickness of interval
q_0	heat flow at the top of the interval, assumed as purely conductive and therefore constant with
z	depth



Modelling: temperature estimation to 5 km *(cont.)*

GSQ Mossman 2-3R
Hodgkinson Province
156 ± 10 ° C

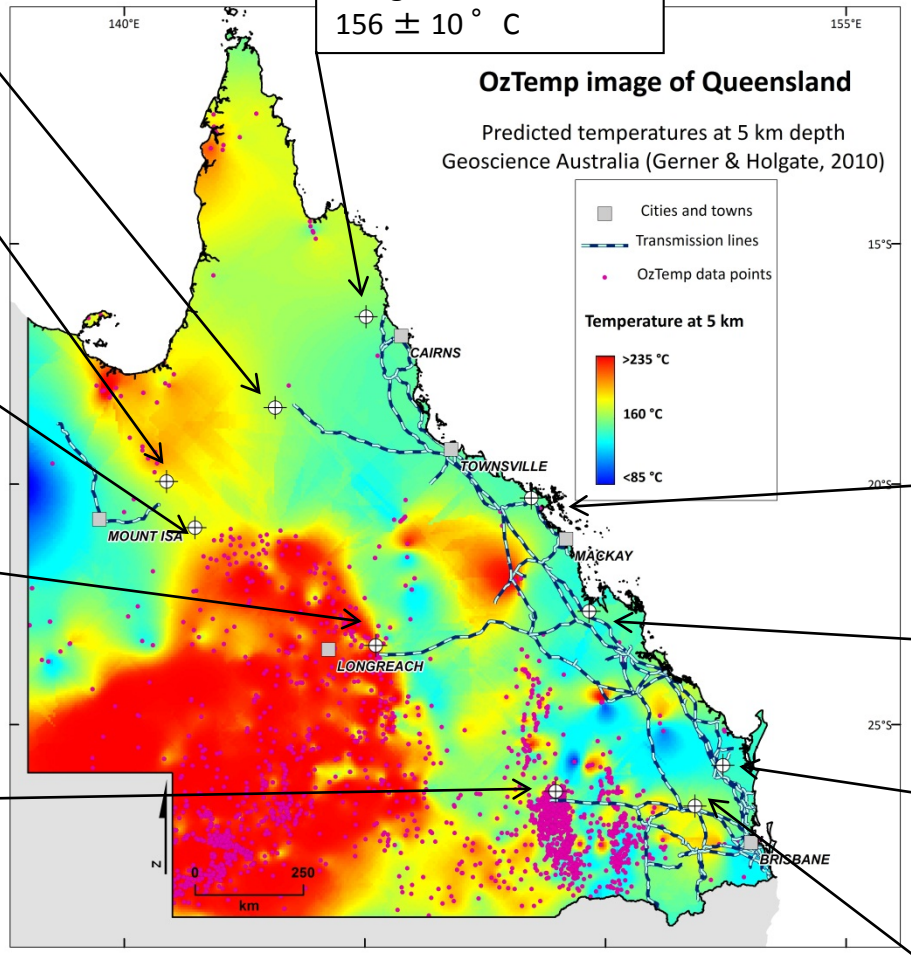
GSQ Georgetown 8-9R
Georgetown inlier
109 ± 5 ° C

GSQ DOBBYN 2
Millungera Basin North
212 ± 15 ° C

GSQ JULIA CREEK 1
Millungera Basin South
239 ± 18 ° C

GSQ Longreach 2
Eromanga Basin
(Barcaldine region)
146 ± 13 ° C

GSQ ROMA 9-10R
Surat Basin (Roma Shelf)
187 ± 14 ° C



Oztemp, Geoscience Australia 2011

GSQ BOWEN 1
Hillsborough Basin
204 ± 16 ° C

GSQ St Lawrence 1 **Styx Basin**
170± 16 ° C

GSQ MARYBOROUGH 16
Maryborough Basin
206 ± 14 ° C

GSQ Gympie 7
Tarong Basin
106 ± 9 ° C

Preliminary resource assessment

ESTIMATING STORED HEAT

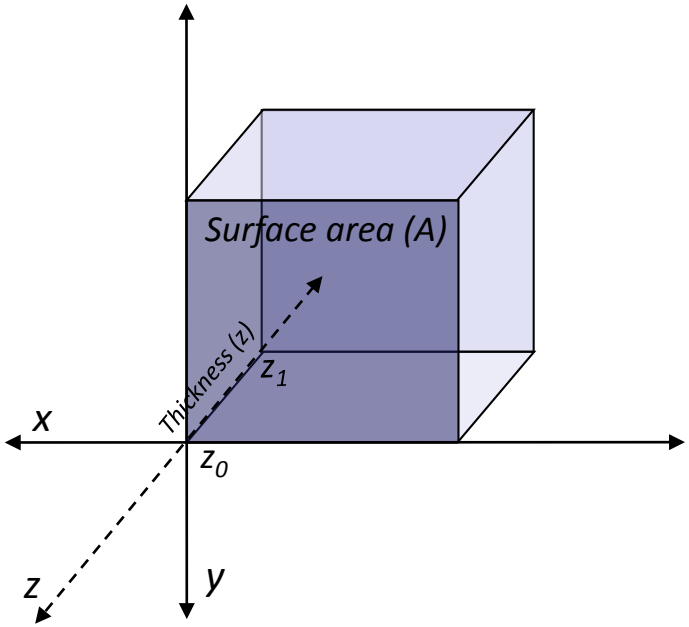
Volumetric method

- Stored heat is contained within a box

$$Q \approx \rho_r C_r V (T_R - T_r)$$

Where:

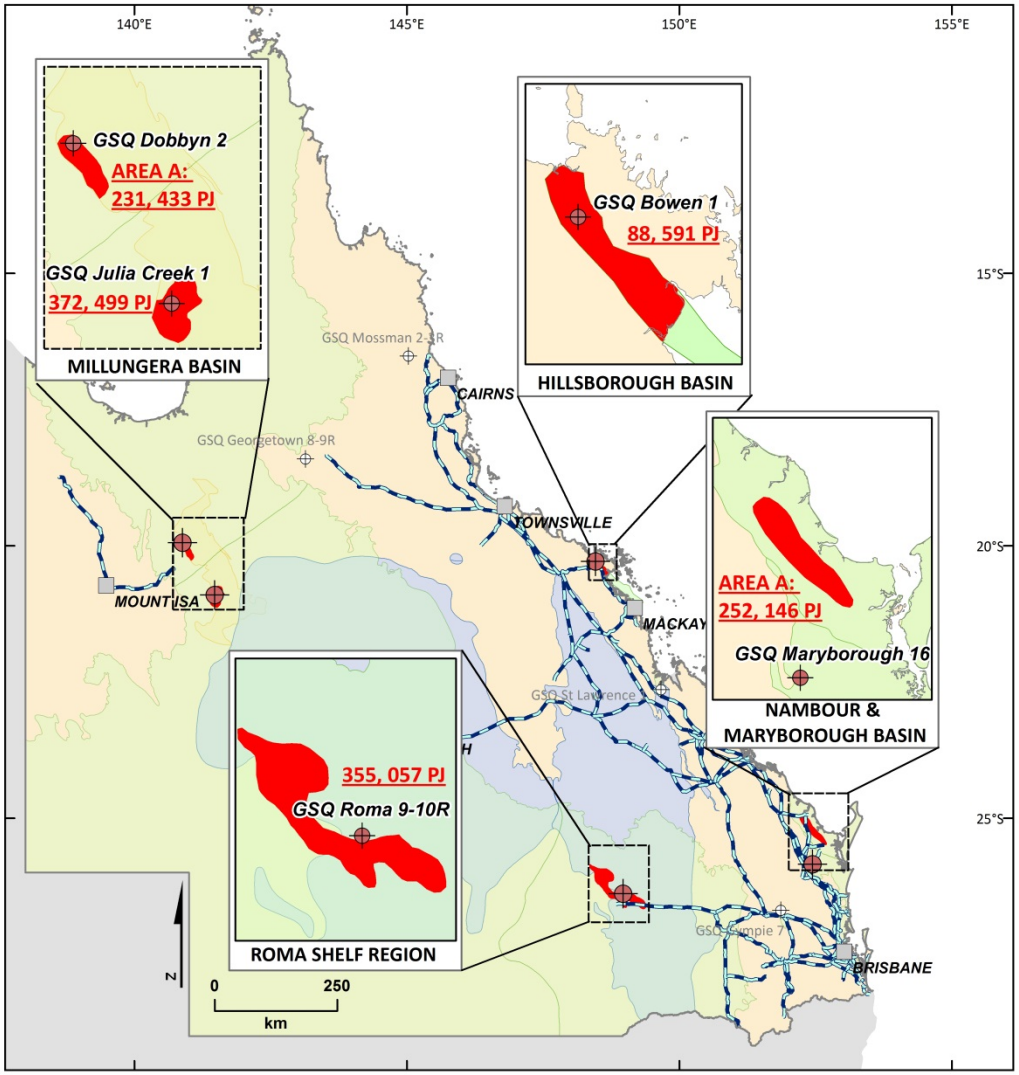
Q	**total thermal energy (J)**
ρ_r	Rock density (kg/m^3)
V	Rock (resource) volume (m^3)
C_r	Rock specific heat capacity (J/kg° C)
T_R	Rock (resource) average temperature (° C)
T_r	Reference (rejection) temperature (° C)



Preliminary resource assessment *(cont.)*

Input parameters	Estimation rationale
Density **(ρ_r) kg/m^3**	Internal GSQ density database; **2600-2900 kg/m^3**
Specific heat capacity **(C_r) J/kg°C**	Estimated from existing data (Vosteen and Schellschmidt, 2003); **900-1000 J/kg°C**
Surface area **(A) km^2**	Lateral extent of potential resource; **heat source**
Resource thickness **(H) km**	Depth of 150 °C cut-off temperature to 5 km (base of resource)
Resource mean temperature **(T_R) °C**	Average temperature between cut-off temp (150 °C) & temp at base of resource (i.e. 5 km)
Reference temperature **(T_r) °C**	Average between cut-off temperature (150 °C) and rejected fluid temperature (70 °C); **110°C**

Estimated thermal energy in place



CGEI Boreholes

Geothermal prospectivity:

- Prospective
- Unprospective
- Inferred resource area
- Towns
- Transmission lines
- Mesozoic basins
- Paleozoic basins
- Proterozoic basins

Equivalent electric power generation potential

Input parameters	Rationale	Estimate
Recovery factor	Varies between 5-50% between conventional and unconventional systems	**5%**
Thermal conversion efficiency	Temperature range 150-250°C between 7-12%	**7%**
Plant capacity factor	Base-load (conventional) geothermal power plant used as an estimate	***90%***
Plant/project economic life	Base-load (conventional) geothermal power plant used as an estimate	***25 years***

$$= \left[\frac{(\textbf{\textit{stored heat}}.\ \textit{recovery factor}.\ \textit{conversion factor})}{\textit{plant capacity}.\ \textit{plant life}} \right]$$

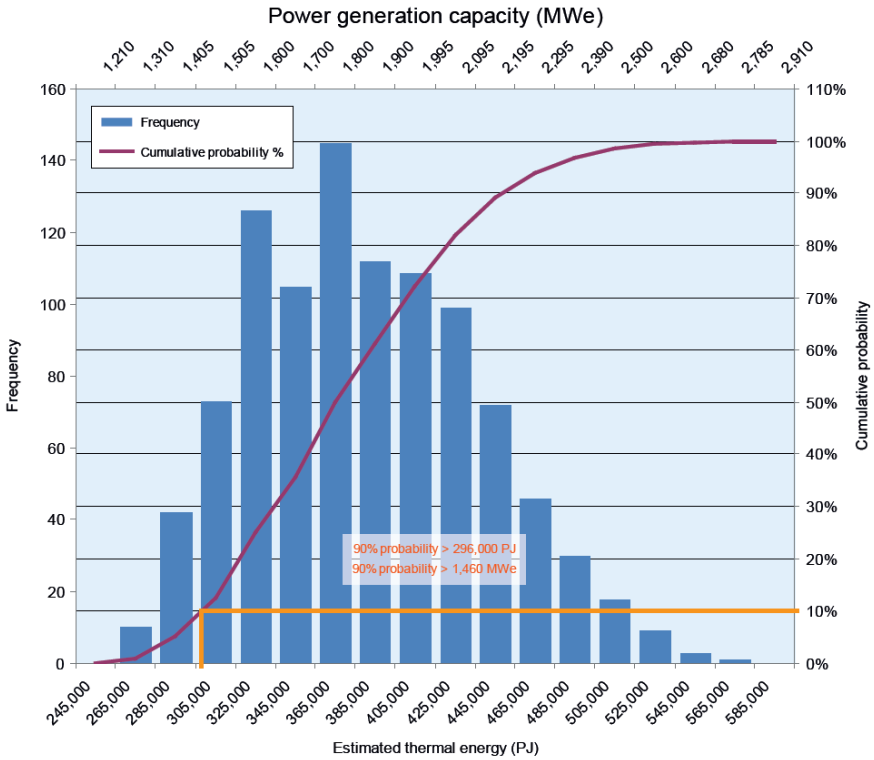
Equivalent electric power generation potential

Region	Thermal energy estimate (PJ)	Inferred resource recoverable heat (PJ)	Equivalent gross electric power generation potential (MWe)
Millungera Basin – South	372,499	18,625	***1,837***
Millungera Basin – North	231,433	11,572	***1,142***
Surat Basin (Roma Shelf)	355,057	17,753	***1,751***
Maryborough Basin	252,146	12,607	***1,244***
Hillsborough Basin	88,591	4,430	***437***

STORED HEAT IN PLACE → RECOVERABLE HEAT → GROSS POWER GENERATION

Addressing uncertainty: Monte Carlo simulation

Input parameters	Minimum	Most likely guess	Maximum
Resource surface area (km^2)	763	848	933
Resources thickness (m)	1630	1811	1992
Resource mean temperature (°C)	179	194	209
Rock density (kg/m^3)	2592	2880	3168
Rock specific heat capacity (J/kg °C)	900	1000	1100



e.g. GSQ Julia Creek 1

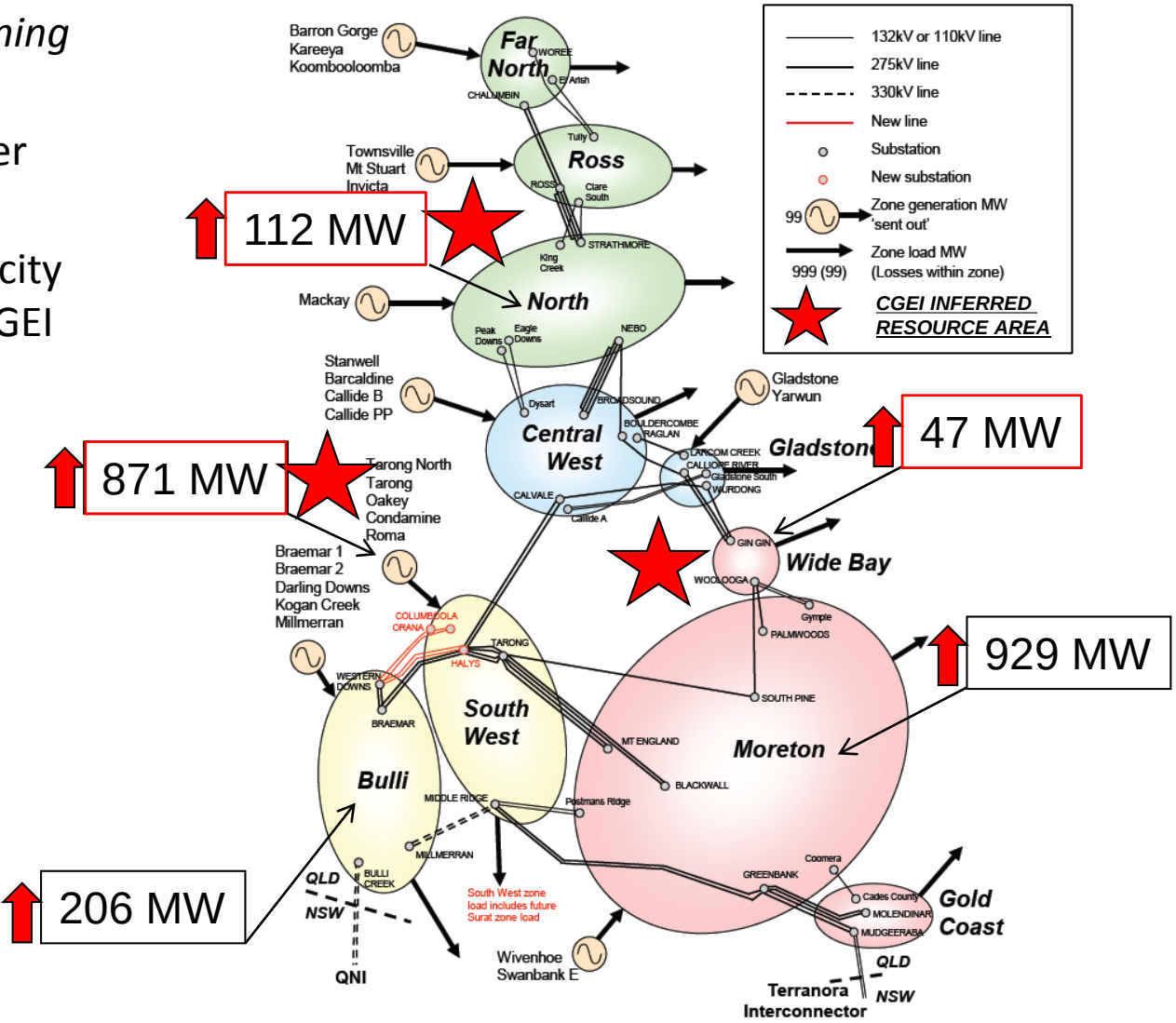
Monte Carlo simulation: other CGEI resource areas

Tectonic unit	Total thermal energy P_{90} (PJ)	Equivalent electric power potential P_{90} (MWe)	Annual electricity generation P_{90} (GWh)
Millungera Basin – South	>296,000	>1,460	>11,510
Millungera Basin – North	>185,000	>912	>7,190
Surat Basin (Roma Shelf)	>280,000	>1,380	>10,880
Maryborough Basin	>205,000	>1,010	>7,963
Hillsborough Basin	>69,000	>340	>2,680

Geothermal & Queensland's future energy

Powerlink Annual Planning Report 2013:

- 3% growth p.a. over the next 10 years
- Regions and electricity grids proximal to CGEI inferred resources.



Adapted from Powerlink Annual Planning Report 2013

Deliverables

- **Collect new data** sets for both heat flow and temperature
- **Predict temperature** at 5 km
- **Highlight geothermal potential** in eastern QLD
- **Quantify** potential resource areas
- **Estimate thermal energy** in place and equivalent electric power generation in potential areas
- **Assist potential explorers** to conduct their own exploration programs by reducing risk.

REPORTING

- ***Well completion reports*** — ***OUT NOW***
- ***Final Report*** — ***March 2014***

Thank you

http://mines.industry.qld.gov.au/geoscience/coastal-geothermal.htm

Unconventional resources in the Toolebuc Formation, western Queensland

Alison Troup, Sally Edwards, Micaela Grigorescu, Owen Dixon and Suraj Gopalakrishnan

Unconventional Resource Assessment

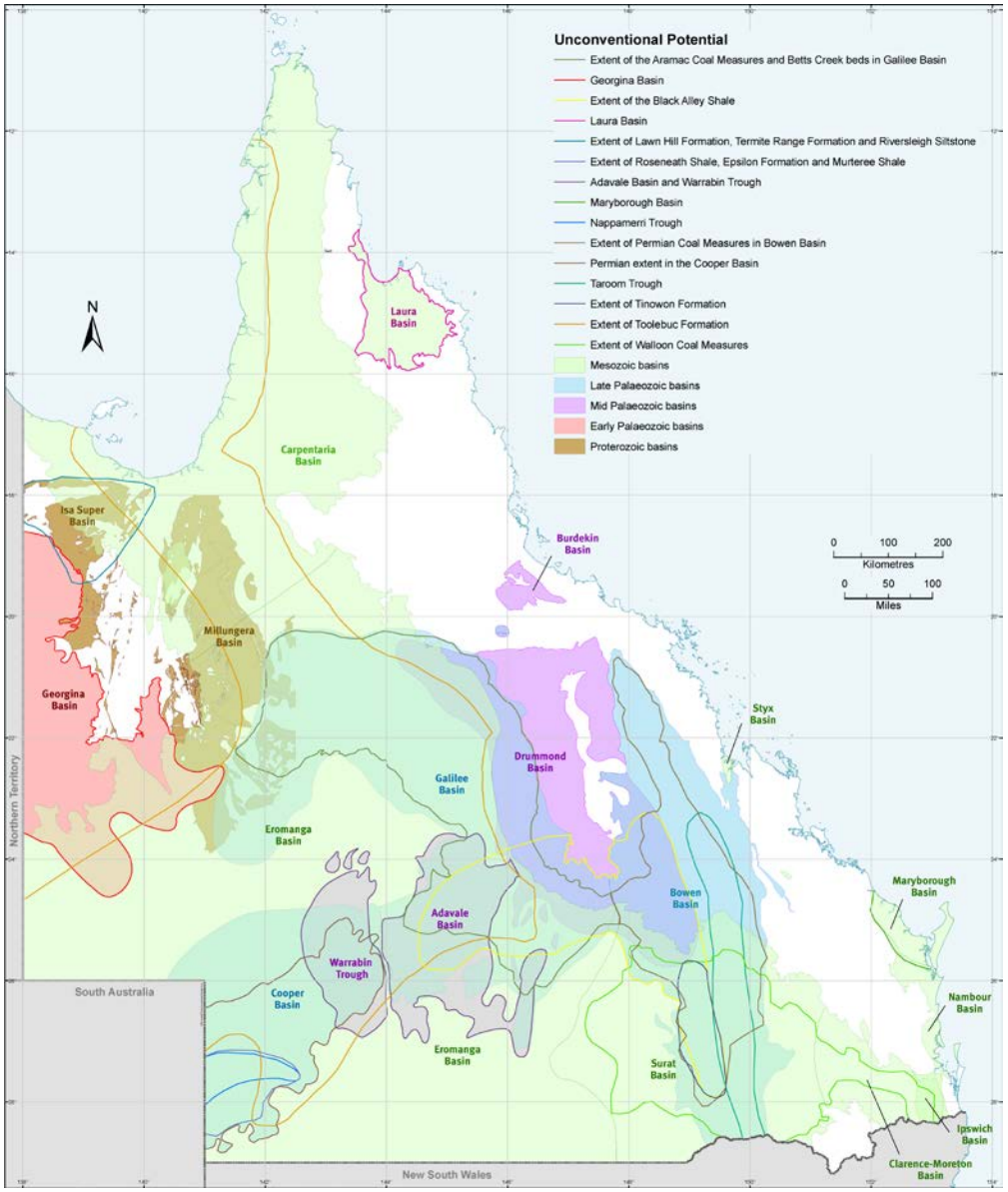
- Unconventional petroleum accumulations may be present along a continuum from source rock to conventional trap
- Requires a shift in the way resources are assessed
- Collaboration between state surveys and Geoscience Australia to undertake regional assessments
- Assessments have adopted USGS methodology for assessment of continuous petroleum
- Geological approach with a focus to define an ‘assessment unit’

Regional Assessment

- **USGS minimum requirements for shale gas assessment:**
  - Net thickness > 15m
  - TOC >2 wt %
  - Kerogen type I, II or IIS
  - Ro > 1.1% (formation within the gas window)
  - Gas is thermogenic
  - Evidence of gas in matrix/organic storage

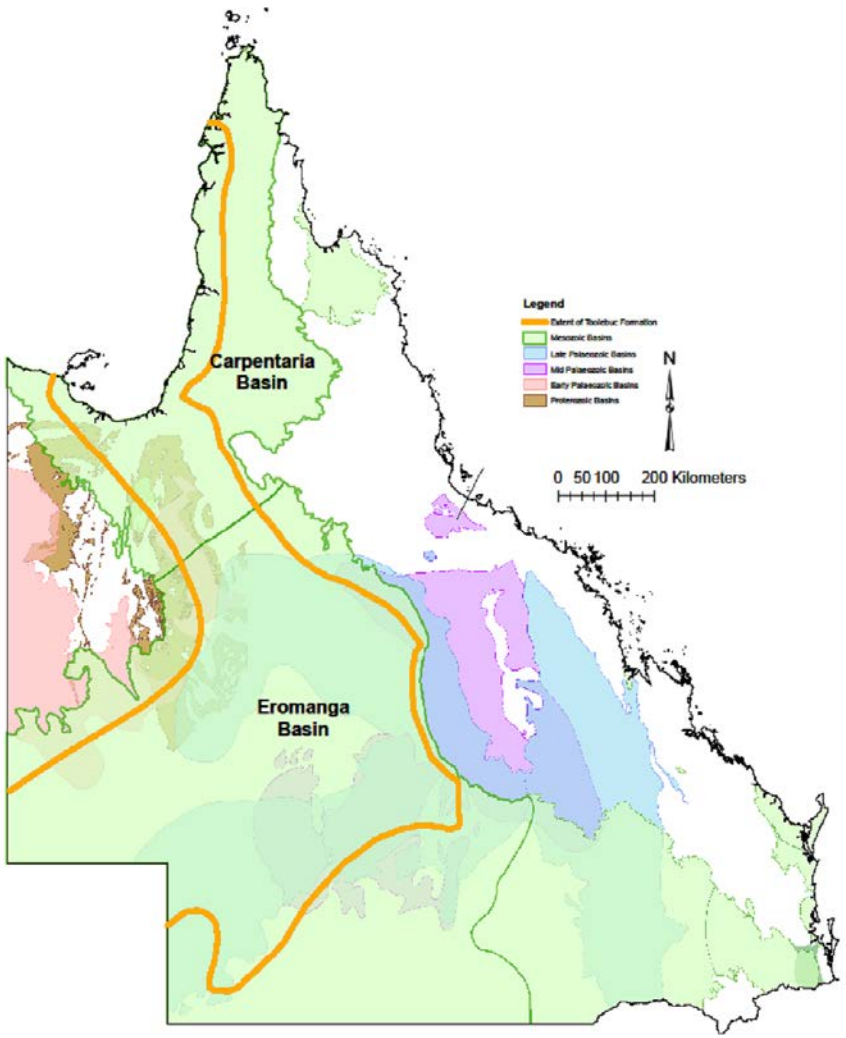
- **Other information that is good to know:**
  - High gamma ray values in shale
  - Hydrogen index of greater than 250mg/g
  - Depth greater than 1500m
  - Not intensely structured
  - Overpressured

Queensland Petroleum Exploration



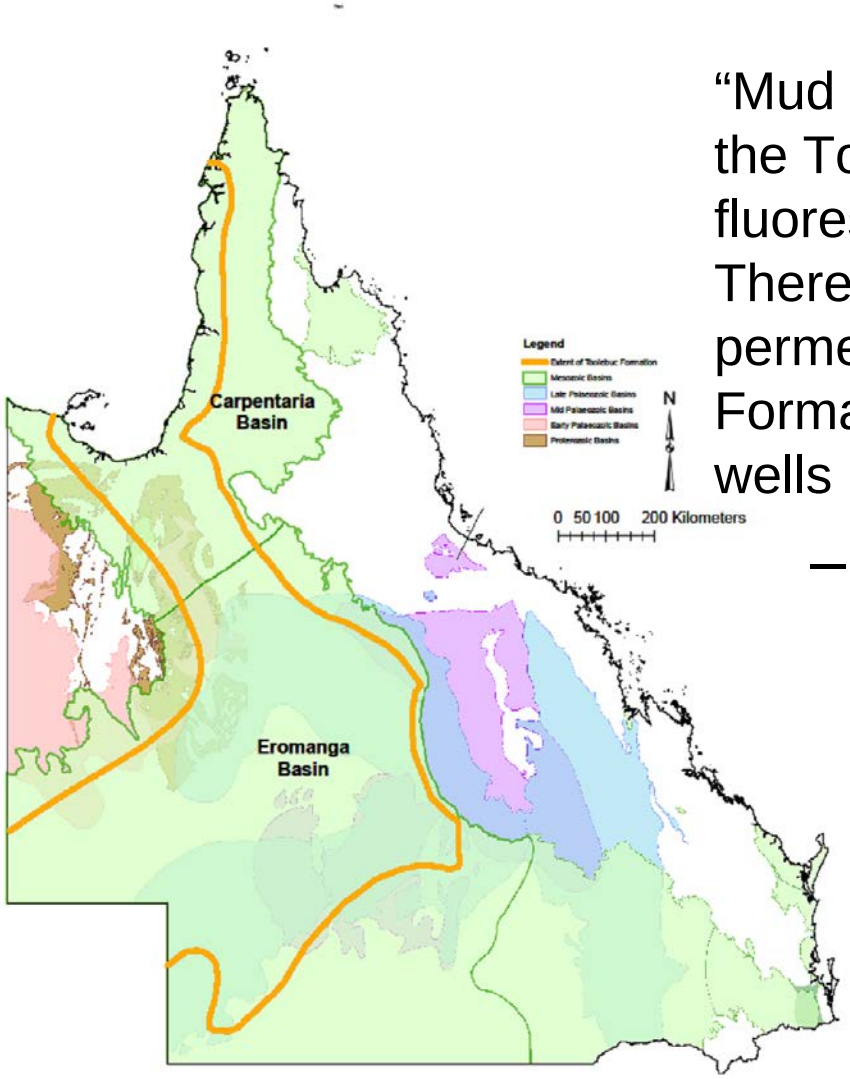
- Nearly every basin in Queensland has been the target of petroleum exploration
- Literature review of well reports and studies highlighted several formations and basins
- Records from conventional exploration used to reassess earlier exploration results
- Many of these formations and basins are data-poor

Toolebuc Formation



- Early Cretaceous marine formation
- Laminated calcareous and kerogenous mudstone, with minor coquinitic limestone and labile sandstone
- Organic rich marine source rock
- Known to have oil shale potential around Julia Creek.
- Distinctive high gamma-ray anomaly
- Typically considered to have low maturity
- Gas shows known from mudlogs

Toolebuc Formation



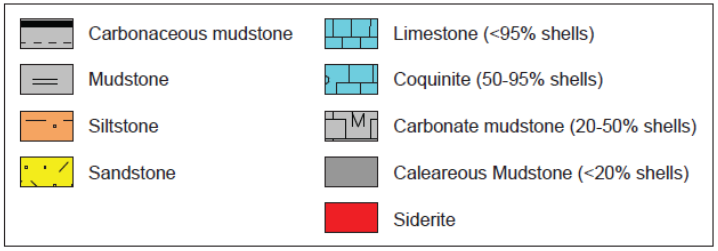
"Mud gas shows were recorded from the Toolebuc Formation where fluorescence and cut were recorded. … There is no recorded porosity or permeability within the Toolebuc Formation even though hundreds of wells have penetrated the interval."

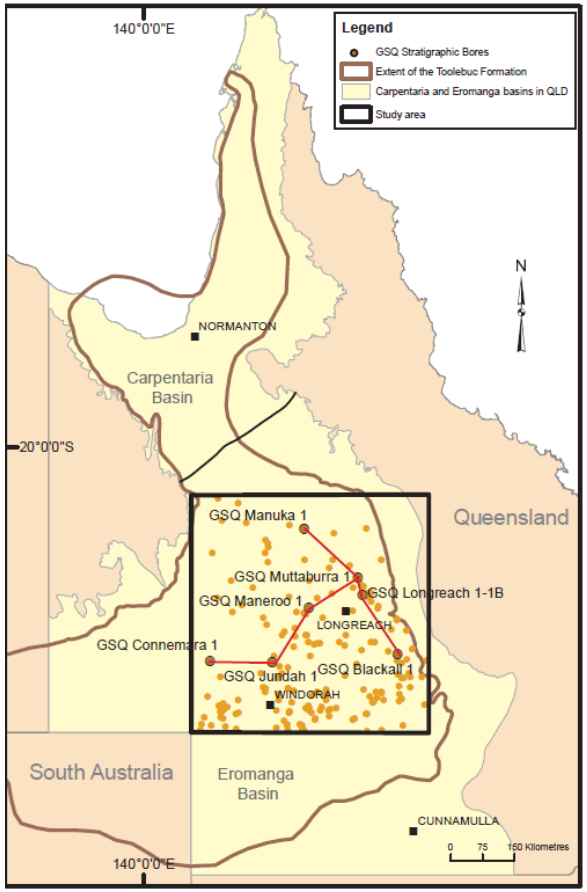
– EEA Rodney Creek 3 1995

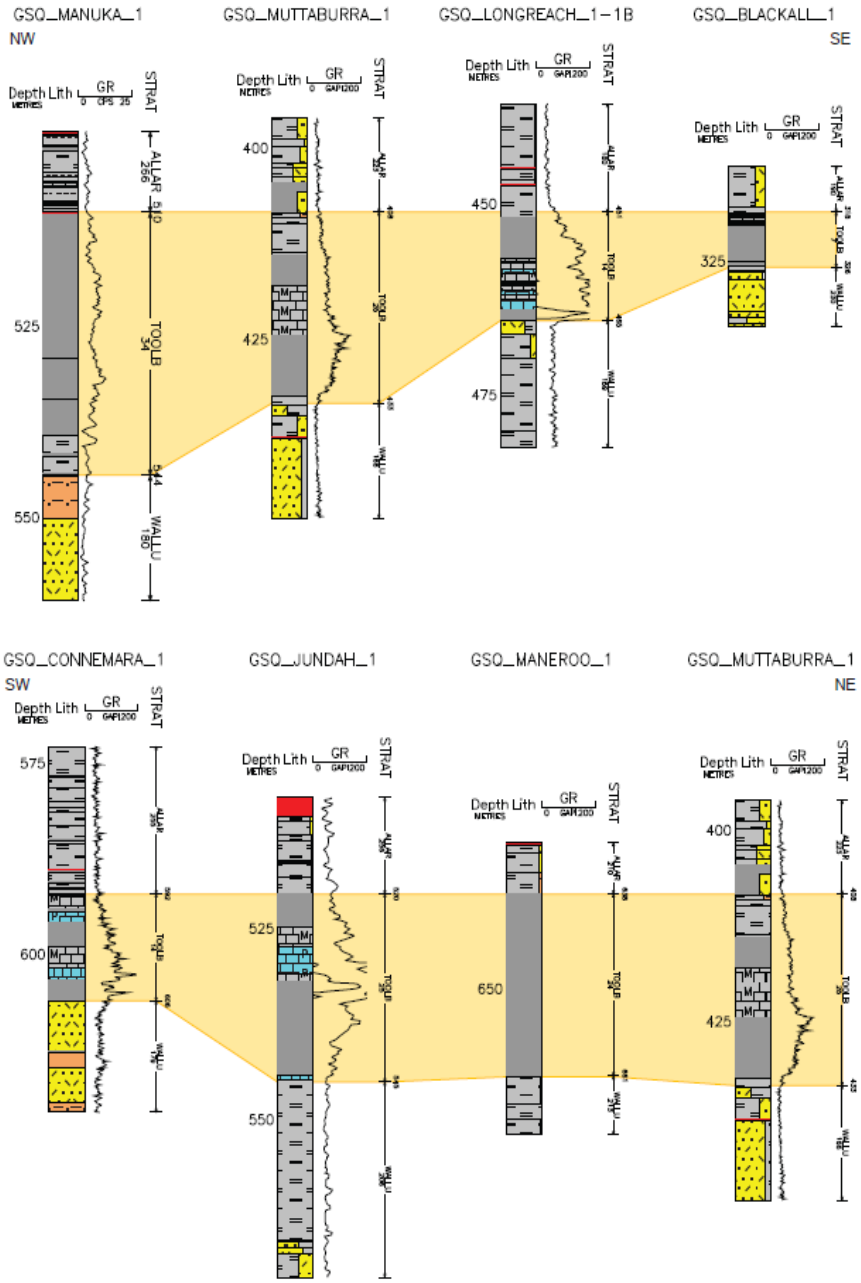
Regional Assessment

- **Lithological Framework** (core logging)
- **Mineralogy** (infrared spectra and XRD analysis)
- **Depth to top** (from formation picks)
- **Gross thickness** (from formation picks)
- **TOC** (pyrolysis and delta log R ‘Passey equation)
- **Thermal Maturity** (R_{vmax} from well profiles, Tmax)
- **Gas composition** (gas chromatography from mudlogs)

Lithological Framework

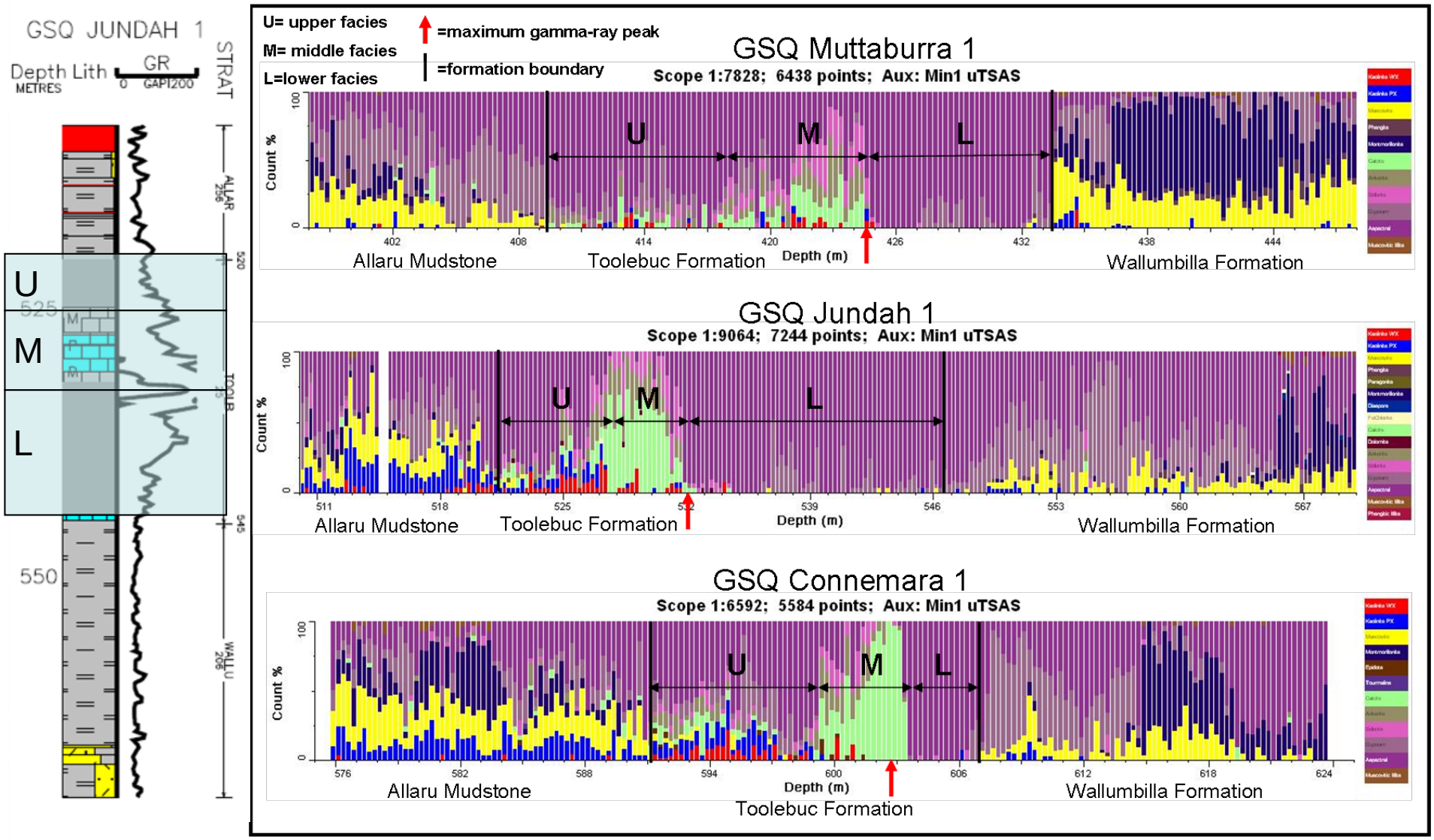






Datum: Top Toolebuc Formation

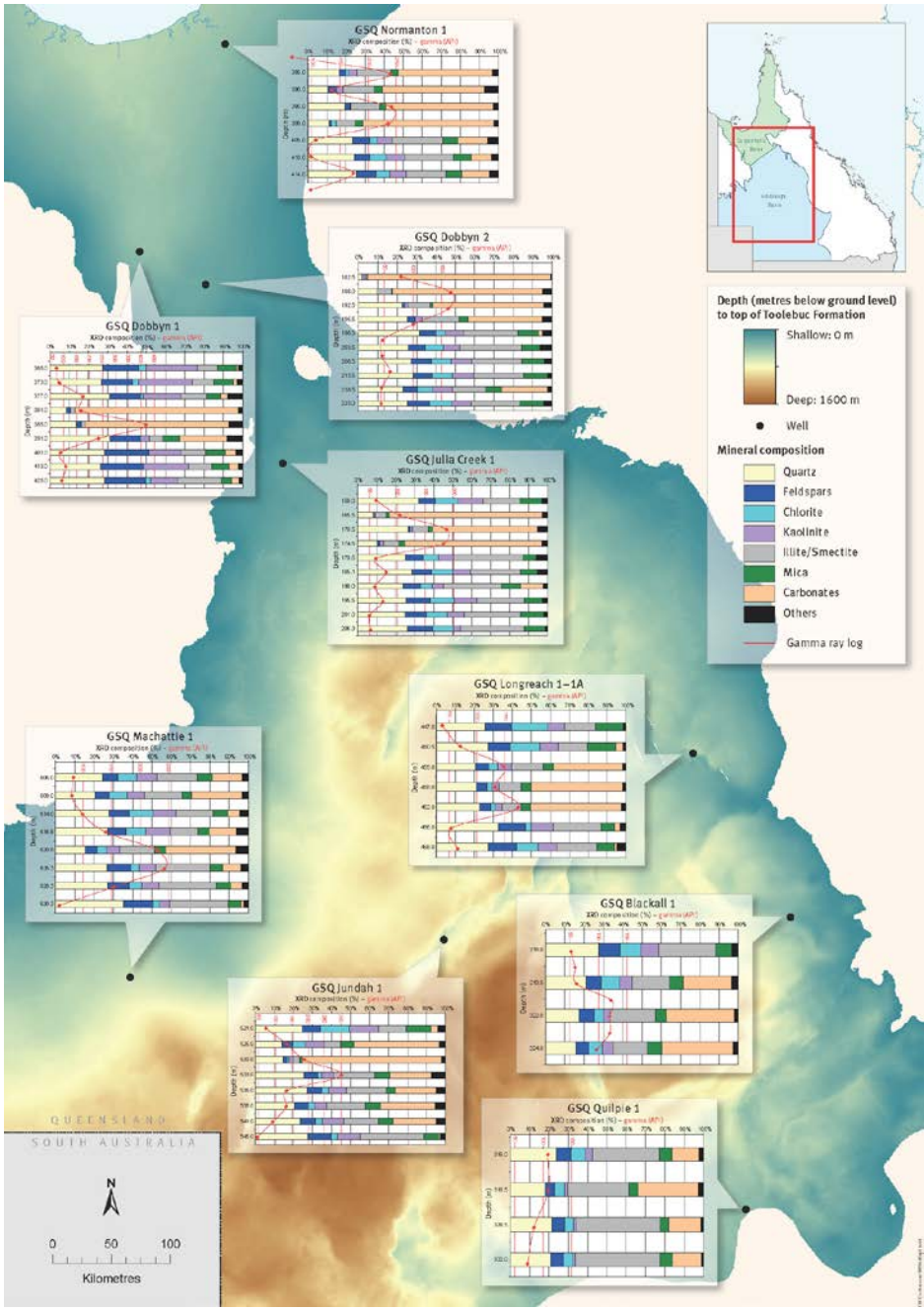
Mineralogy – Shortwave Infrared Hylogger



Down-hole →

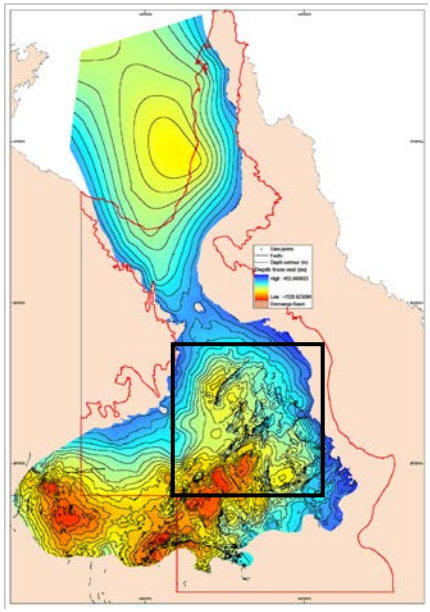
Mineralogy

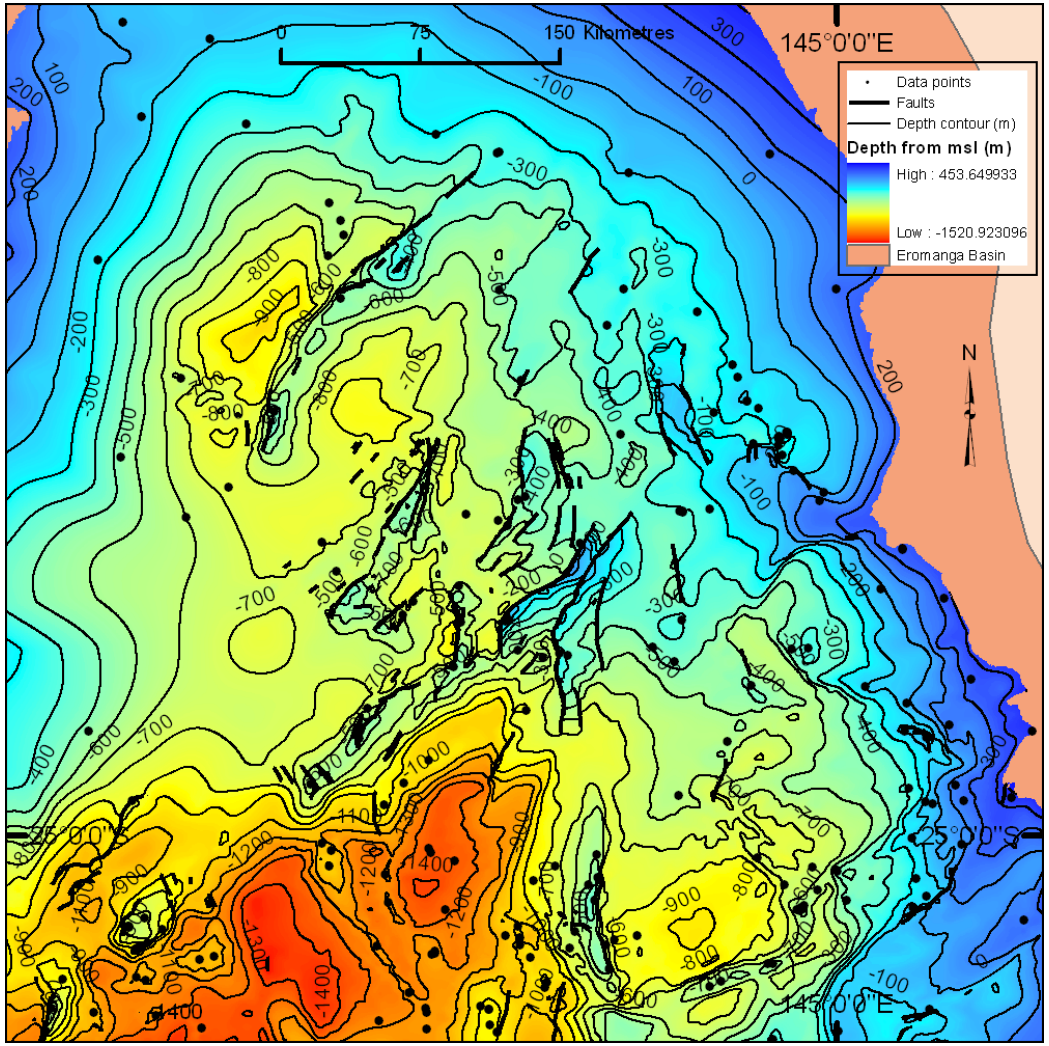
- XRD results show the variability of mineralogy within the formation
- Can be tied to zones observed in core logging and to wireline log character
- High GR values appear to indicate a higher proportion of calcite



Depth to top

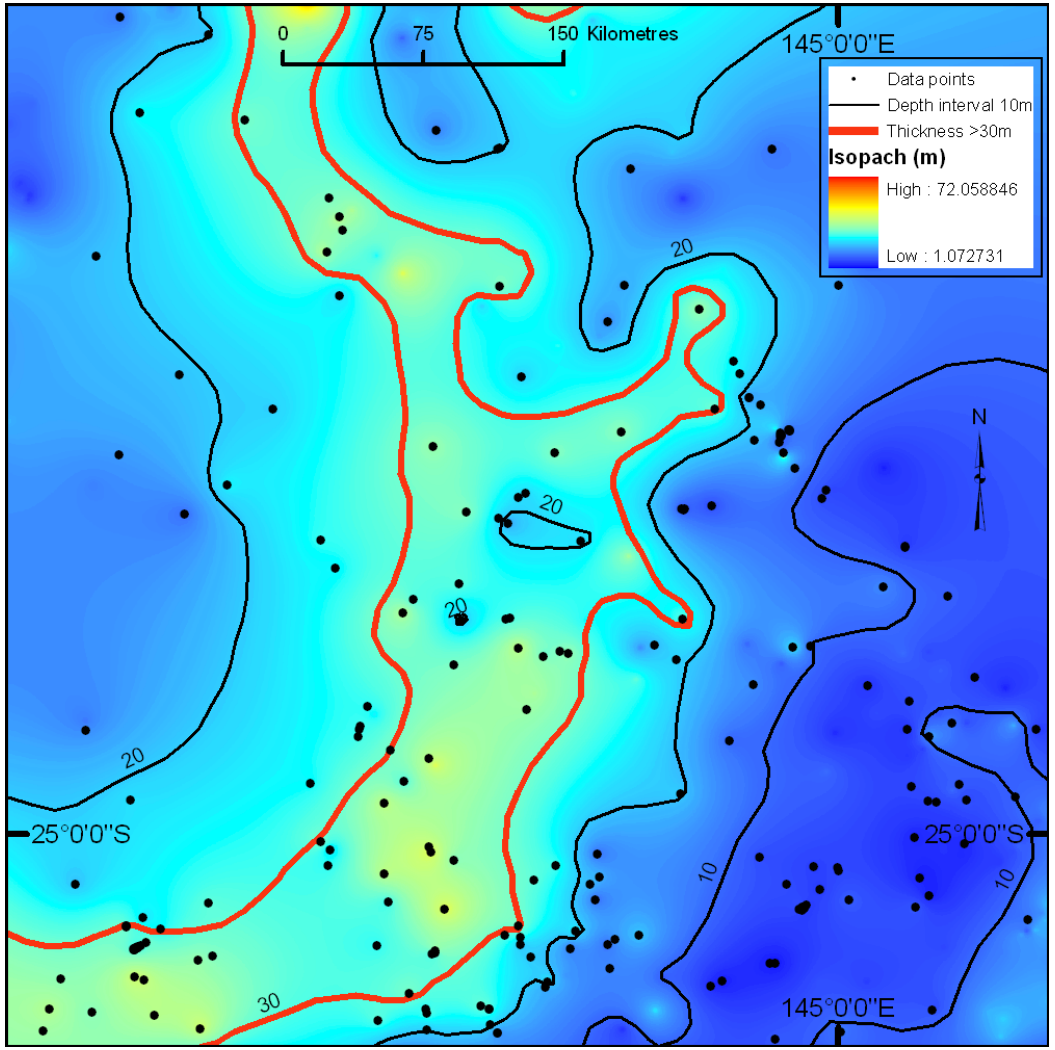
- Relatively shallow
  - Outcrop to approximately 1500m
- Deepens to the south-west
- Shallows to the north into the Carpentaria Basin





Thickness

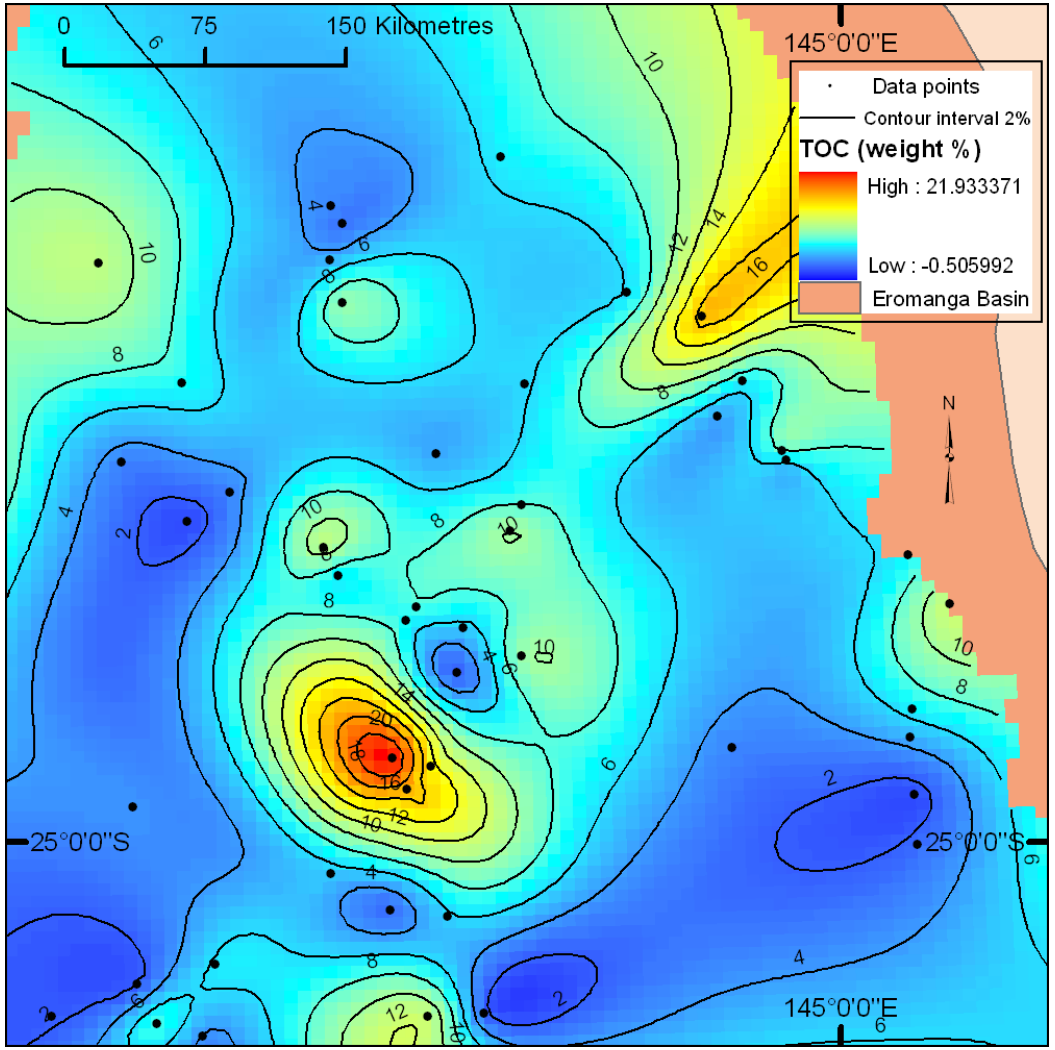
- Average thickness of 23m across the formation
- May exceed 50m in thickness
- Formation is generally thicker over the central part of the project area



Thickness >30m

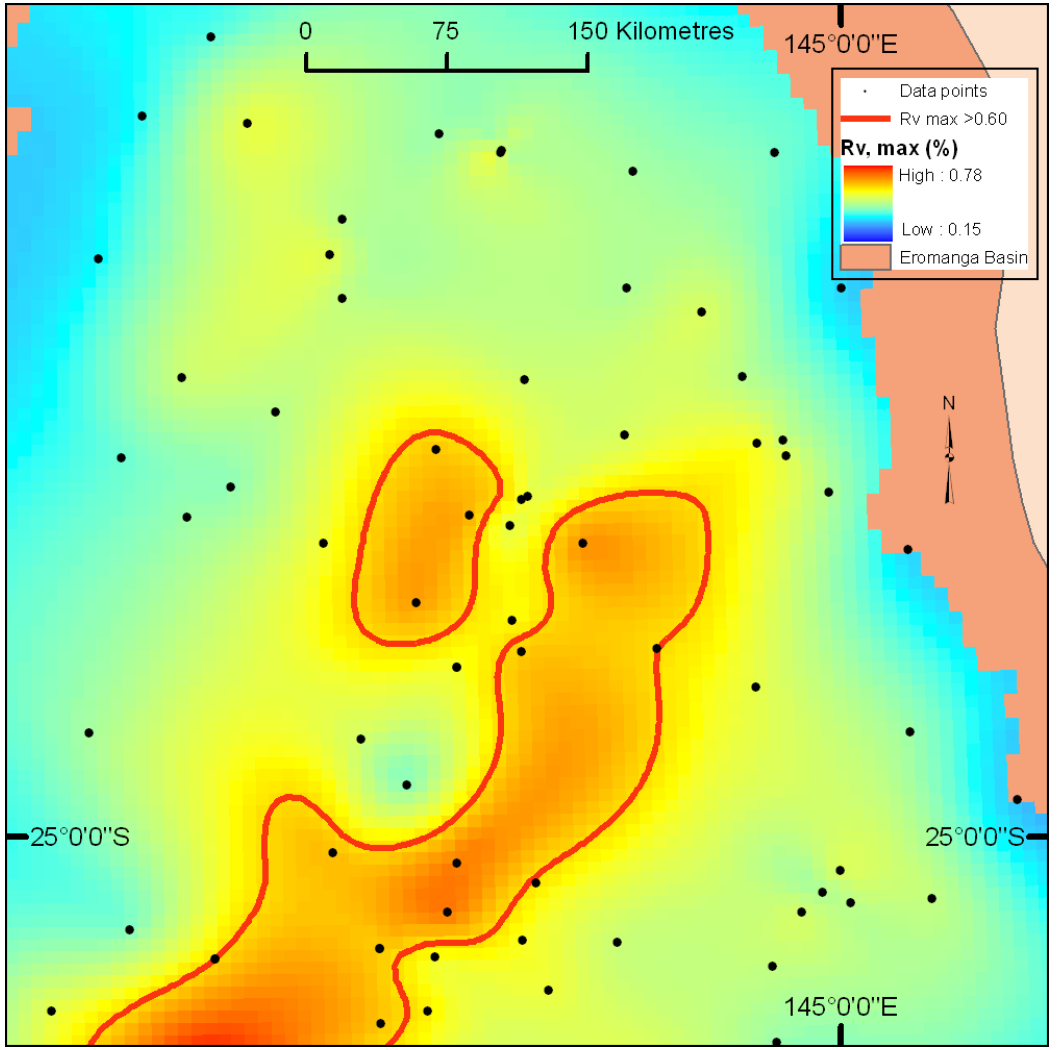
TOC

- TOC ranging from 0.2-26.1 wt %
- Pyrolysis data used where available.
  - Δ log R Passey equation used for additional data
- Exceeds 2 wt% across nearly all of the formation



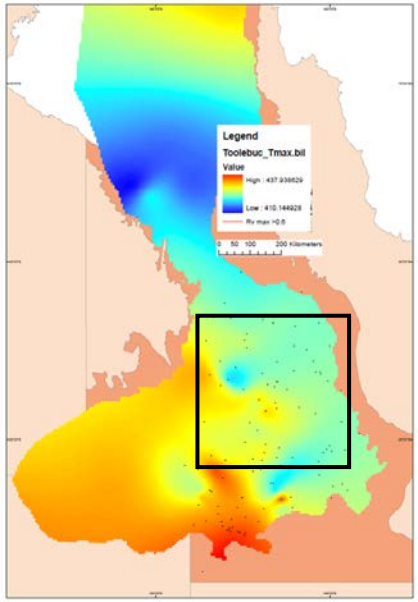
Thermal Maturity

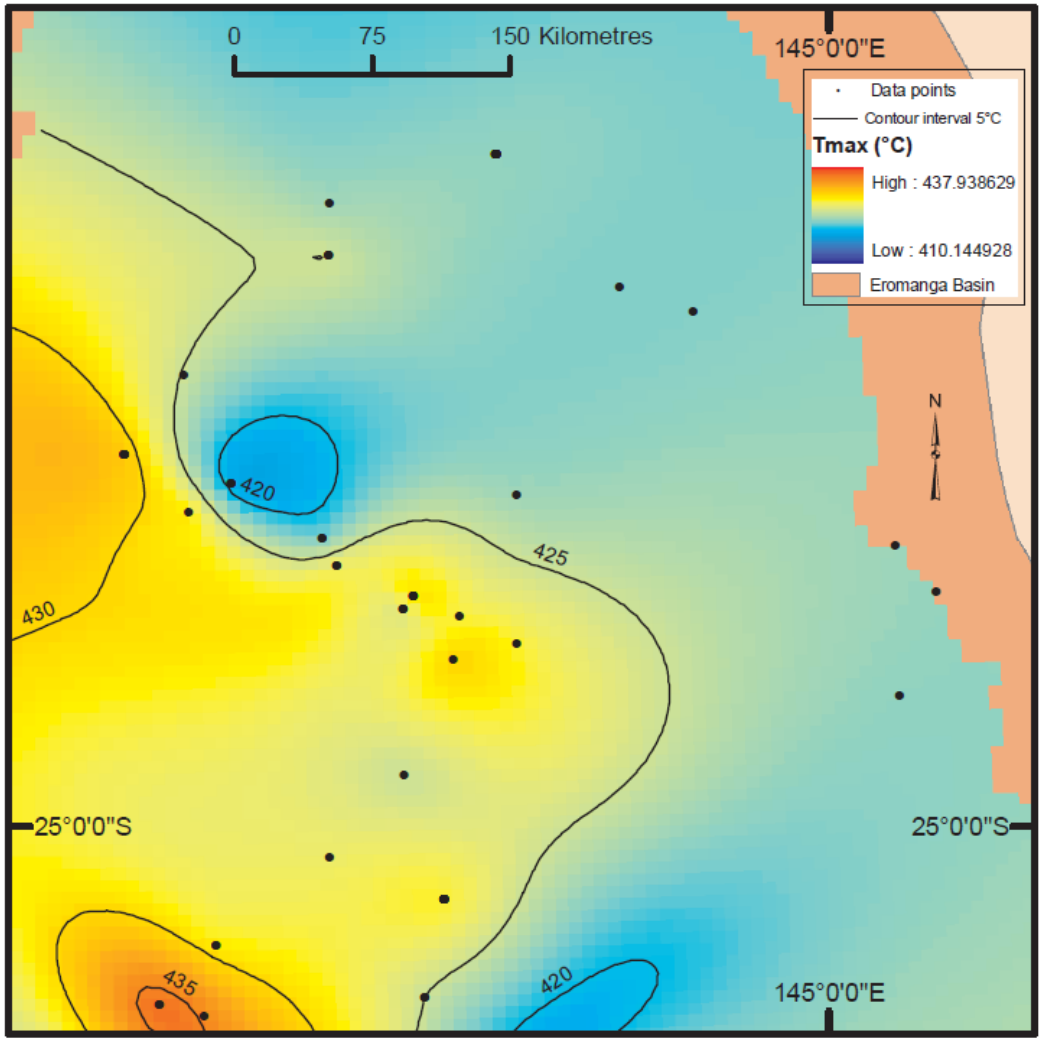
- Rv_{max} has been estimated from reflectance profiles established from petroleum wells across the Eromanga Basin
- Ranges from 0.20 to 0.78%
- Zone of higher maturity through the deeper part of the study area



Thermal Maturity

- Tmax (ºC) data suggests only small areas are mature for generation
- Limited pyrolysis data are available across the extent of the formation.

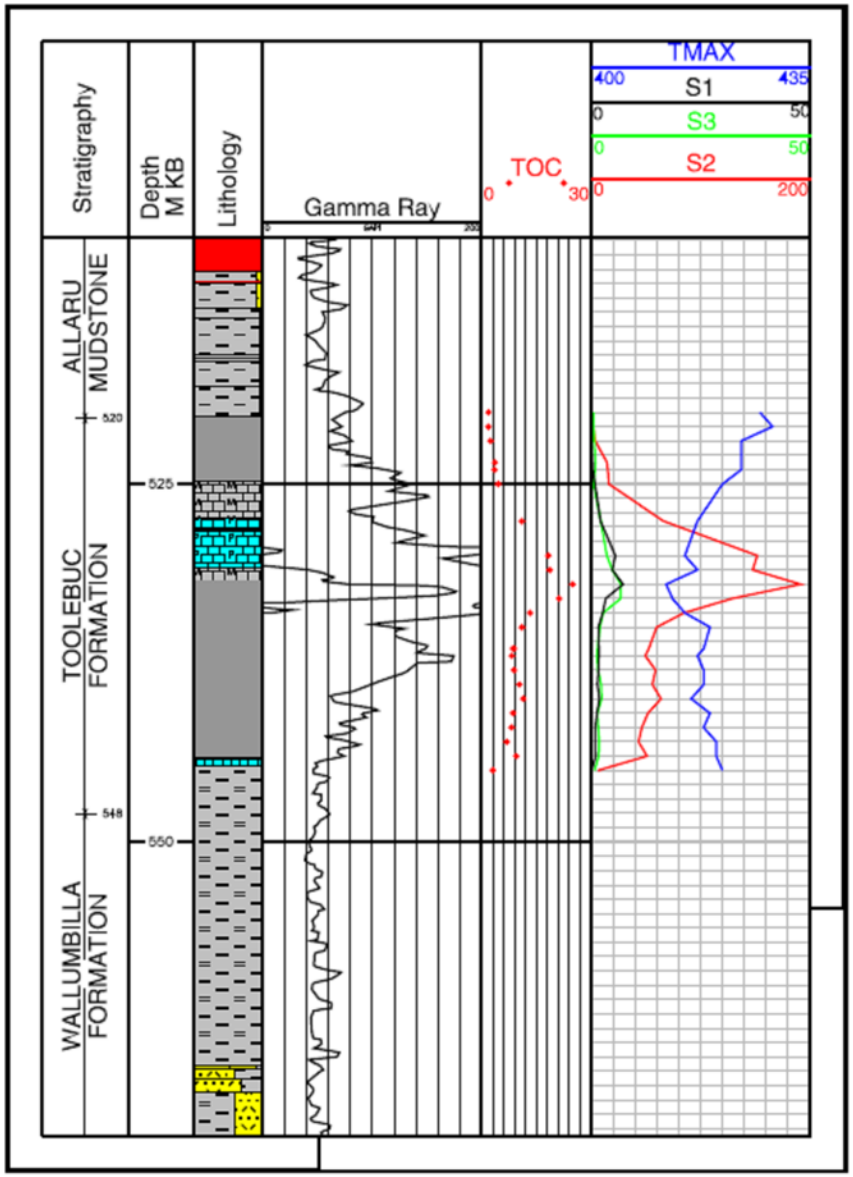




Thermal Maturity

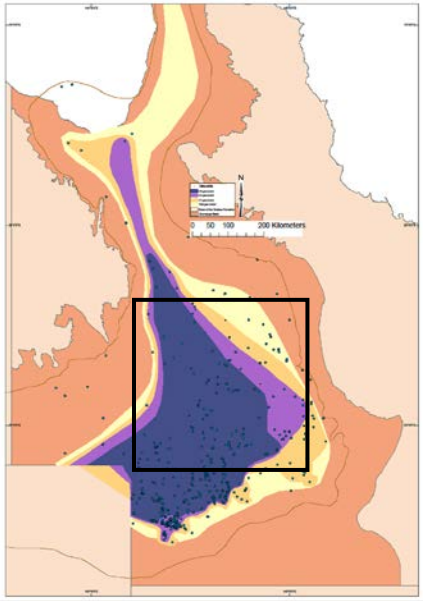
- Pyrolysis profiles over GSQ stratigraphic boreholes show that the T_{max} of the Toolebuc Formation decreases as the TOC increases
- Suggests the Tmax is suppressed, and well profiles will give a better indication

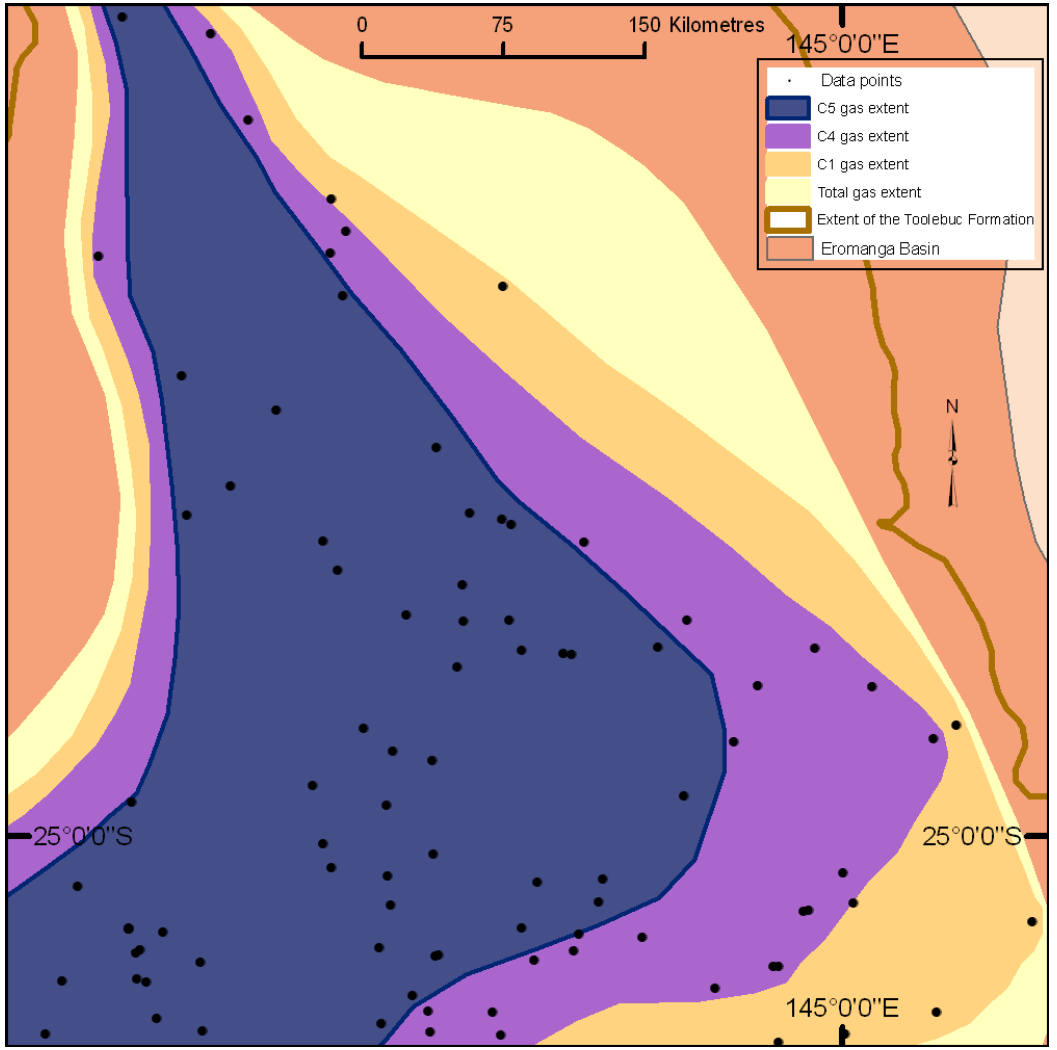
GSQ Jundah 1



Gas composition

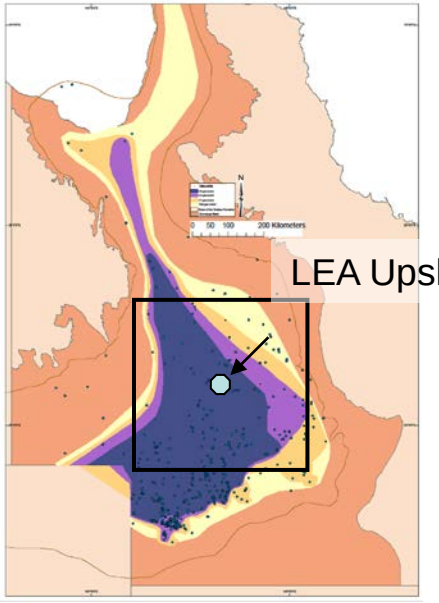
- Methane present across the Toolebuc Formation where depths are greater than 300m
- Gasses up to C5 are present where depths are greater than 600m.
  - C4 and C5 also occur to the north, where the formation is much shallower

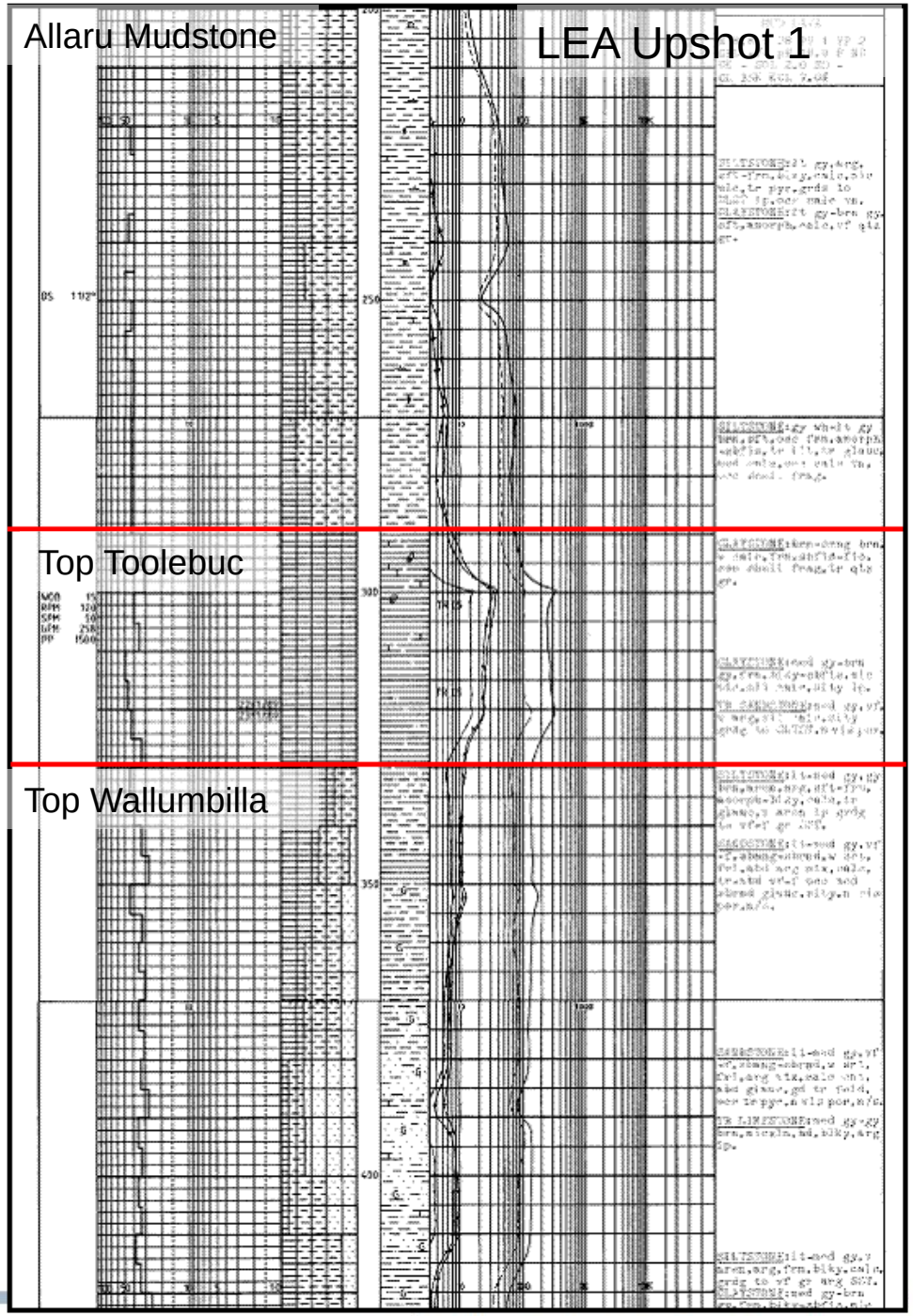




Gas Composition

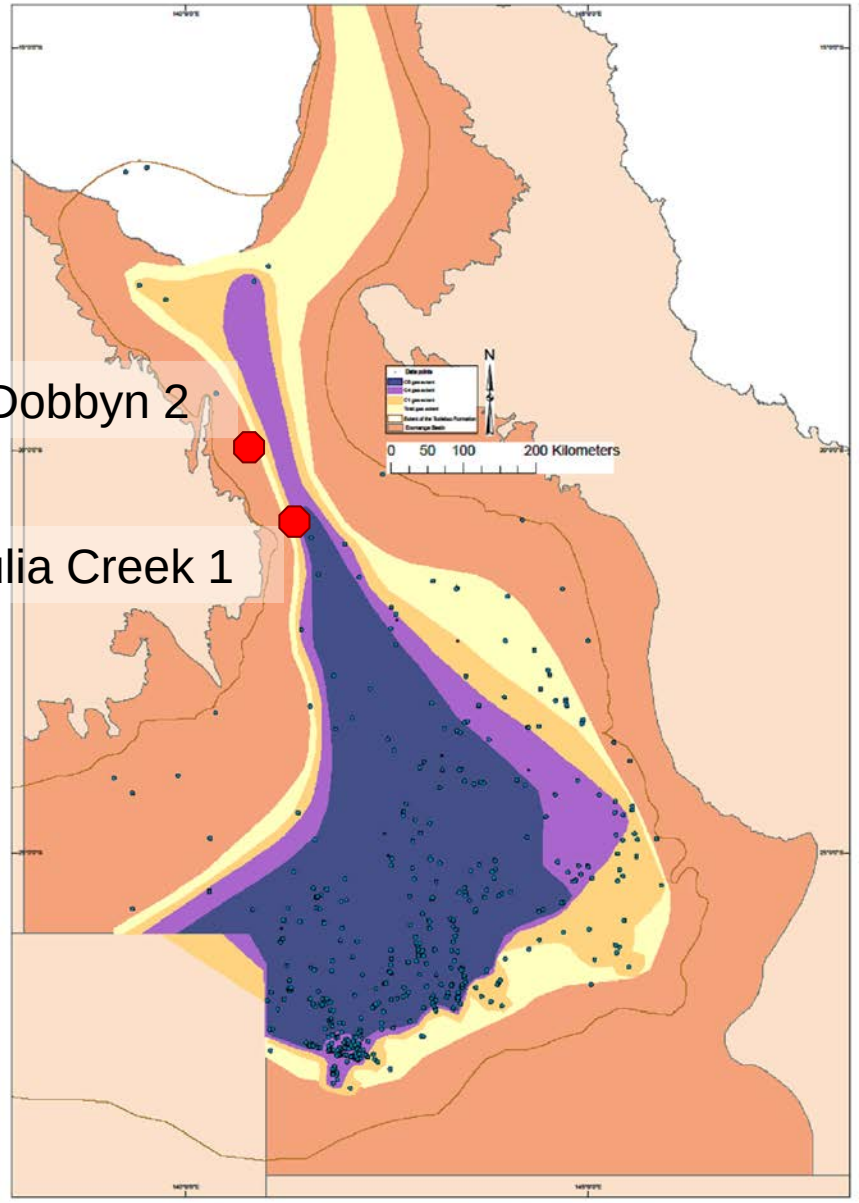
- Strength of the kick varies from well to well
- Peak in the Toolebuc Formation, but also extends into Allaru Mudstone and Wallumbilla Formation.





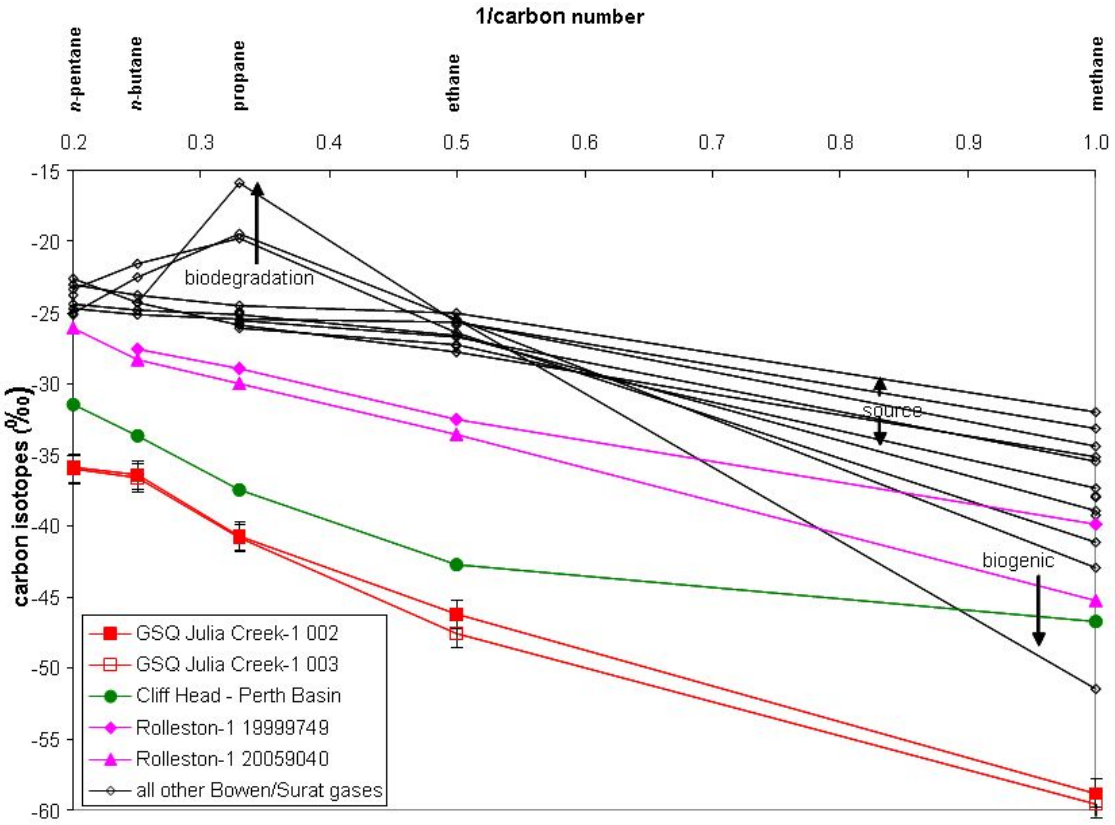
Gas Composition

- Desorption samples from GSQ Julia Creek 1 and GSQ Dobbyn 2 produced small volumes of desorbed gas upon crushing
- These wells are to the north of the study area, where the Toolebuc Formation is approximately 180m deep



Gas Composition

- Results:
  - **Single (early thermogenic) source with little to no biogenic component**

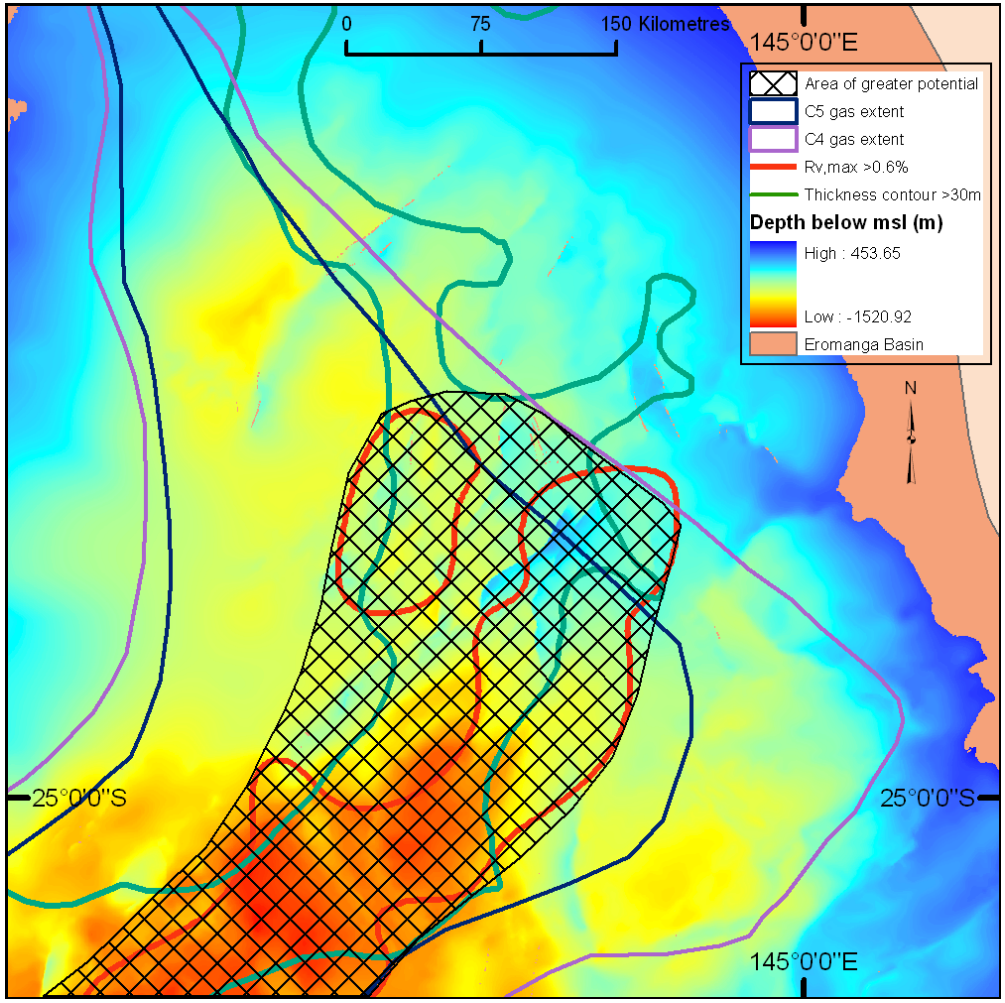


Unpublished data courtesy of Dr Chris Boreham, Geoscience Australia

Gas composition

- Gas wetness ratios calculated from digitised mud logs
- Appear to indicate oil in formation where the formation is deepest and gas in formation at shallower depths

“Sweet Spot”



- **USGS Minimum Requirements for Shale Gas assessment**
  - ✓ **Gross thickness > 30m**
  - ✓ **TOC >2 wt %**
  - ✓ **Kerogen type** I, **II** or IIS
  - – Ro > 1.1% (formation within the gas window)
  - ✓ **Gas is thermogenic**
  - ✓ **Evidence of gas in matrix/organic storage**

Summary

- Regional assessment of key criteria across Queensland has identified several basins and formations that may hold unconventional resources

- Initial assessment of the Toolebuc Formation has highlighted a possible ‘sweet spot’ in the central Eromanga Basin

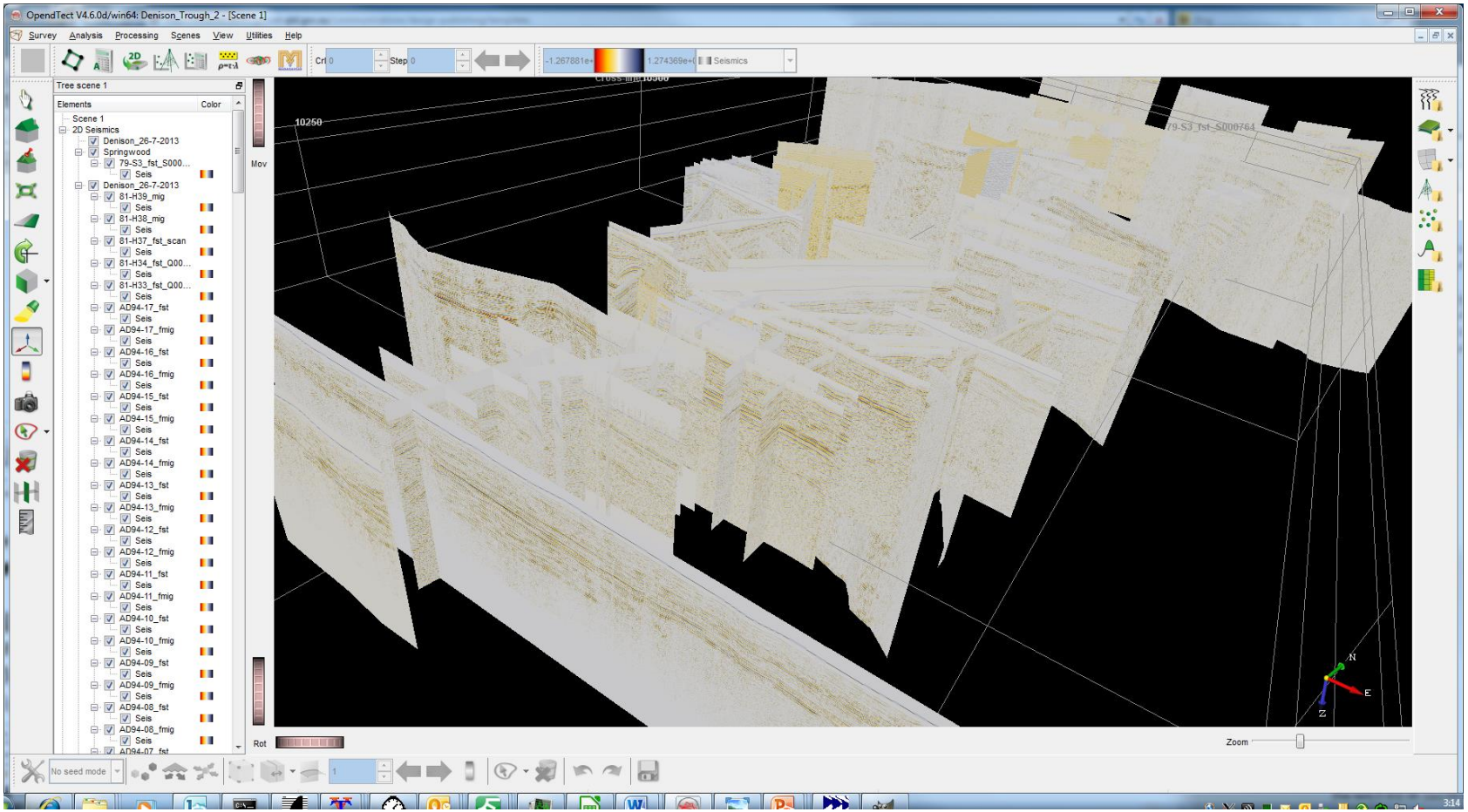
Creating SEGY digital data from scanned images of seismic sections

- making old data live again

Digging Deeper 11
4 December 2013, 111 George Street Brisbane

Owen Dixon
Geological Survey of Queensland, Department of Natural Resources and Mines

What do you need to import seismic data to an interpretation workstation?



What do you need to import seismic data to interpretation workstation?

SEG-Y stack data

What do you need to import seismic data to interpretation workstation?

SEG-Y stack data **EBCDIC header ?**

```
C 1 CLIENT                              COMPANY                                 CREW NO
C 2 LINE              AREA                                MAP ID
C 3 REEL NO             DAY-START OF REEL      YEAR       OBSERVER
C 4 INSTRUMENT: MFG               MODEL               SERIAL NO
C 5 DATA TRACES/RECORD          AUXILIARY TRACES/RECORD          CDP FOLD
C 6 SAMPLE INTERVAL           SAMPLES/TRACE        BITS/IN      BYTES/SAMPLE
C 7 RECORDING FORMAT          FORMAT THIS REEL          MEASUREMENT SYSTEM
C 8 SAMPLE CODE: FLOATING PT      FIXED PT      FIXED PT-GAIN      CORRELATED
C 9 GAIN  TYPE: FIXED      BINARY      FLOATING POINT      OTHER
C10 FILTERS: ALIAS      HZ  NOTCH      HZ  BAND      -      HZ  SLOPE     -    DB/OCT
C11 SOURCE: TYPE              NUMBER/POINT          POINT INTERVAL
C12     PATTERN:                                  LENGTH         WIDTH
C13 SWEEP: START      HZ  END      HZ  LENGTH       MS  CHANNEL NO      TYPE
C14 TAPER: START LENGTH         MS  END LENGTH         MS  TYPE
C15 SPREAD: OFFSET          MAX DISTANCE          GROUP INTERVAL
C16 GEOPHONES: PER GROUP      SPACING      FREQUENCY      MFG            MODEL
C17     PATTERN:                                  LENGTH         WIDTH
C18 TRACES SORTED BY: RECORD      CDP      OTHER
C19 AMPLITUDE RECOVERY: NONE       SPHERICAL DIV        AGC     OTHER
C20 MAP PROJECTION                          ZONE ID        COORDINATE UNITS
C21 PROCESSING:
C22 PROCESSING:
C23
C24
C25
C26
C27
C28
C29
C30
C31
C32
C33
C34
C35
C36
C37
C38
C39
C40 END EBCDIC
```

What do you need to import seismic data to interpretation workstation?

SEG-Y stack data

EBCDIC header ?
Binary header ?

What do you need to import seismic data to interpretation workstation?

SEG-Y stack data

EBCDIC header ?
Binary header ?
Trace – station relationship ?

What do you need to import seismic data to interpretation workstation?

SEG-Y stack data

- EBCDIC header ?
- Binary header ?
- Trace – station relationship ?
- Location data ?

What do you need to import seismic data to interpretation workstation?

SEG-Y stack data

- EBCDIC header ?
- Binary header ?
- Trace – station relationship ?
- Location data ?

Reprocess

What do you need to import seismic data to interpretation workstation?

SEG-Y stack	**EBCDIC header ?**
	Binary header ?
	Trace – station relationship ?
	Location data ?
Reprocess	**Field tapes**
	Support data
	Time

What do you need to import seismic data to interpretation workstation?

SEG-Y stack	**EBCDIC header ?**
	Binary header ?
	Trace – station relationship ?
	Location data ?
Reprocess	**Field tapes**
	Support data
	Time
Seismic Section	

What do you need to import seismic data to interpretation workstation?

SEG-Y stack	**EBCDIC header ?**
	Binary header ?
	Trace – station relationship ?
	Location data ?
Reprocess	**Field tapes**
	Support data
	Time
Seismic Section	
	Import and rectify image

What do you need to import seismic data to interpretation workstation?

SEG-Y stack	**EBCDIC header ?**
	Binary header ?
	Trace – station relationship ?
	Location data ?
Reprocess	**Field tapes**
	Support data
	Time
Seismic Section	
	Import and rectify image
	Scan image to SEG-Y

What do you need to import seismic data to interpretation workstation?

SEG-Y stack

- EBCDIC header ?
- Binary header ?
- Trace – station relationship ?
- Location data ?

Reprocess

- Field tapes
- Support data
- Time

Seismic Section

- Import and rectify image
- Scan image to SEG-Y

Commercial services and software

What do you need to import seismic data to interpretation workstation?

SEG-Y stack

- EBCDIC header ?
- Binary header ?
- Trace – station relationship ?
- Location data ?

Reprocess

- Field tapes
- Support data
- Time

Seismic Section

- Import and rectify image
- Scan image to SEG-Y
  - Commercial services and software
  - Open-source software

Baking a SEG-Y file

Creating SEG-Y digital data from scanned images of seismic sections

from a scanned image

using generic ingredients

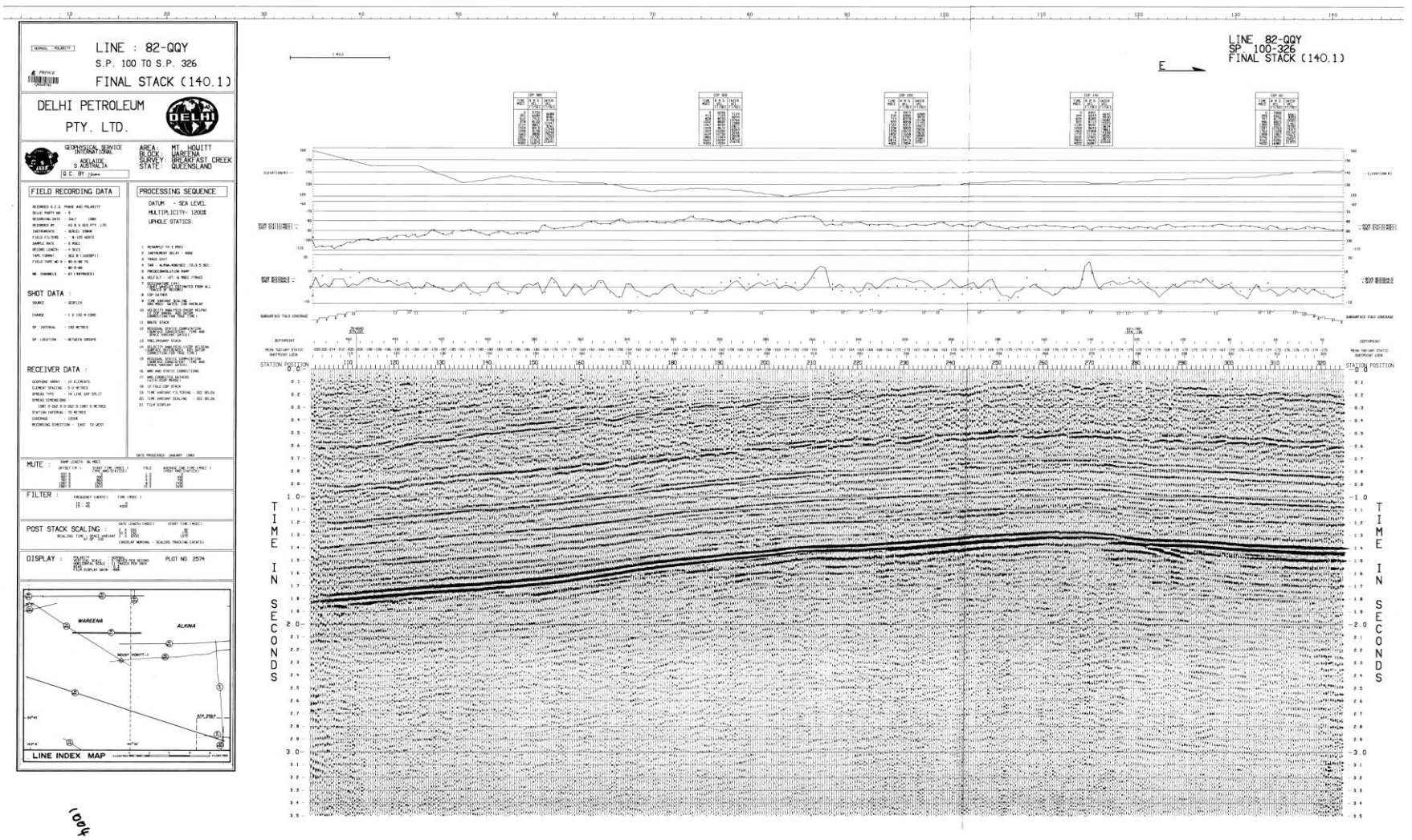
rather than the premium products

- making old data live again

Ingredients :

Scanned seismic section

Location data



Ingredients :

Scanned seismic section
Location data

Utensils :

Image editing software (GIMP – Gnu Image Manipulation Program)
Seismic Unix (SU) in Unix/Linux environment

Ingredients :

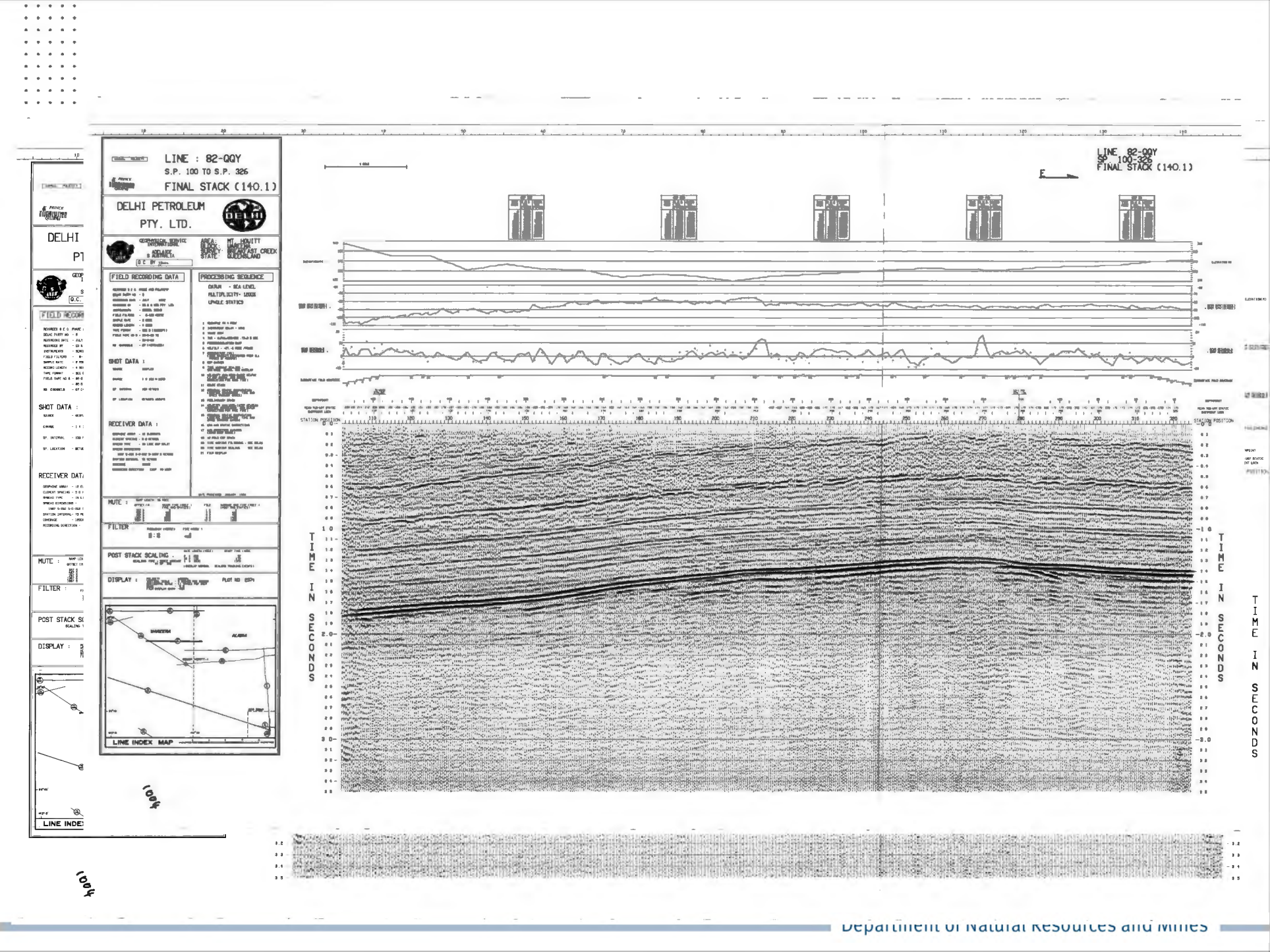
Scanned seismic section
Location data

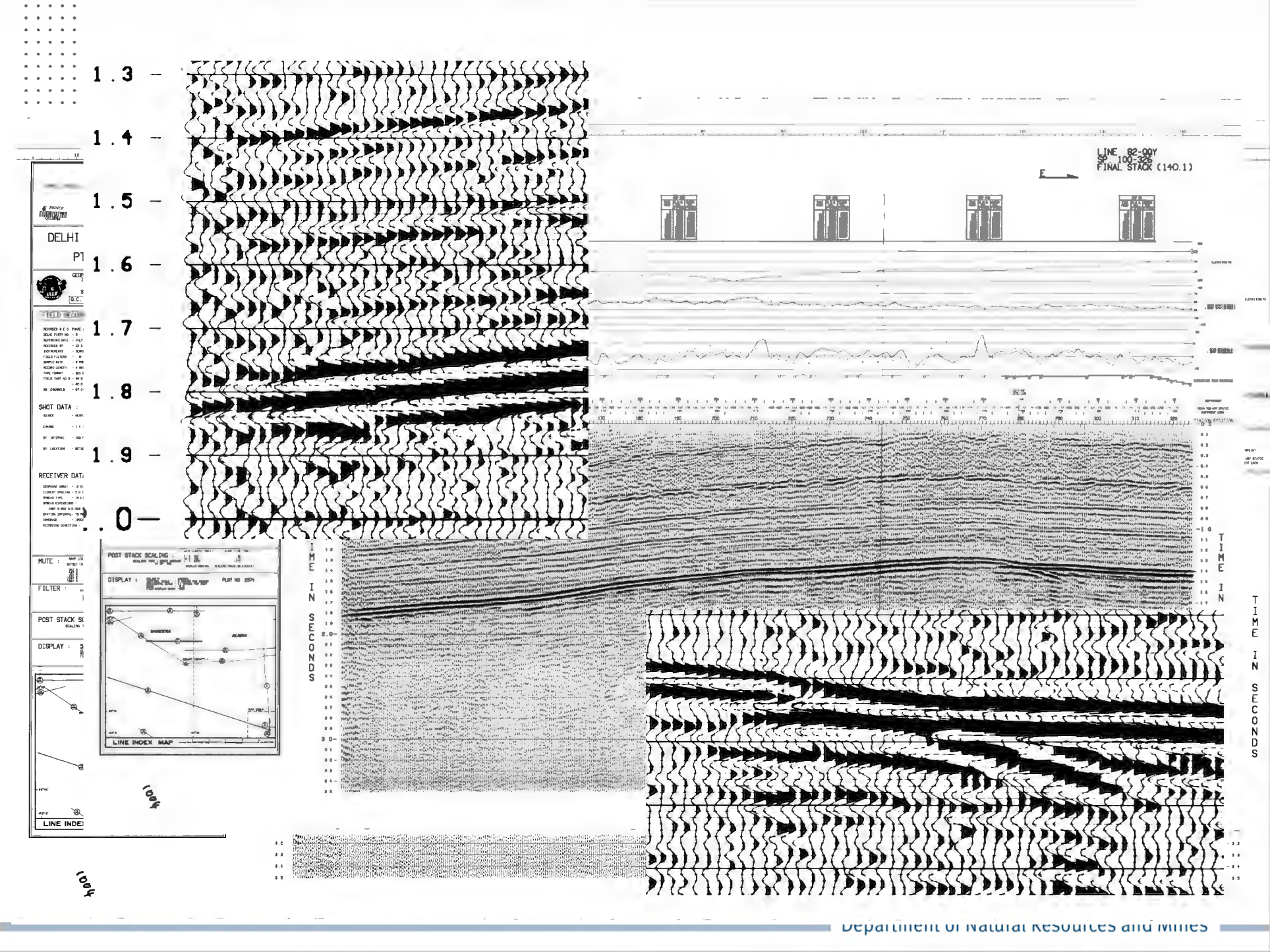
Utensils :

Image editing software (GIMP – Gnu Image Manipulation Program)
Seismic Unix (SU) in Unix/Linux environment

Kitchen :

Windows PC running GIMP
with xterm window to SUN sparc running SU
Windows PC hosting virtual machine running
Fedora with both GIMP and SU
Windows PC running GIMP with
CYGWIN/X running SU
Elderly laptop running Fedora (GIMP and SU)


LINE : 82-QGY
S.P. 100 TO S.P. 326
FINAL STACK (140.1)
DELHI PETROLEUM PTY. LTD.
FIELD RECORDING DATA
PROCESSING SEQUENCE
SHOT DATA :
RECEIVER DATA :
MUTE :
FILTER
POST STACK SCALING :
DISPLAY :
LINE INDEX MAP
LINE 82-QGY
SP 100-326
FINAL STACK (140.1)
TIME IN SECONDS
STATION POSITION


1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
LINE 82-00Y
SP 100-325
FINAL STACK (140.1)
TIME IN SECONDS
POST STACK SCALING :
DISPLAY :
LINE INDEX MAP
SHOT DATA :
RECEIVER DATA
MUTE :
FILTER :
DISPLAY :

1. **Do NOT start playing with the data - yet**

1. **Do NOT start playing with the data – yet**

2. **Prepare basic support information and parameters**

(Survey, LINE, Company, Data type, Source, Geometry, Seismic datum, Geodetic datum, Shotpoint and CDP ranges Trace length, Sampling interval, Filters, scan reference, Location data)

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3. **Prepare the auxiliary data for headers :**

EBCDIC header
Binary header
Trace headers

1. **Do NOT start playing with the data – yet**

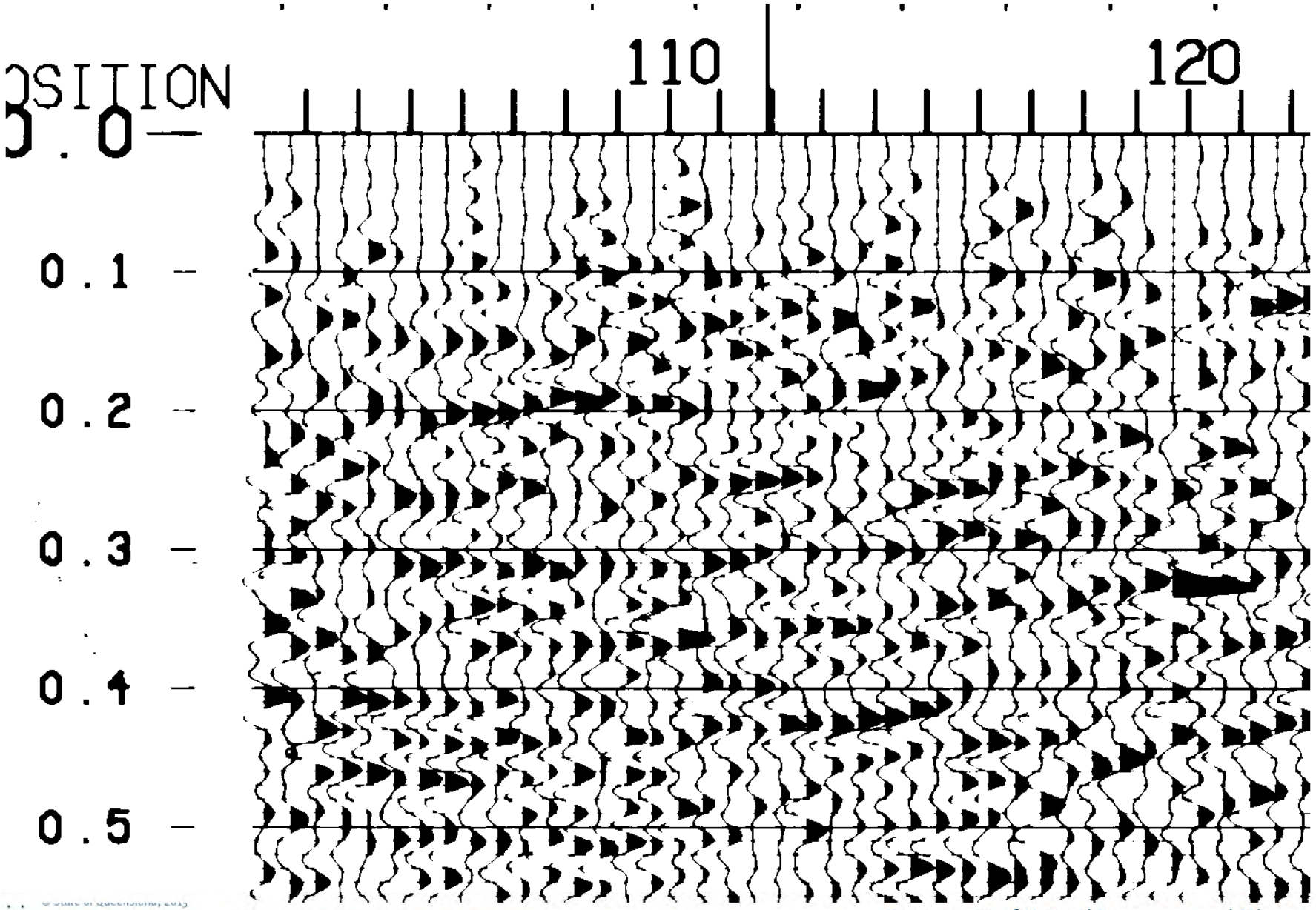
2. **Prepare basic support information and parameters**

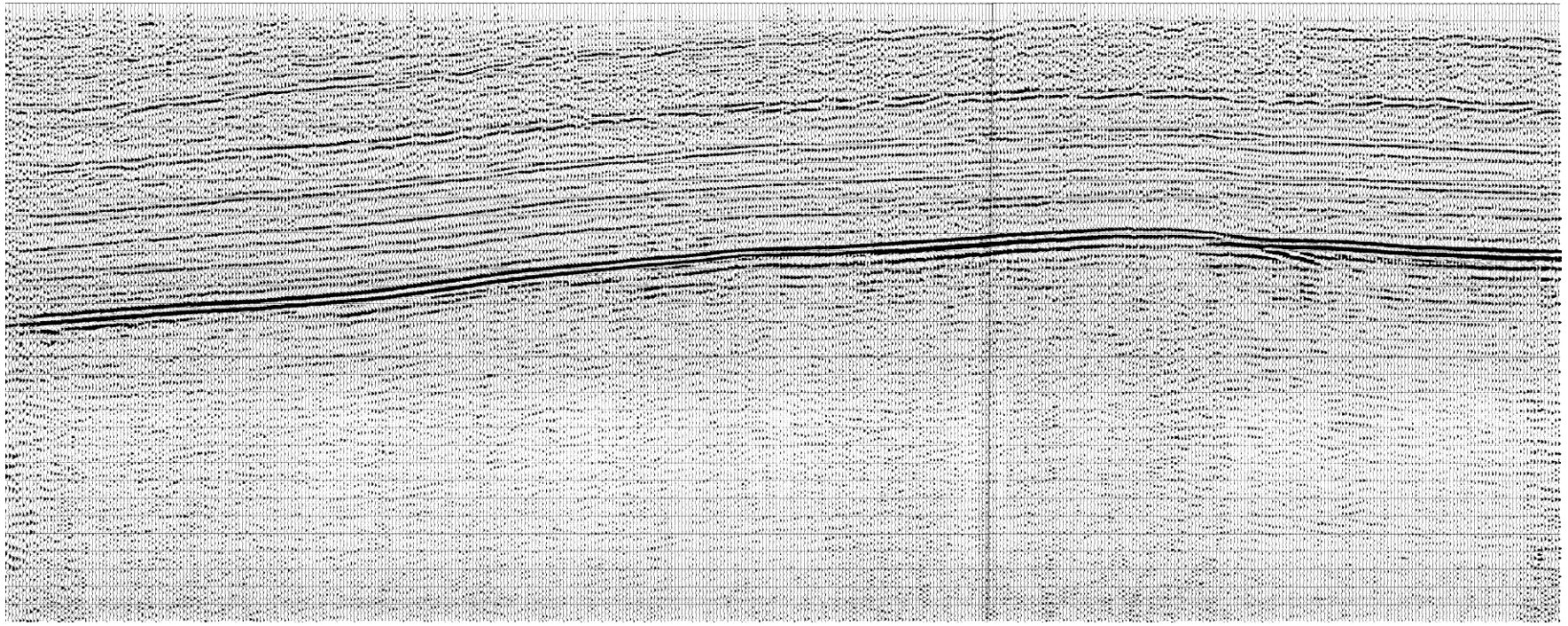
(Survey, LINE, Company, Data type, Source, Geometry,
Seismic datum, Geodetic datum, Shotpoint and CDP ranges
Trace length, Sampling interval Filters, scan reference
Location data)

3. **Prepare all of the auxiliary files :**

EBCDIC header
Binary header
Location data

and set aside in a warm place to rise





Rectified 8-bit greyscale bitmap

Query database for parameters and pass to SU script :

“scan_to_segy 82-QQY_Q0038703 7000 500 102 324.5 32 0.25
10 14 50 60 8 12 40 50 1000 8 12 40 50 2000 20 0 128
300 0 Breakfast_Creek 0 54 Q0038703 1.3 1”

And put it in the oven

- **remove bitmap headers and trailing bytes**
- recast 8-bit binary data to floating point
- rotate resulting grid to set fast dimension in time
- resample in the time dimension to an even, high sampling rate
- resample in the trace dimension to an even number of stripes per data trace
- optional timing line and noise reduction by blurring and threshold
- add trace headers with proper CDP relations
- stack on CDP
- apply time-variant filter matching that of original data
- resample in time to final sample rate
- optional amplitude adjustment to recover relative amplitudes
- wave-shaping to account for distortion from only using positive wave data
- final time-variant filter pass
- populate coordinate data in trace headers
- create ebcdic and binary headers
- output final SEG-Y file

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- **resample in the time dimension to an even, high sampling rate**
- resample in the trace dimension to an even number of stripes per data trace
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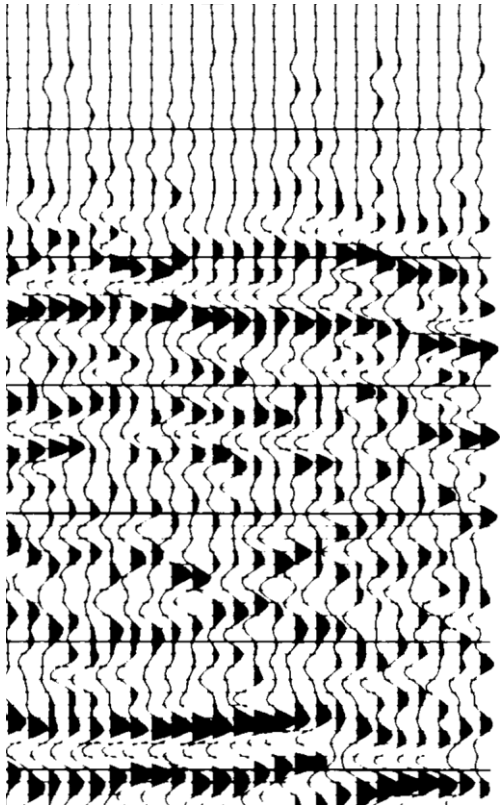
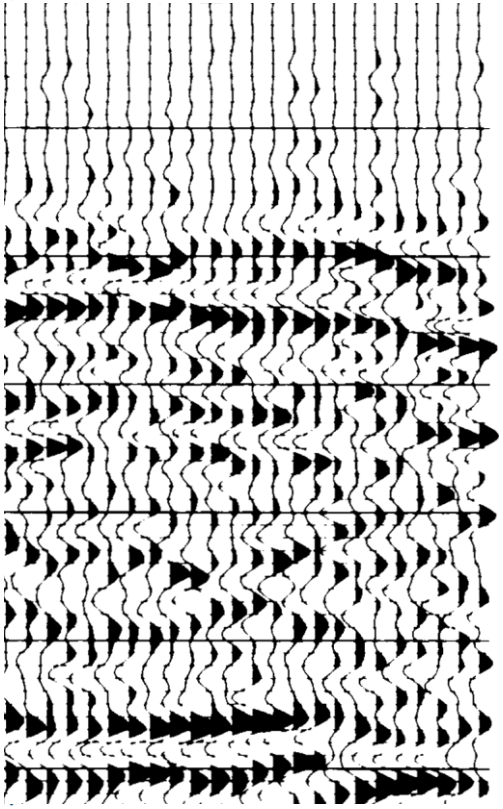
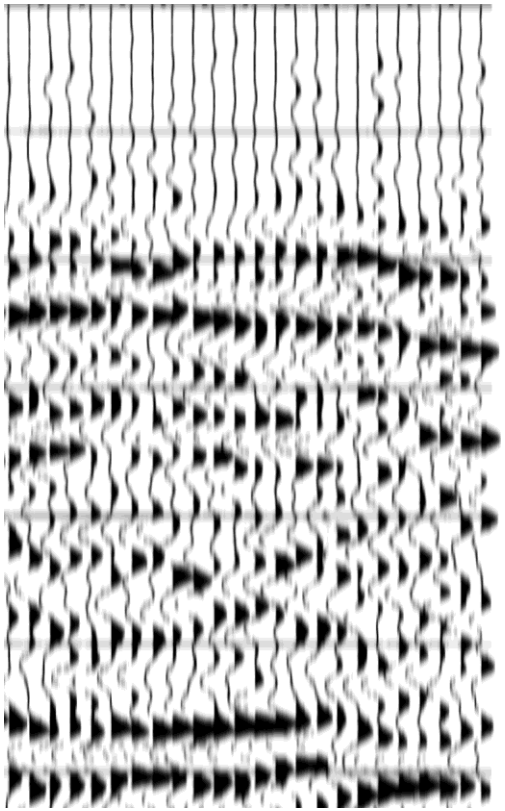
Timing Lines !!

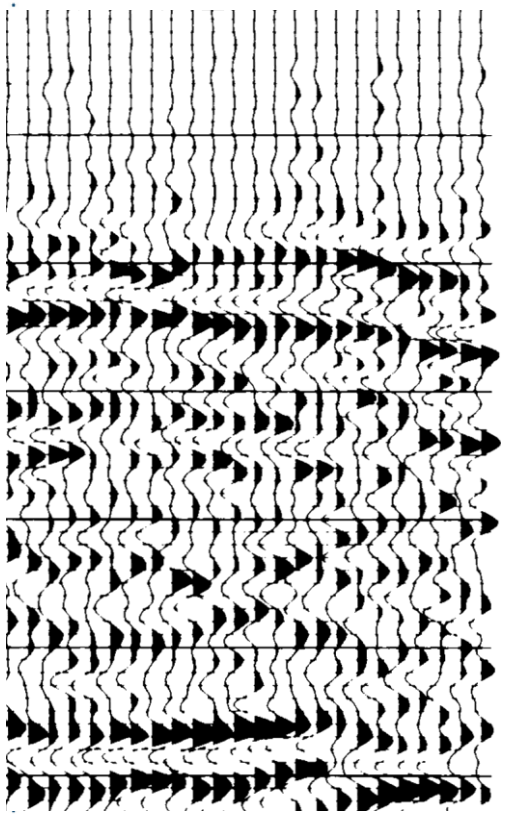


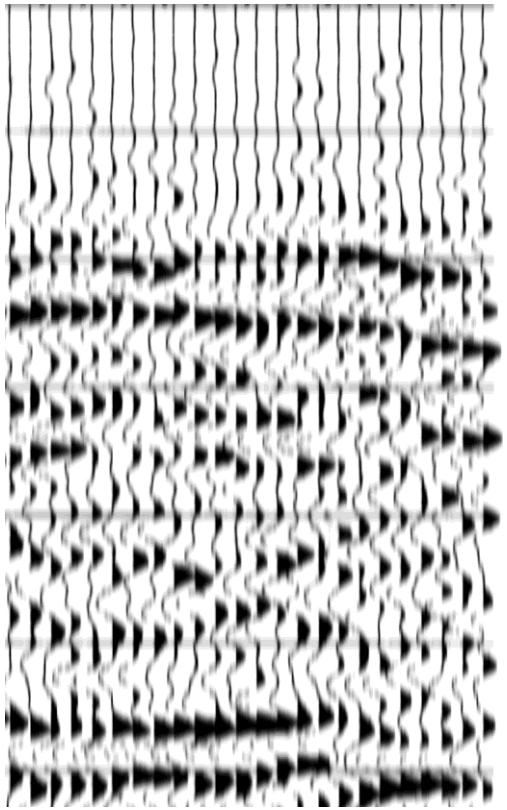
Timing Lines !! - Channel blur

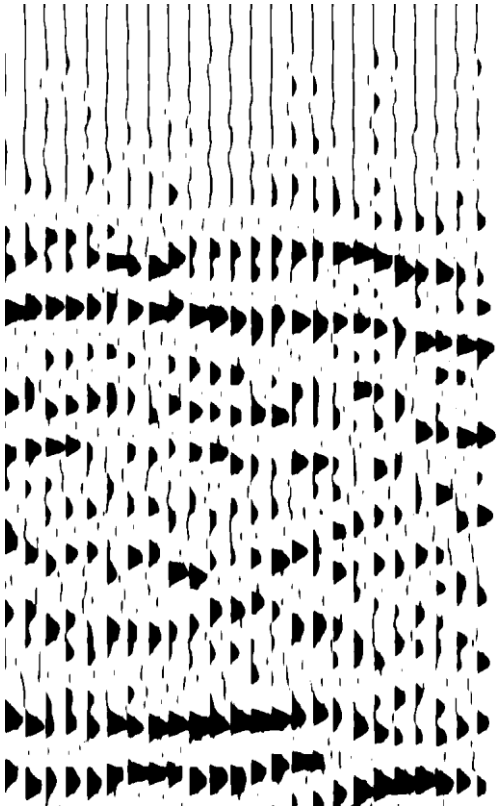




Timing Lines !! - Channel blur - Threshold







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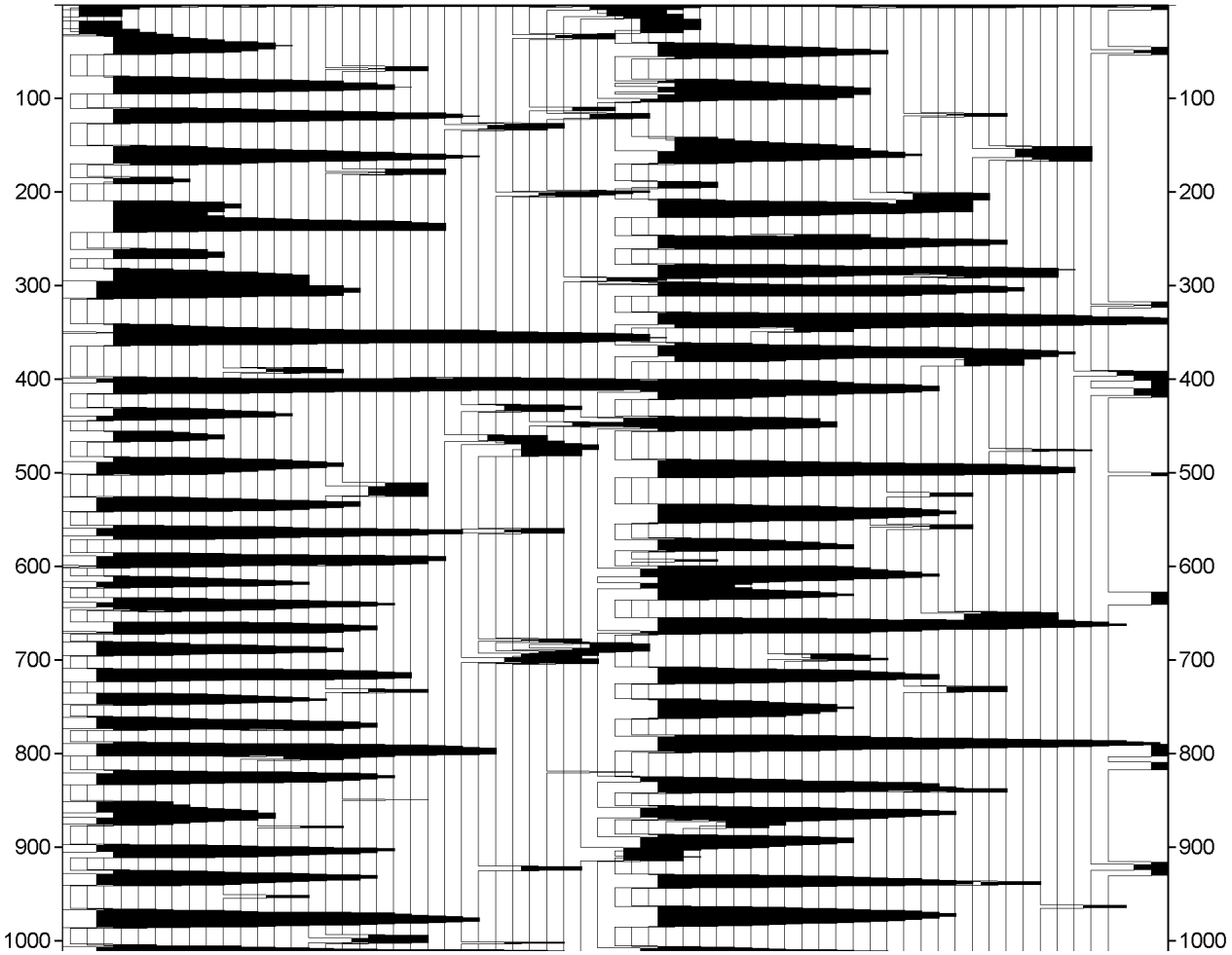
- output final SEG-Y file



Stripes of bitmap data for first two traces (32 stripes per trace)

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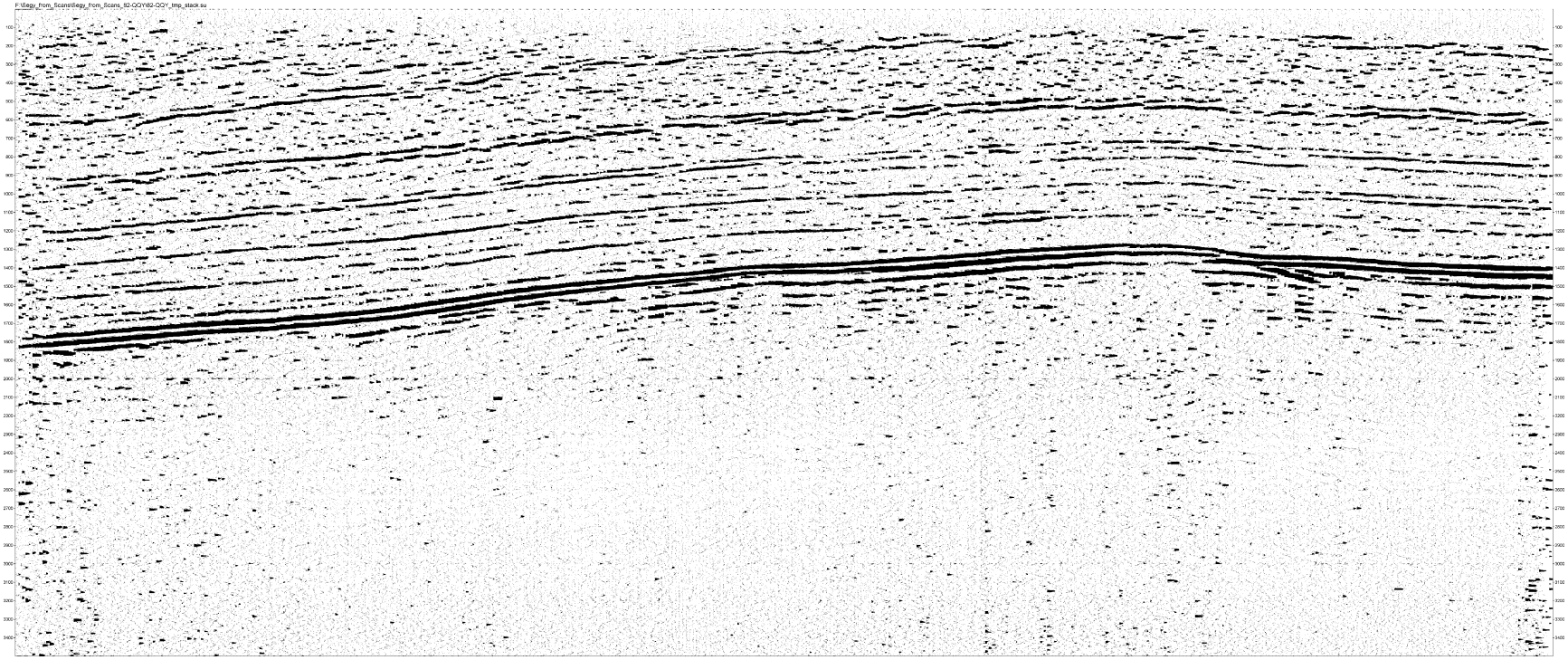
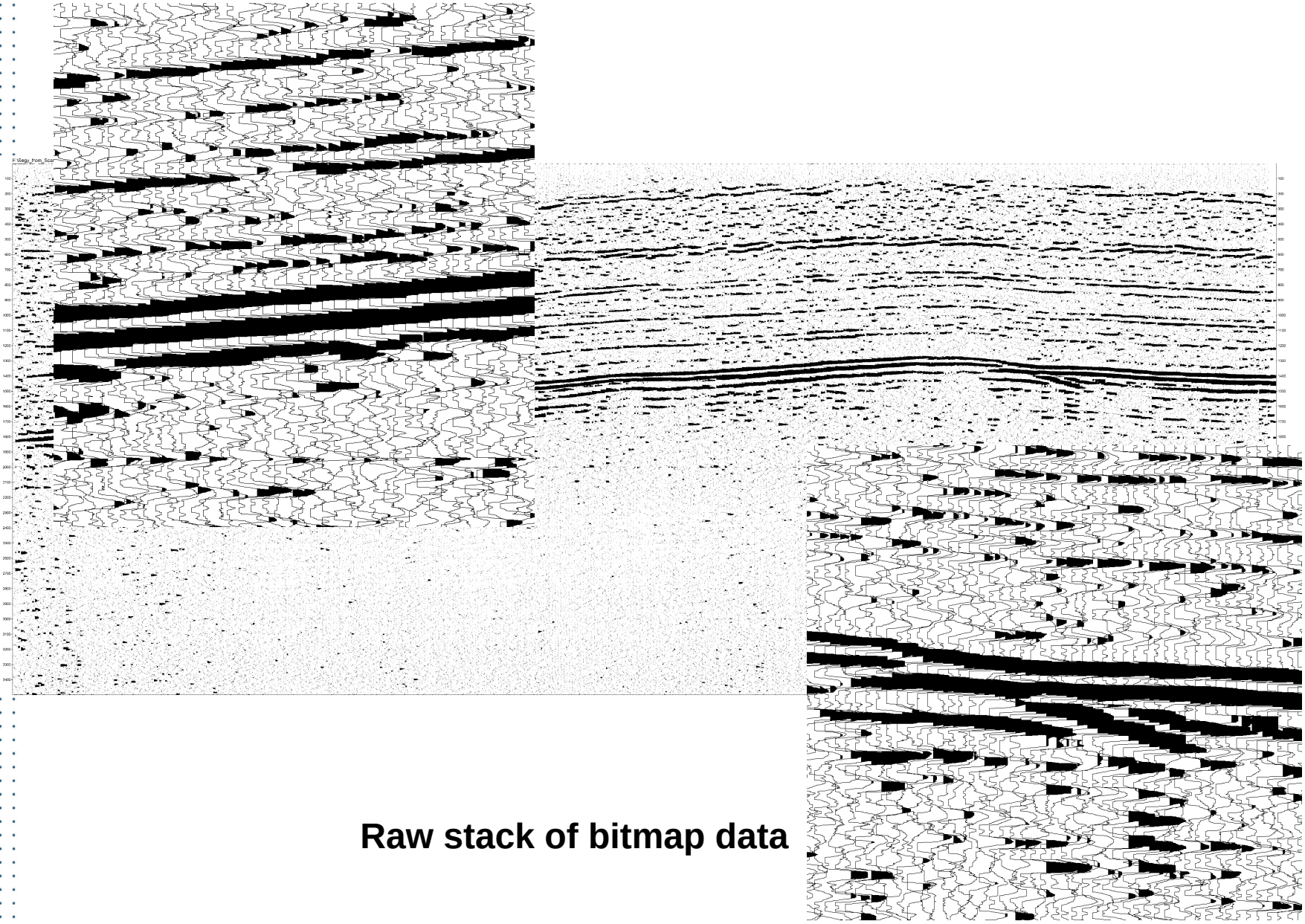


Raw stack of bitmap data



Raw stack of bitmap data

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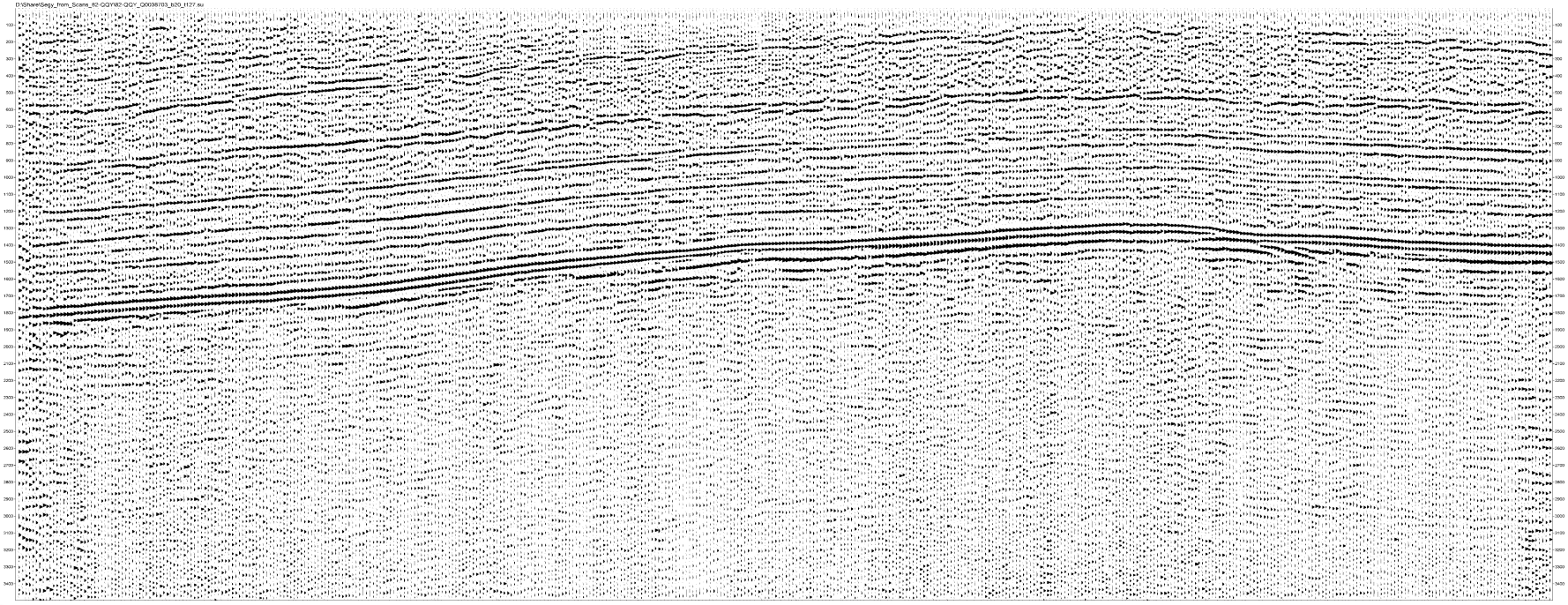
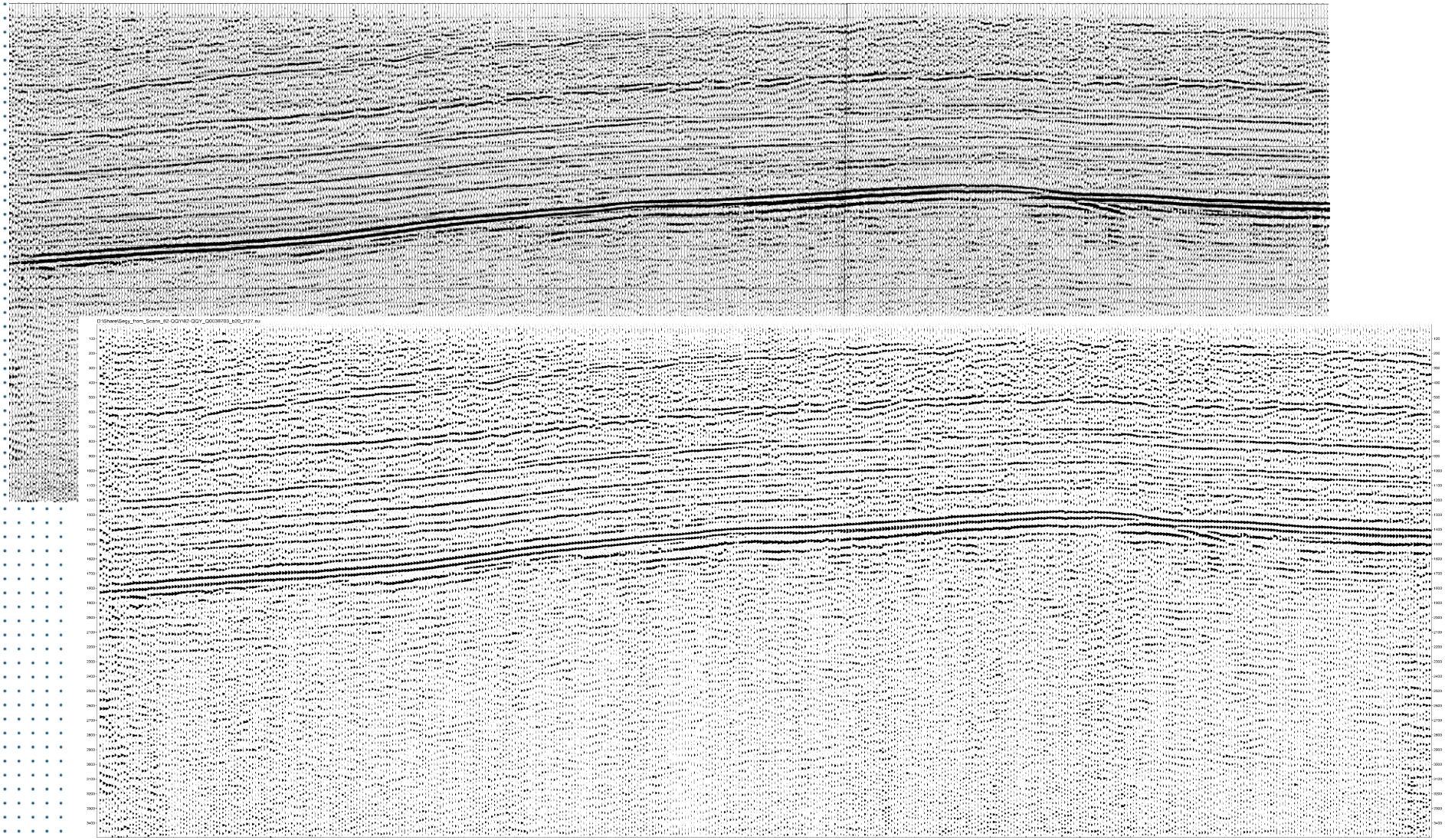


SEG-Y file from scanned image



SEG-Y file from scanned image – comparison with original image

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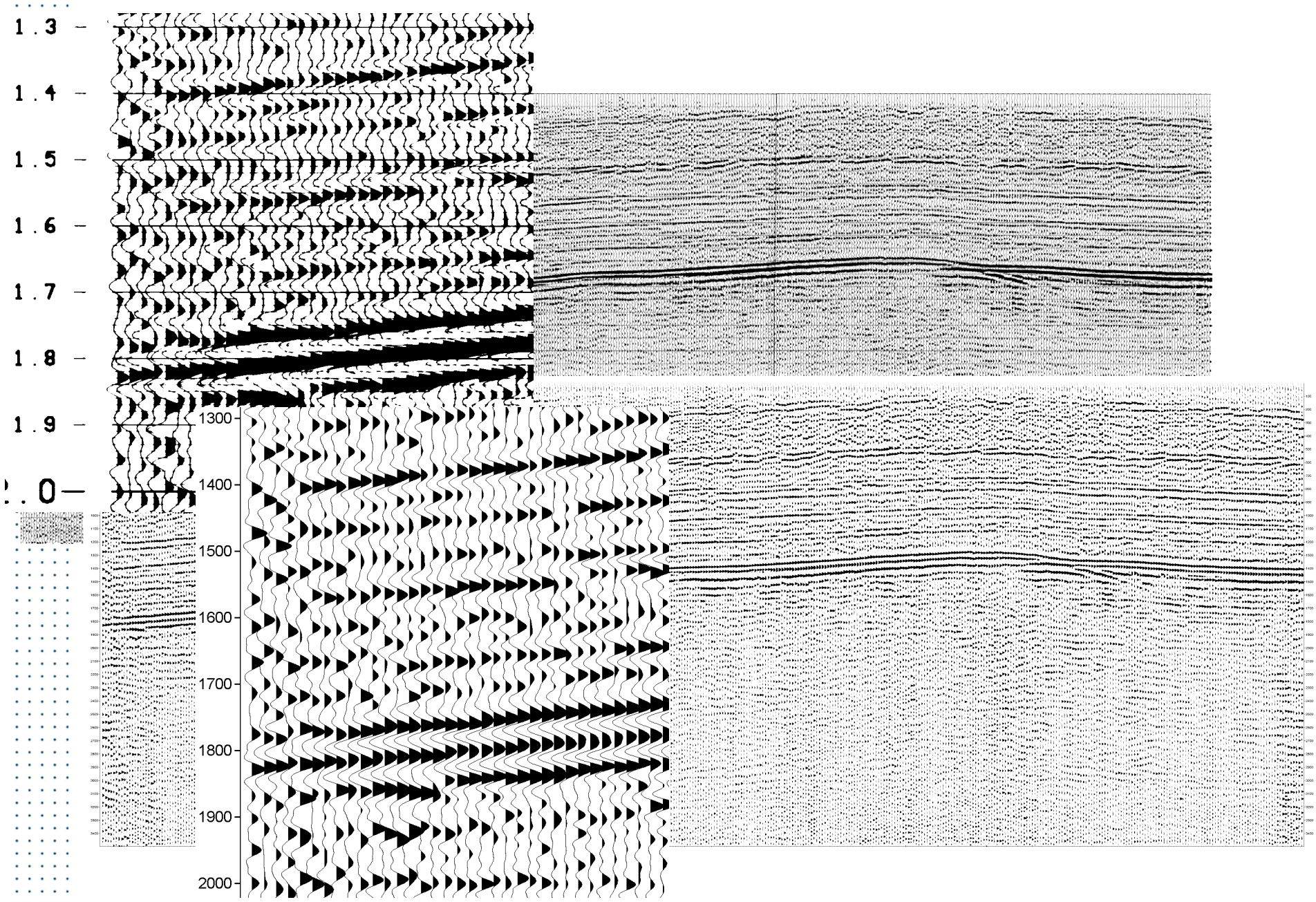
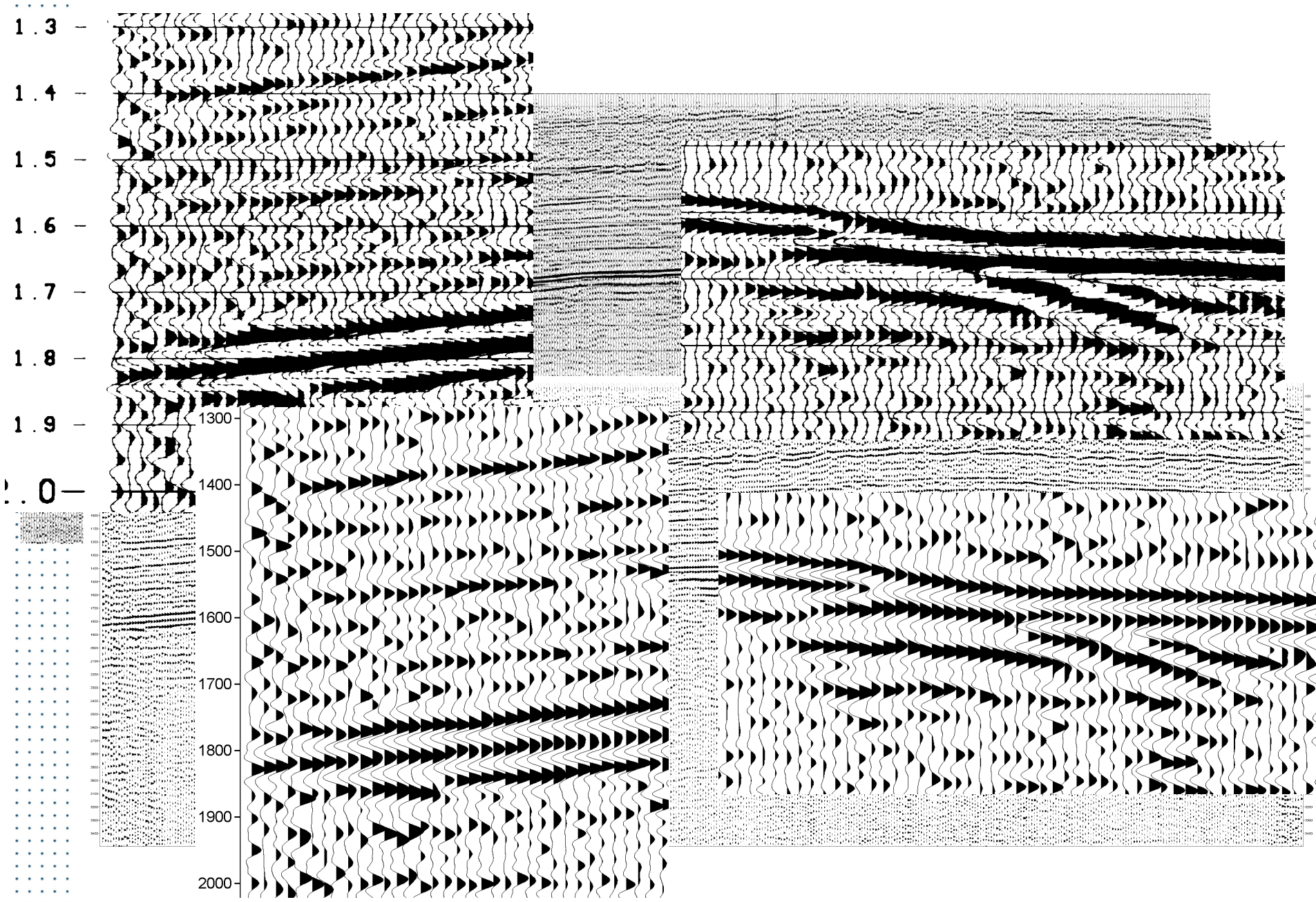
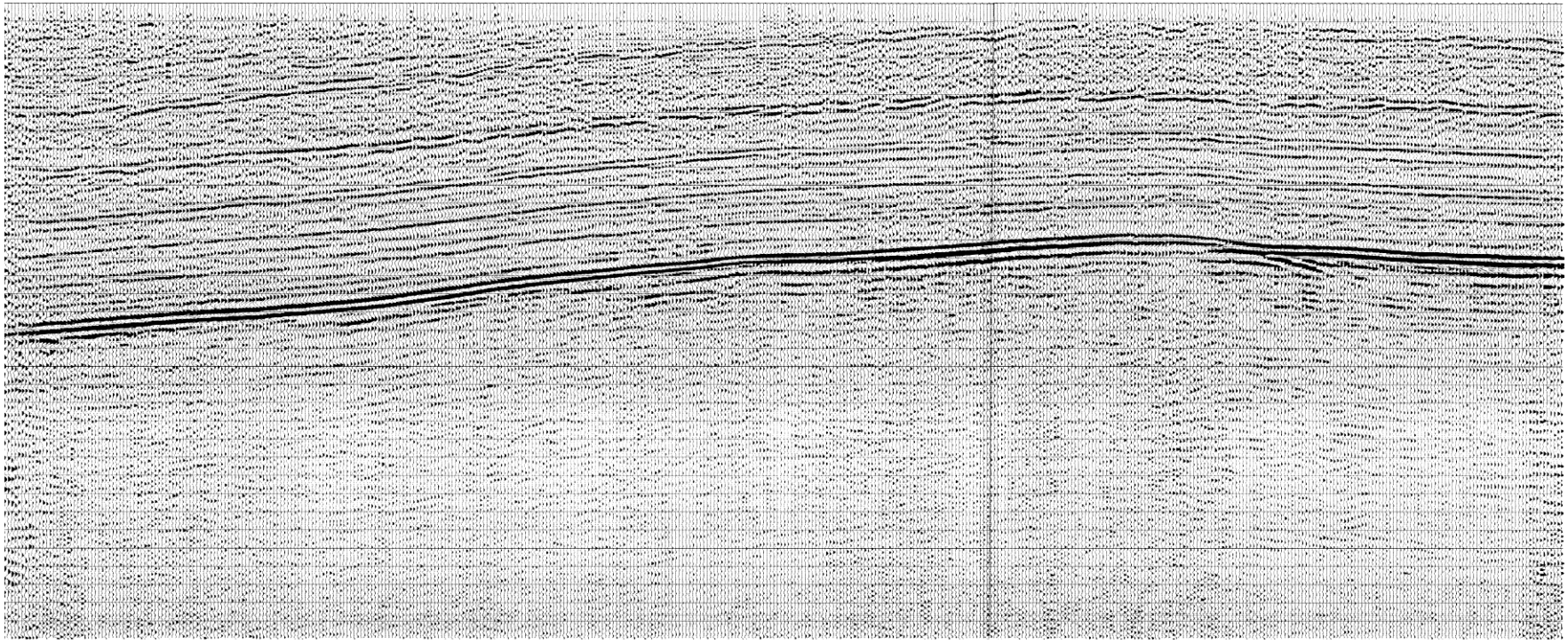


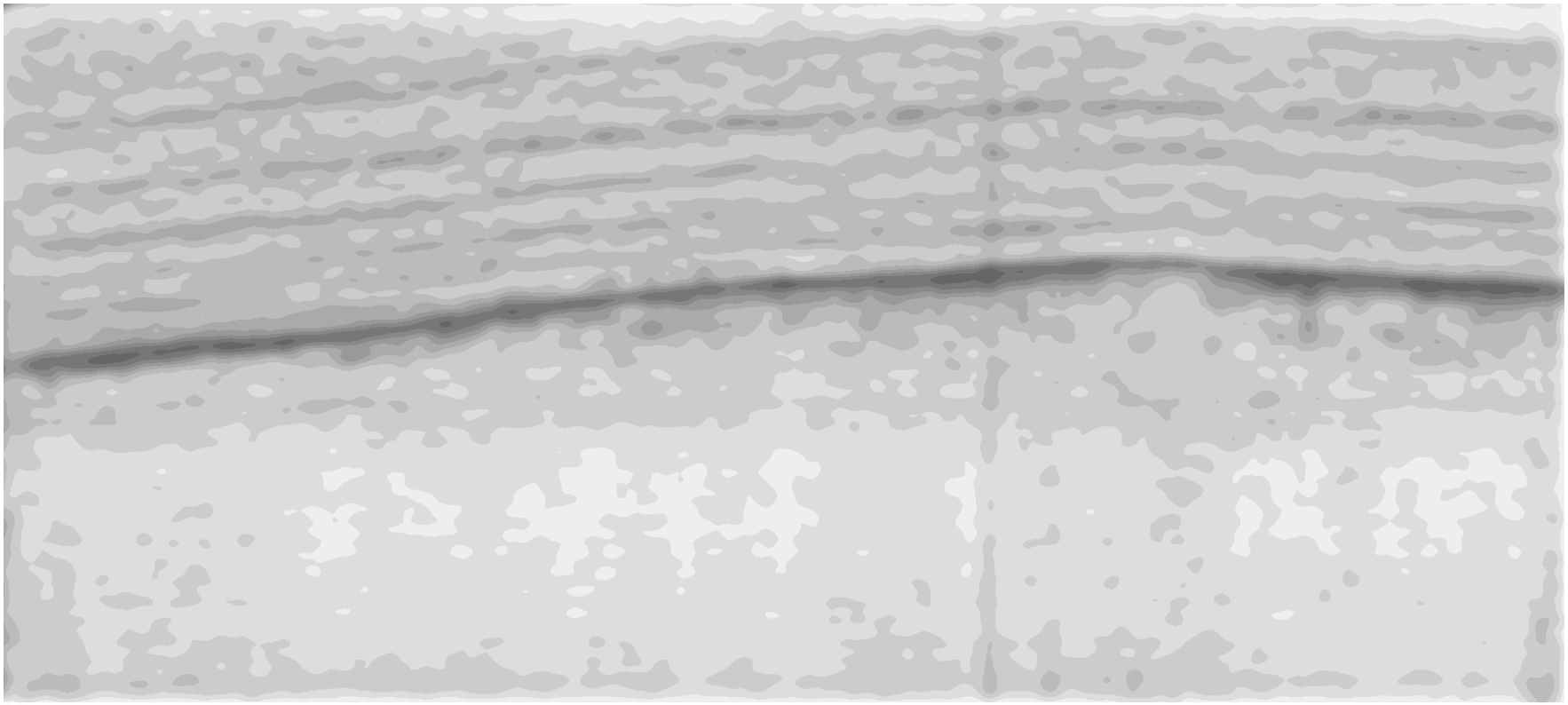
SEG-Y file from scanned image – comparison with original image



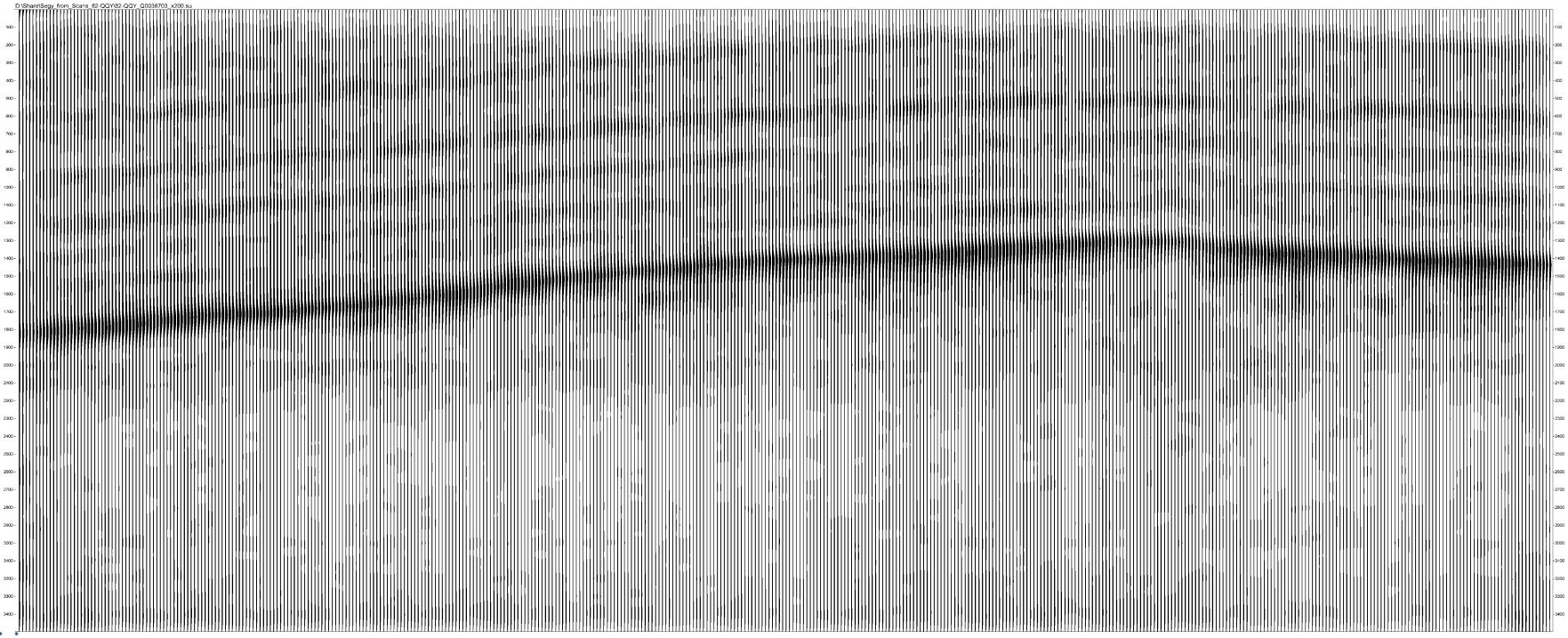
SEG-Y file from scanned image – comparison with original image



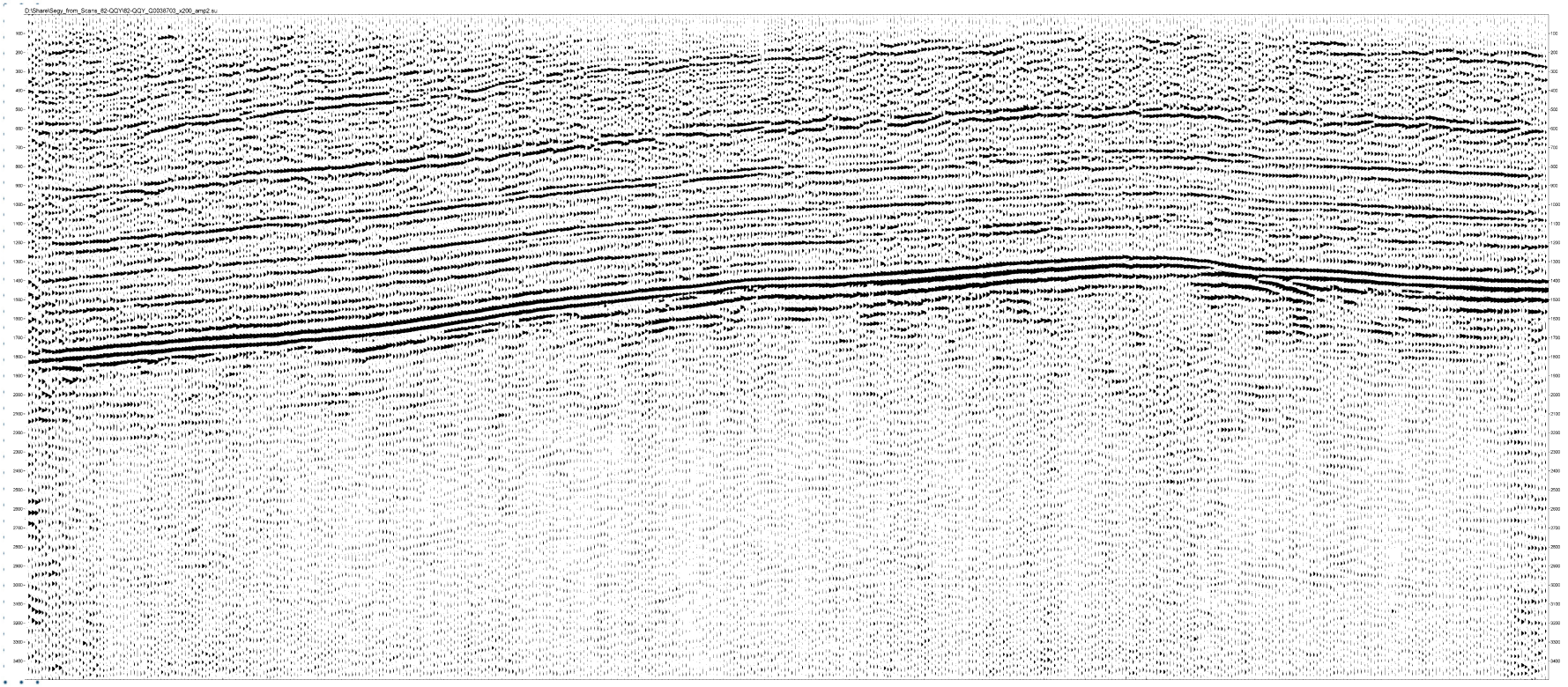
Original image



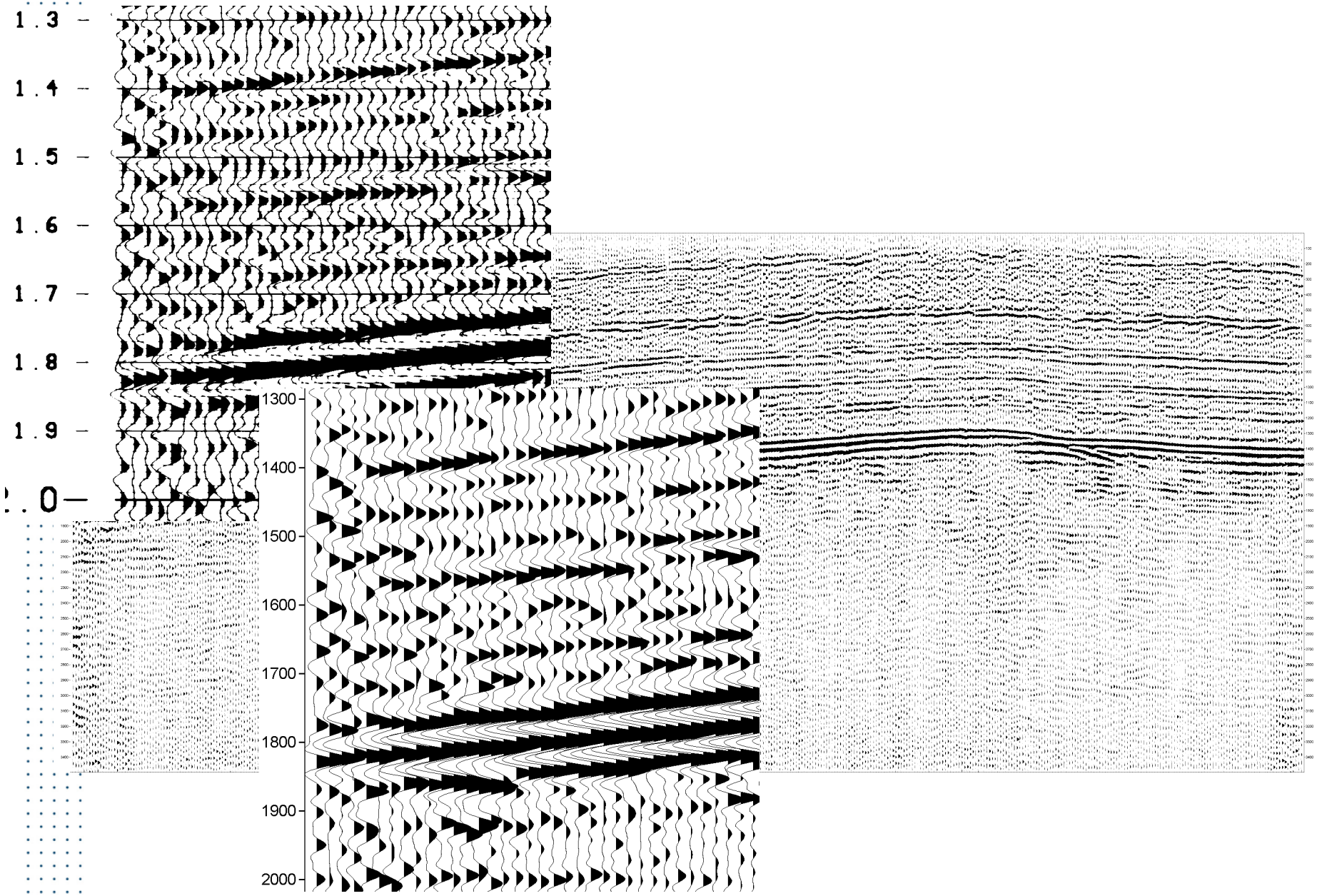
Original image - defocussed



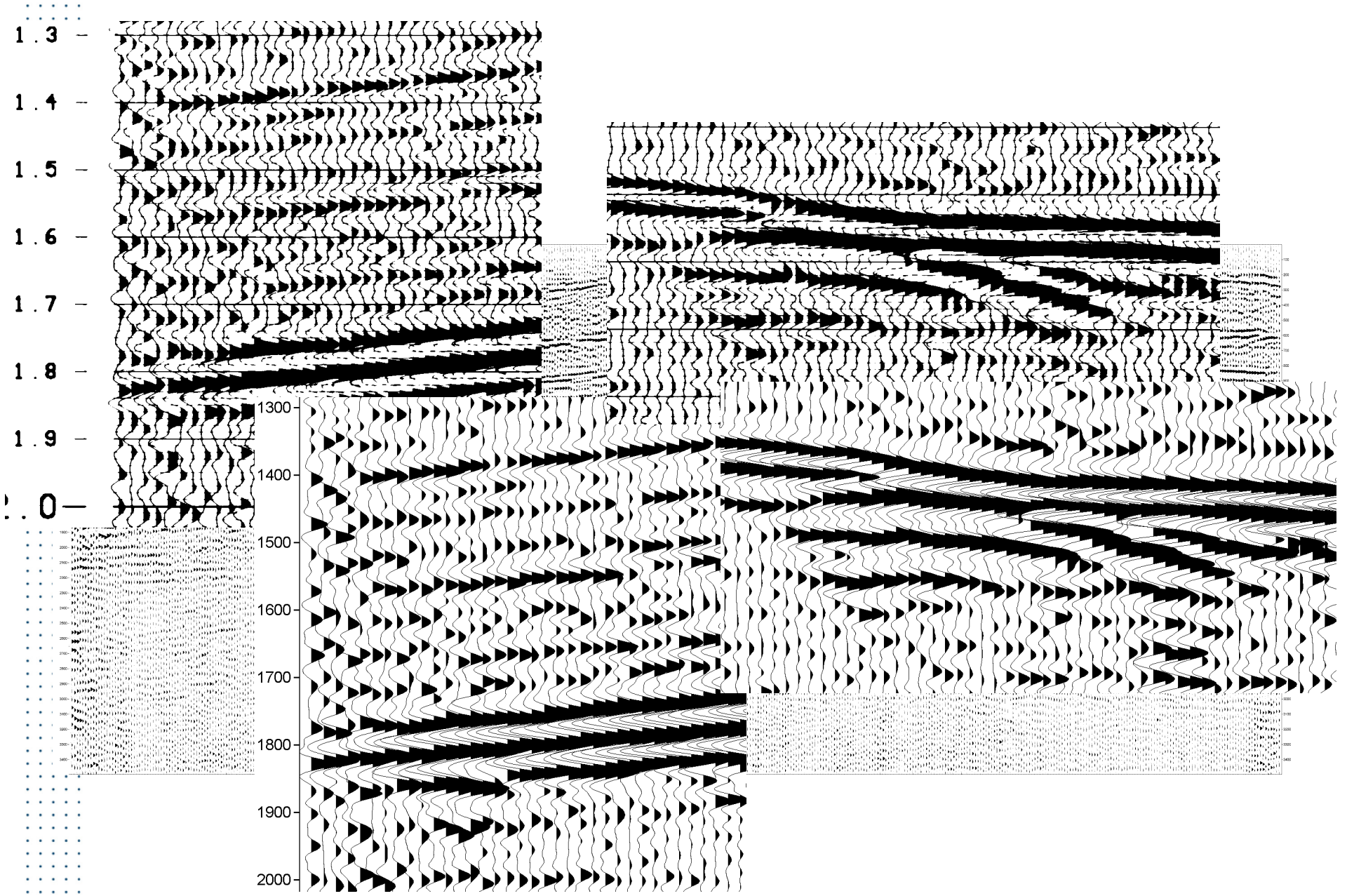
Amplitude character



Final amplitude scaled data



Final amplitude scaled data



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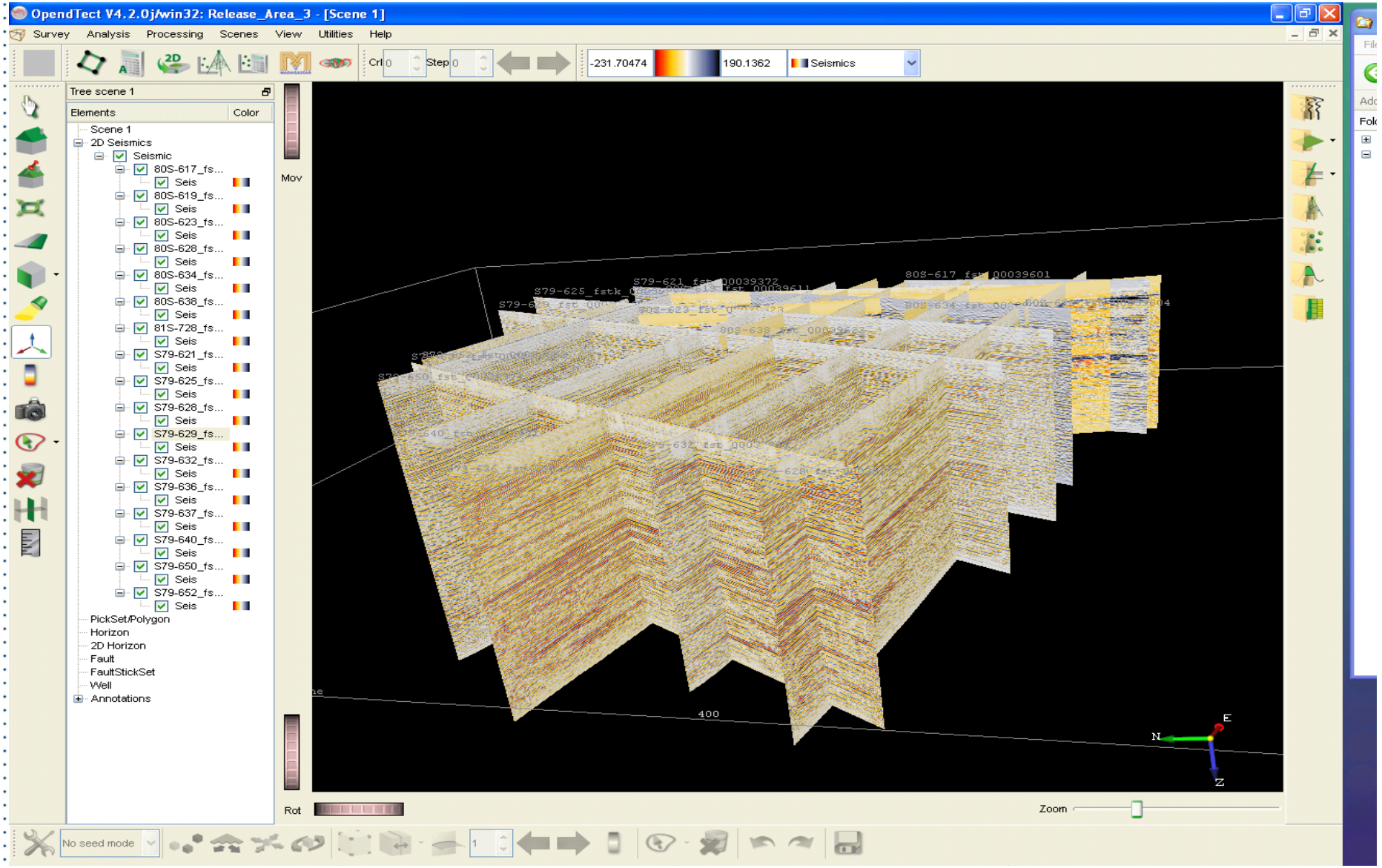
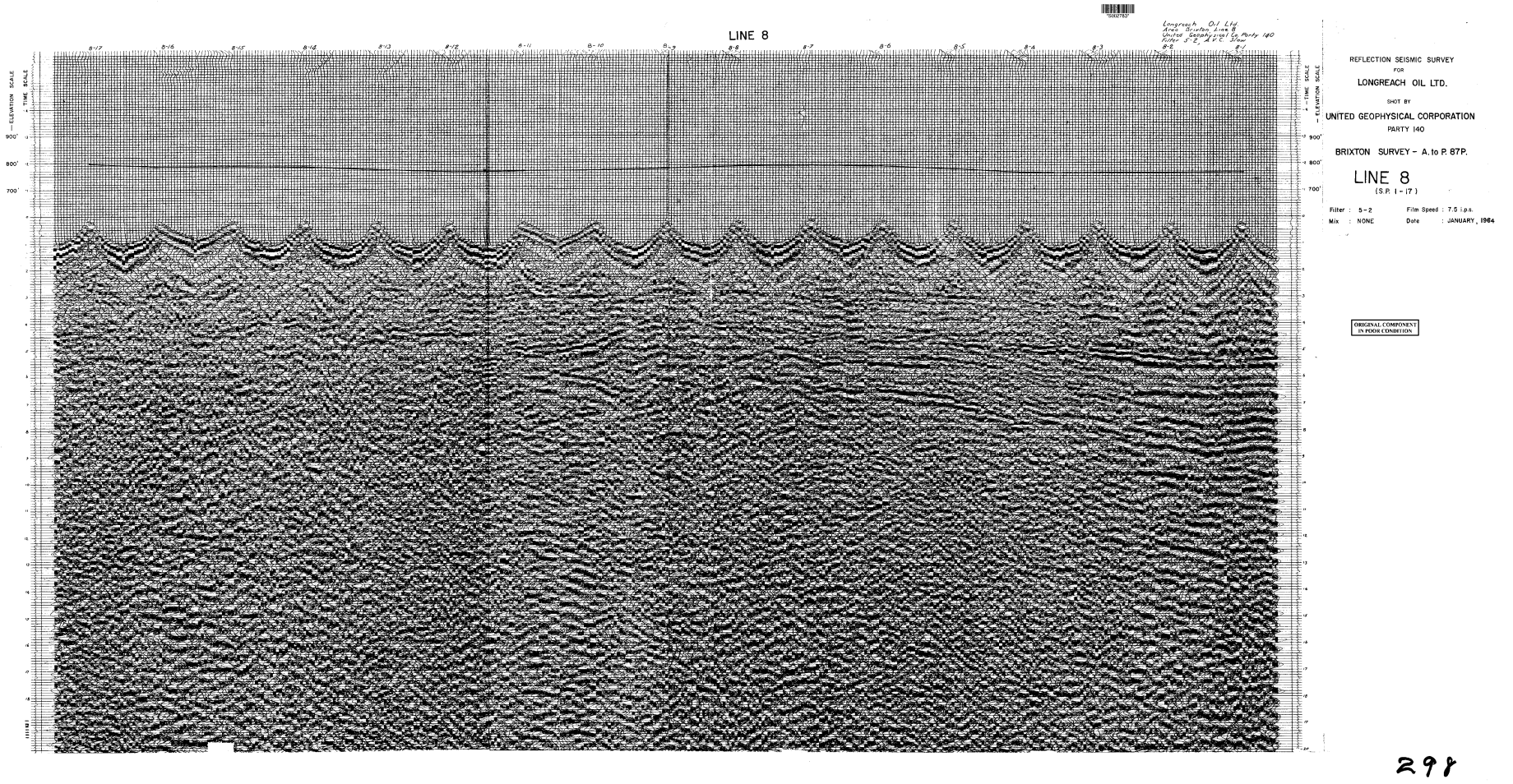
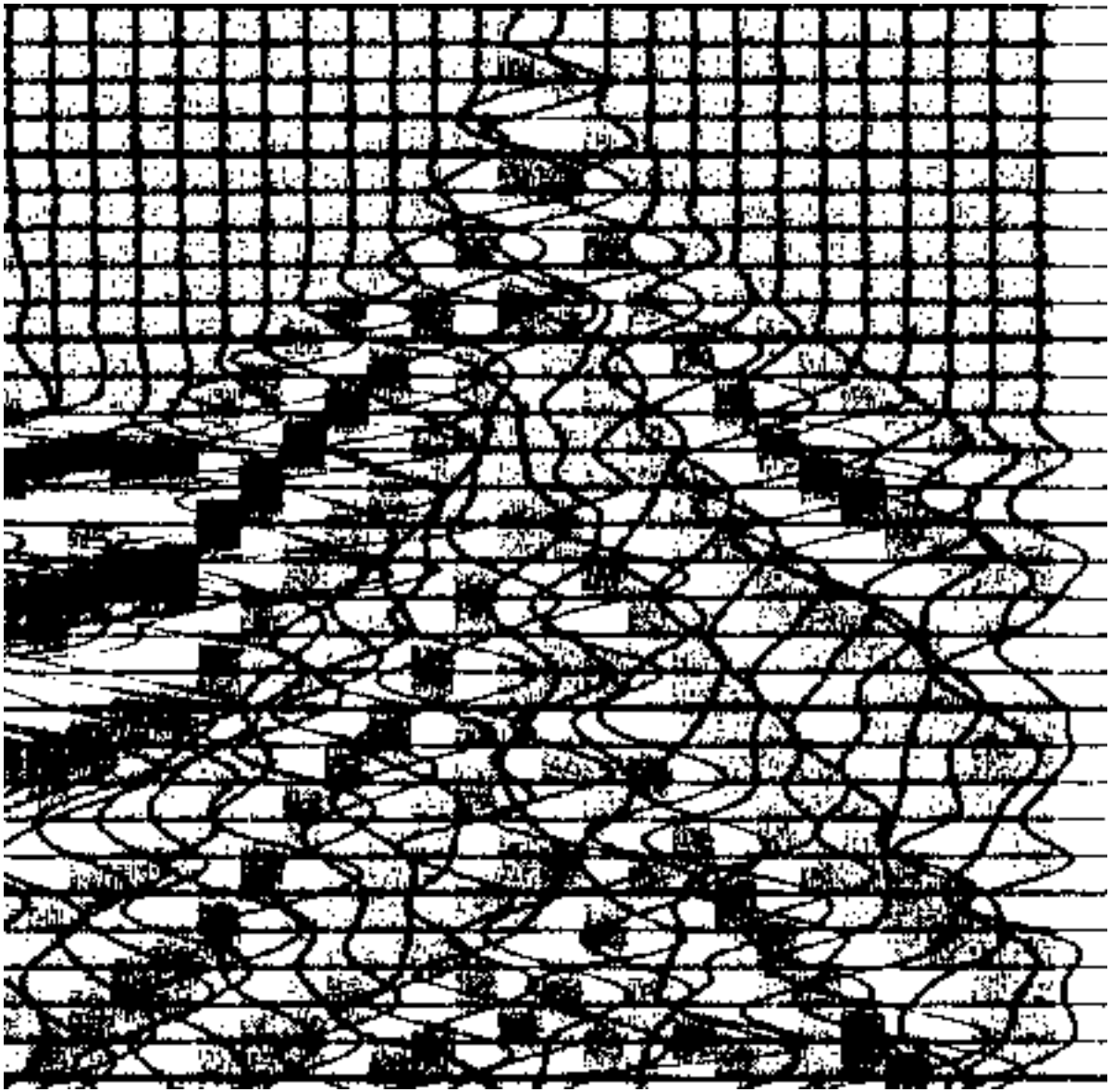


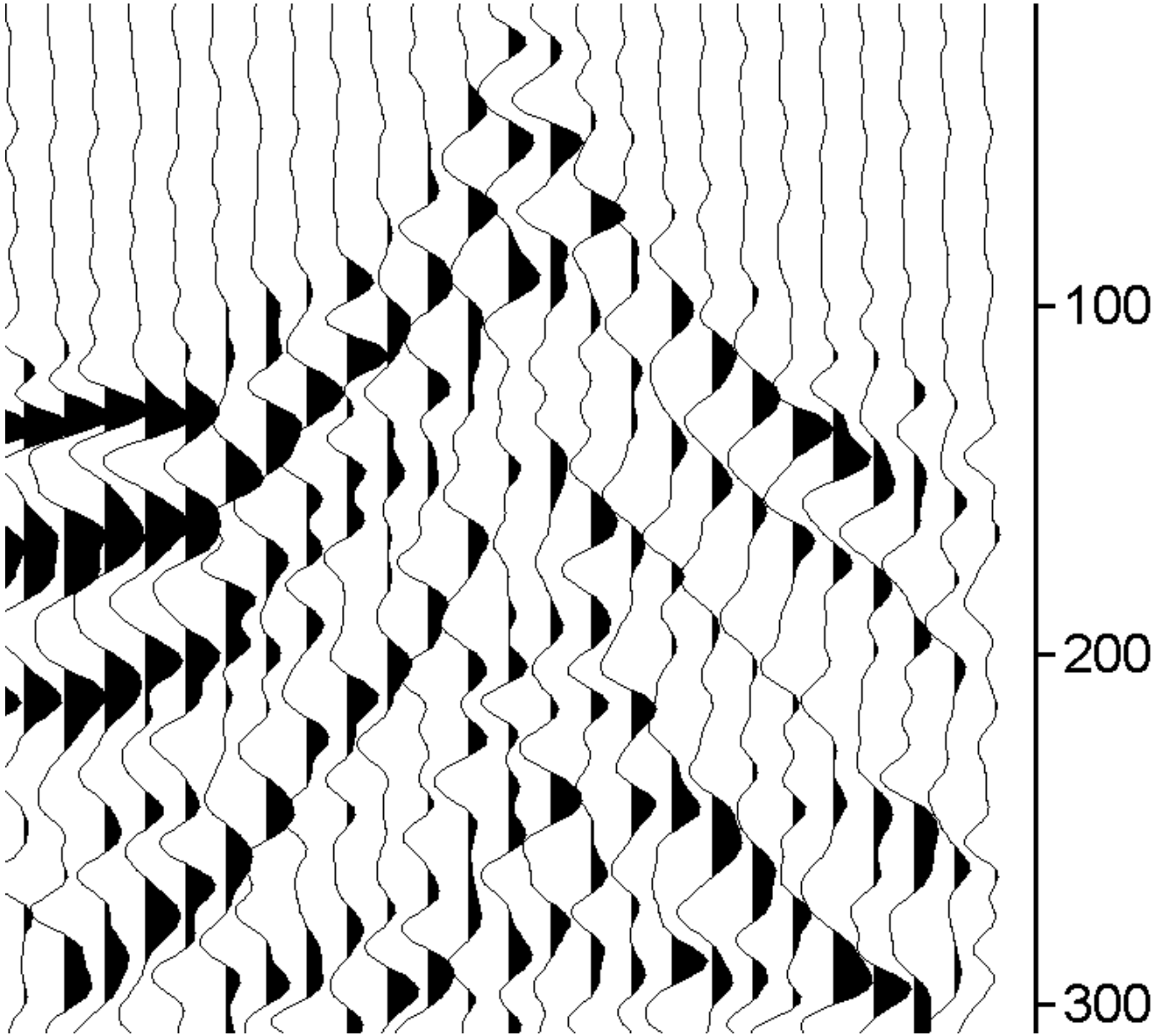
Here is a set I baked previously



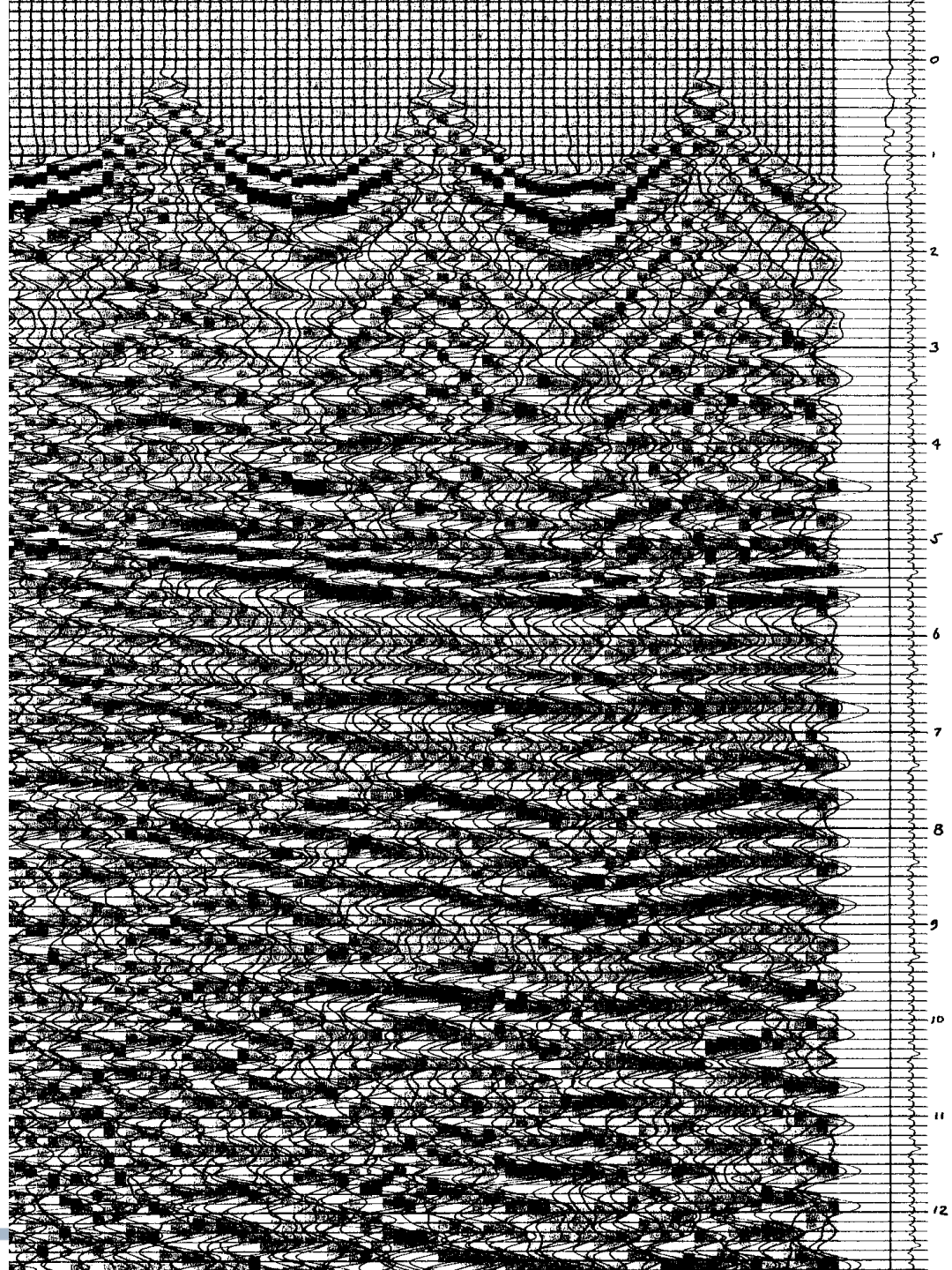
Single-fold line – wiggle trace and variable density



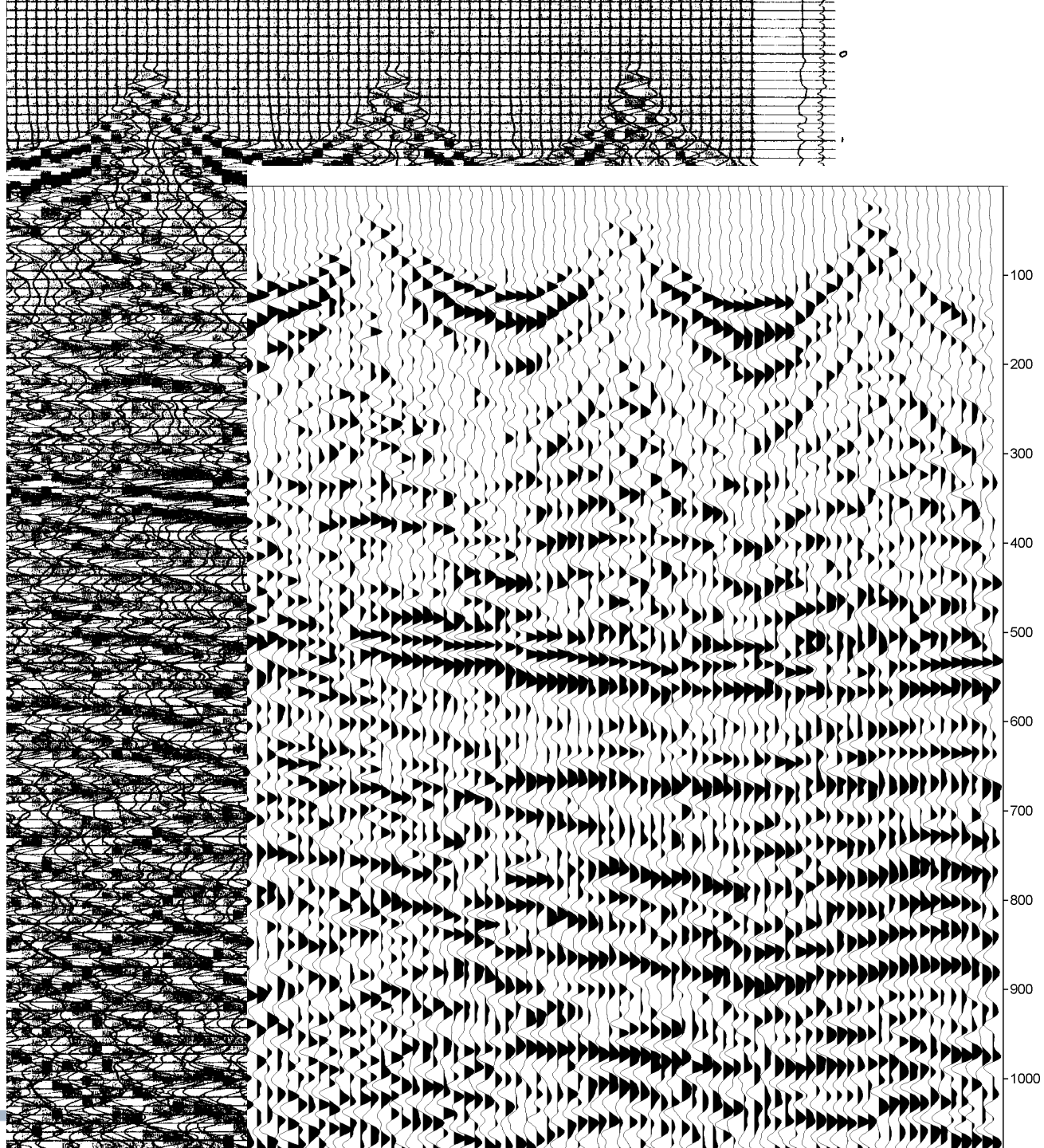
Variable density does not cope well with single bit TIF



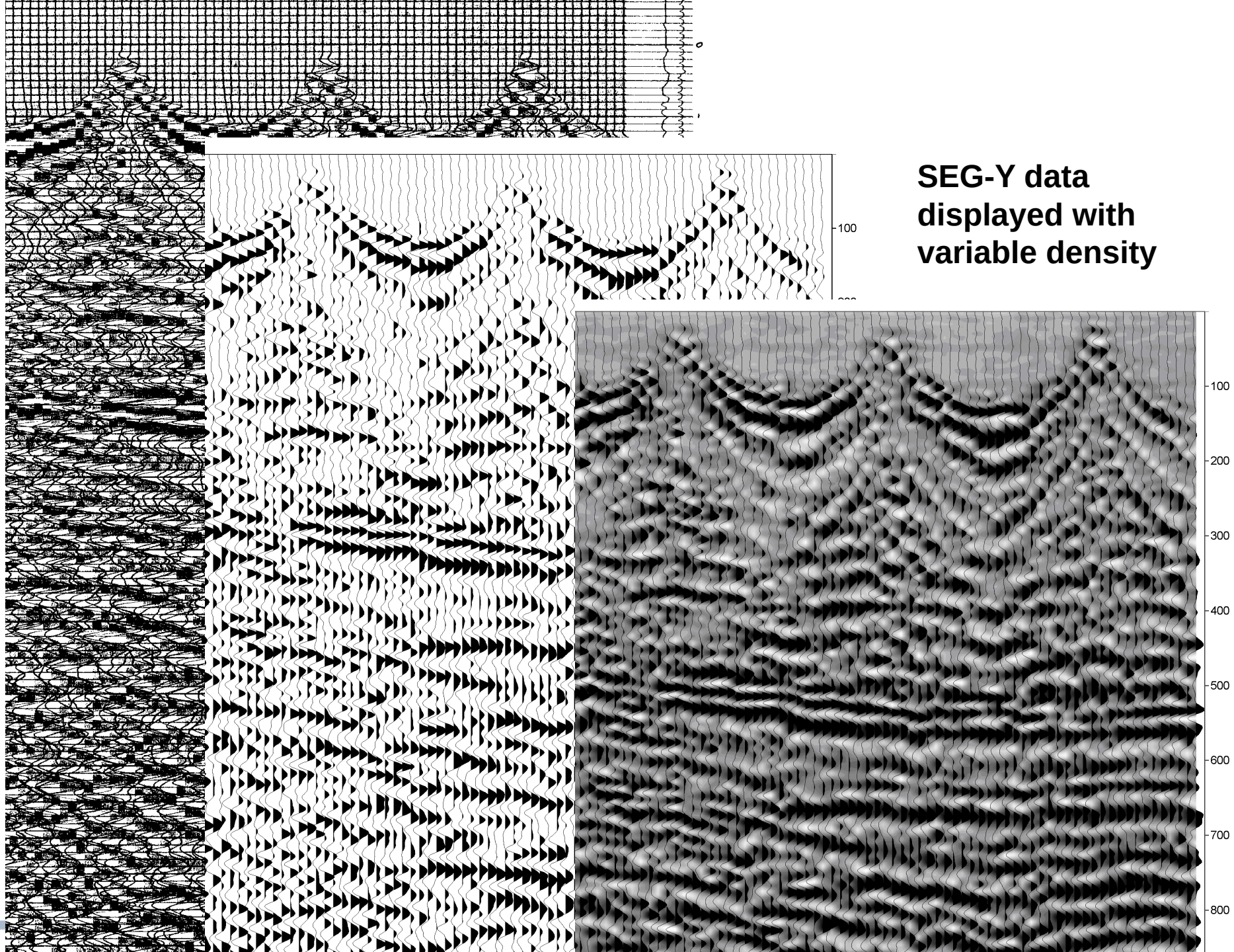
But you can still bake up good SEG-Y data from it



Original data :
Wiggle trace with variable density



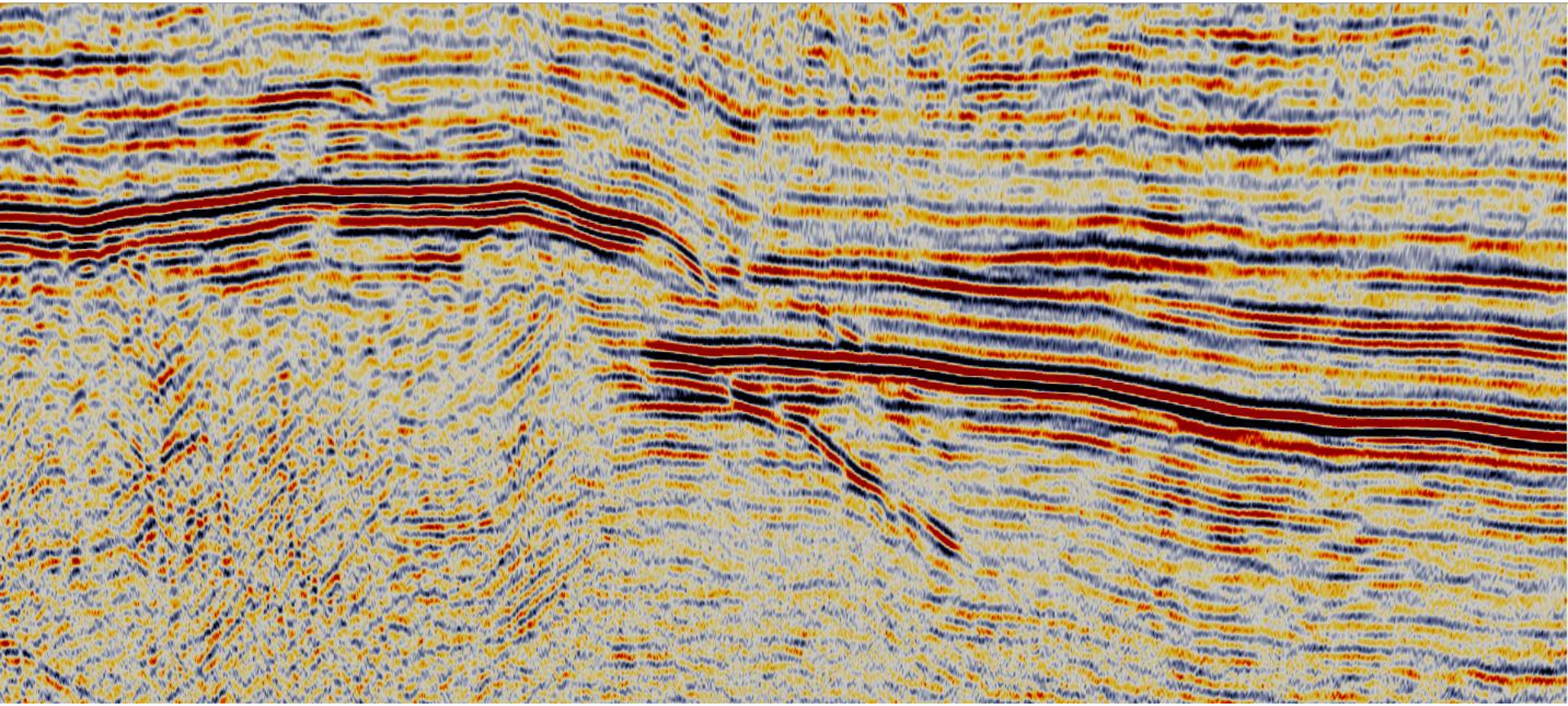
SEG-Y data displayed with variable area



SEG-Y data displayed with variable density

Creating SEGY digital data from scanned images of seismic sections

- making old data live again



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Geological Survey of Queensland
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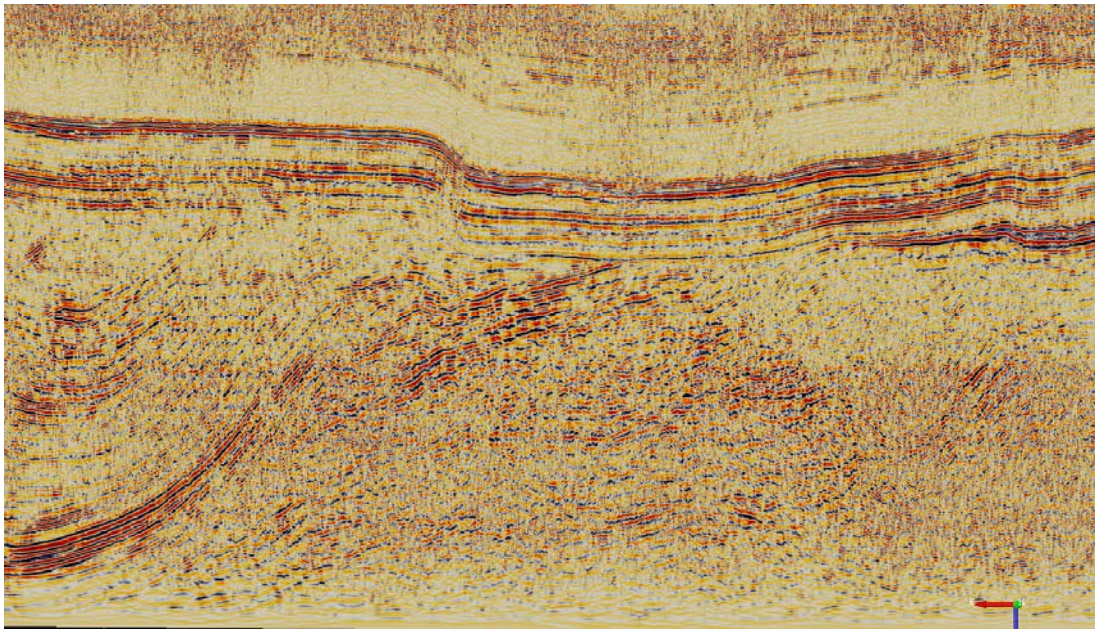
Telephone +61 7 3035 5284
Facsimile +61 7 3003 1438
Email owen.dixon@dnrm.qld.gov.au

Seismic expressions of the Hutton Wallumbilla Fault



Hagay Haviv