Australian Government
Geoscience Australia

“Many hands make light work”!

The scope and value of GSQ – GA collaborations

Andrew Stacey
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Geoscience Australia

Outline

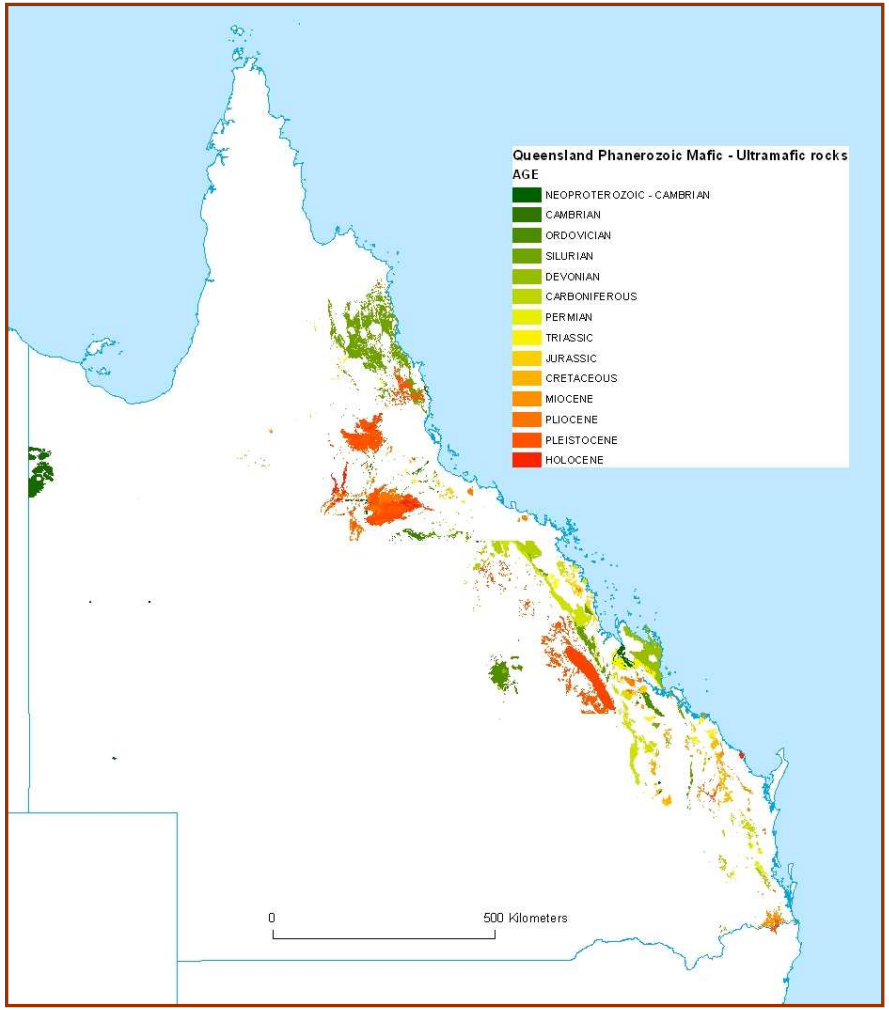
1. **Why collaborate?**

2. **Examples of GSQ-GA collaborations:**
   - Queensland Coastal Geothermal Energy Initiative
   - GA – GSQ Geochronology Project
   - National Geochemical Survey of Australia (NGSA)

3. **National Unconventional Hydrocarbon Resource Assessment**

Why collaborate?

- Jurisdiction
- Data
- Local knowledge
- Share personnel, equipment, software, skills and capabilities
- Mutual benefit
- Enables GA to build a national understanding



Qld Phanerozoic Mafic-Ultramafic Rock Units:
National Mafic-Ultramafic Magmatic Systems Compilation

Outline

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   - **Queensland Coastal Geothermal Energy Initiative**
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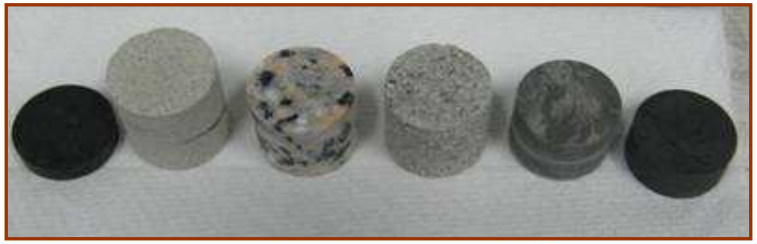
3. National Unconventional Hydrocarbon Resource Assessment

Queensland Coastal Geothermal Energy Initiative

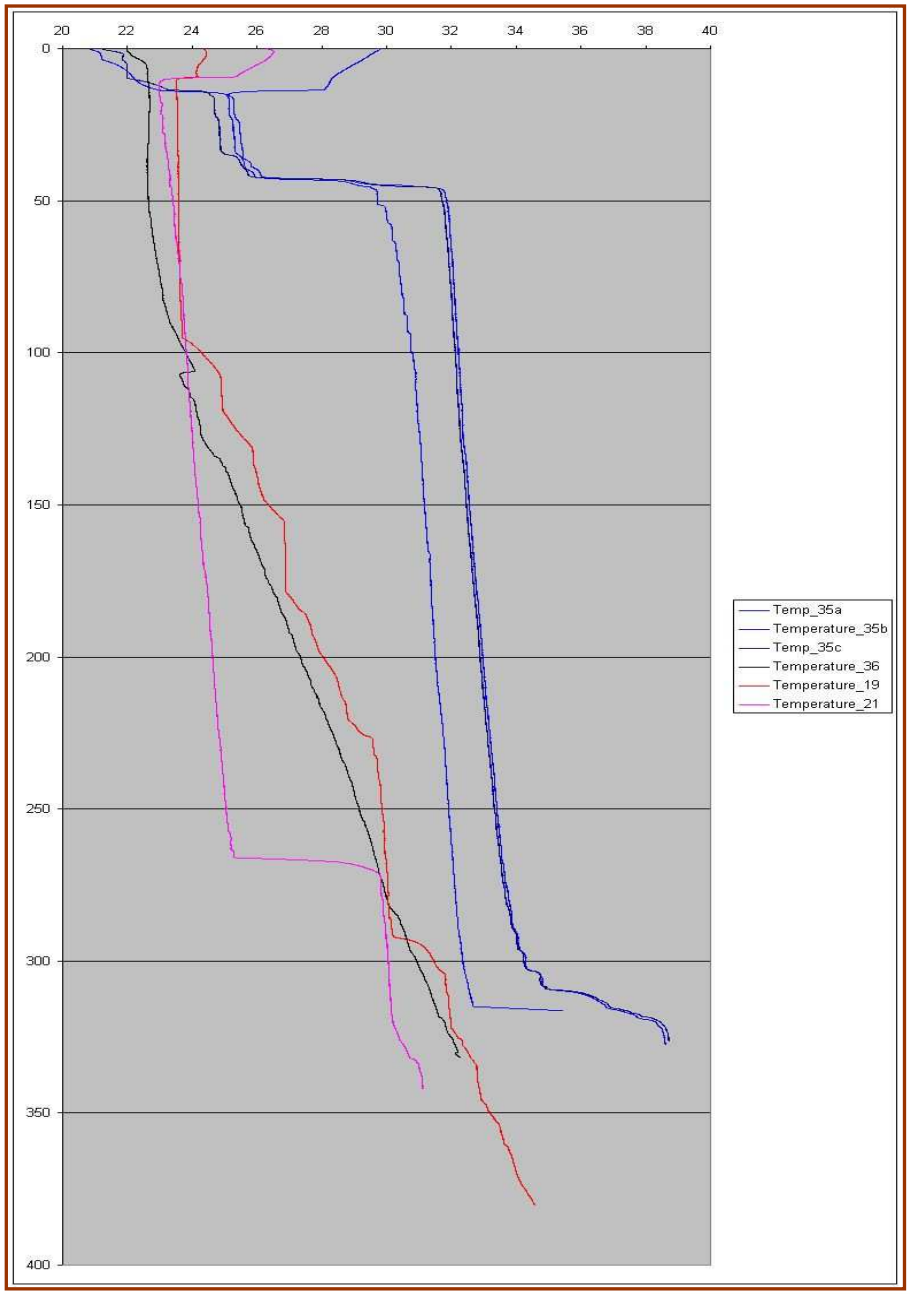
Collaboration in data collection

- Borehole temperature logging
- Measurement of thermal conductivity on samples from drill holes



Queensland Coastal Geothermal Energy Initiative

- 10x boreholes logged
- Logging programme designed to provide heat flow information in data gaps.
- April 2011 – November 2012
- Collaborative work to ensure the best possible data was acquired – relogging etc.



GA – GSQ Geochronology Project

GA – GSQ Geochronology Project

- National Geoscience Agreement (NGA) between the Geological Survey of Queensland (GSQ) and Geoscience Australia (GA)

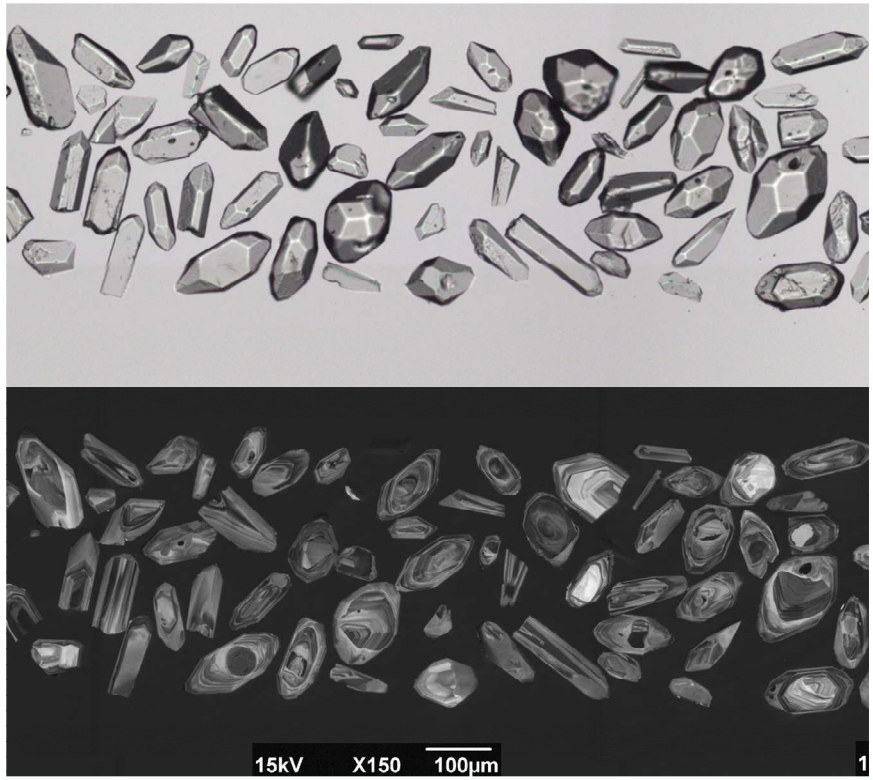
- Since 2006 the collaboration has generated new ages and improved the tectonic understanding for the Mt Isa region, Etheridge Province, Drummond Basin, New England Orogen and Thomson Orogen

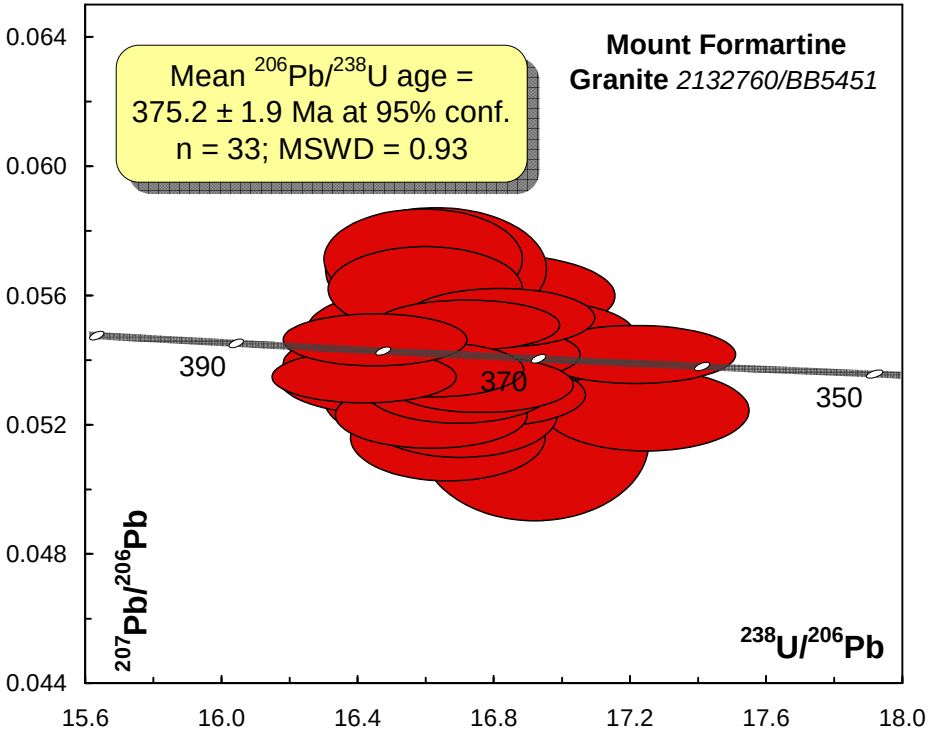
- Current efforts are focussed on the Thomson Orogen where the majority of the new geochronology has been undertaken on deep basement diamond drill cores

GA – GSQ Geochronology Project

Mount Formartine Granite (2132760/BB5451)

- Existing U-Pb age = 357 ± 6 Ma (Zucchetto et al 1999)
- Magmatic age = 375.2 ± 1.9 Ma (n = 33, MSWD = 0.93)

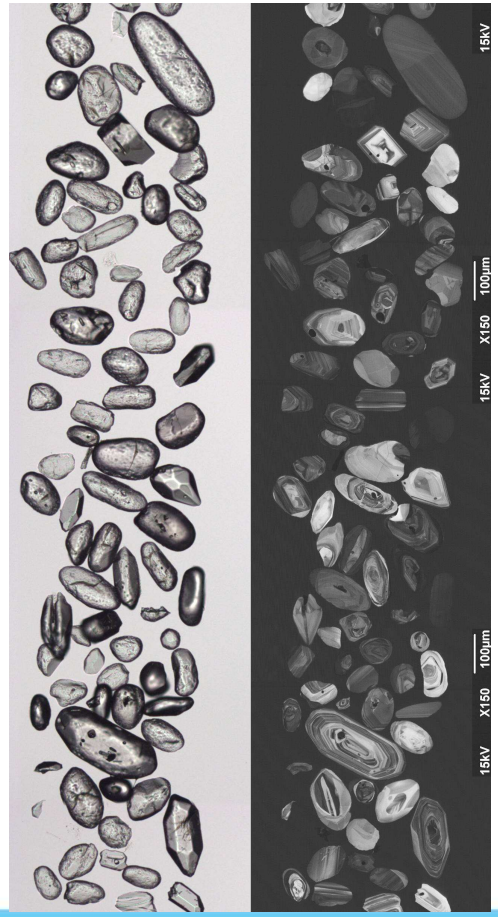


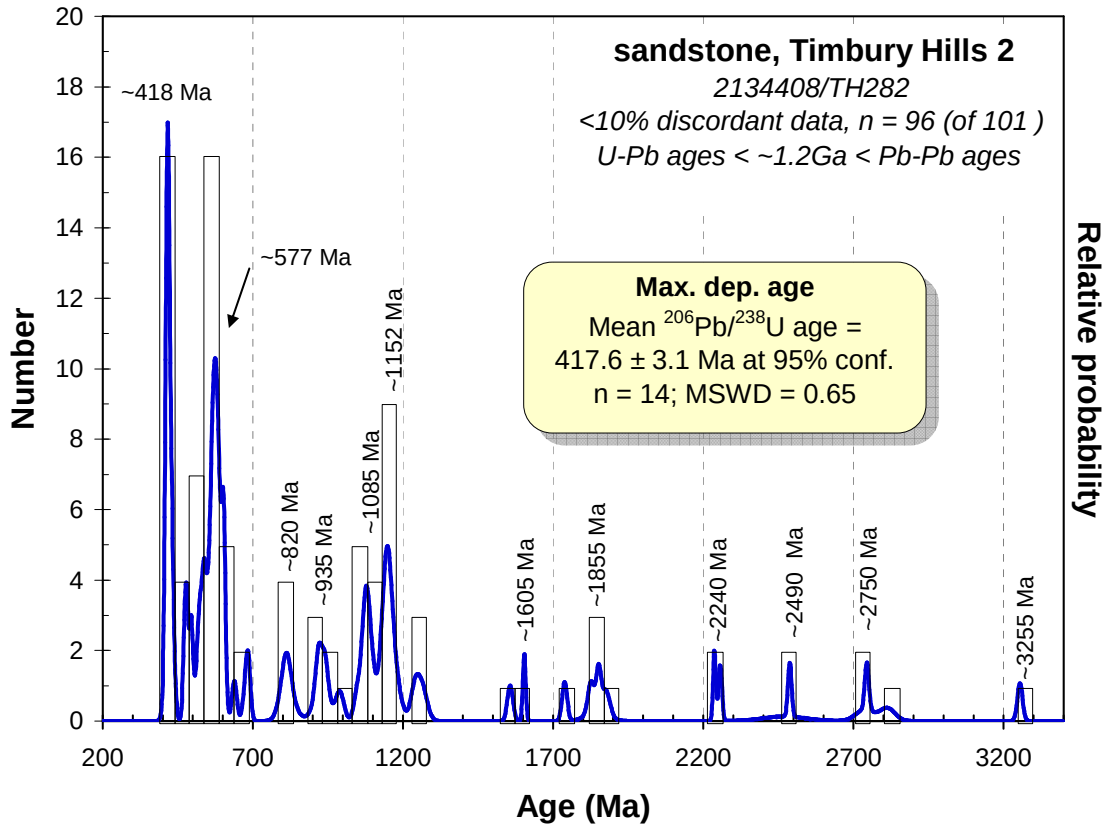


GA – GSQ Geochronology Project

Sandstone, Timbury Hills 2 (2134408/TH282)

- **Maximum Depositional Age = 417.6 ± 3.1 Ma**

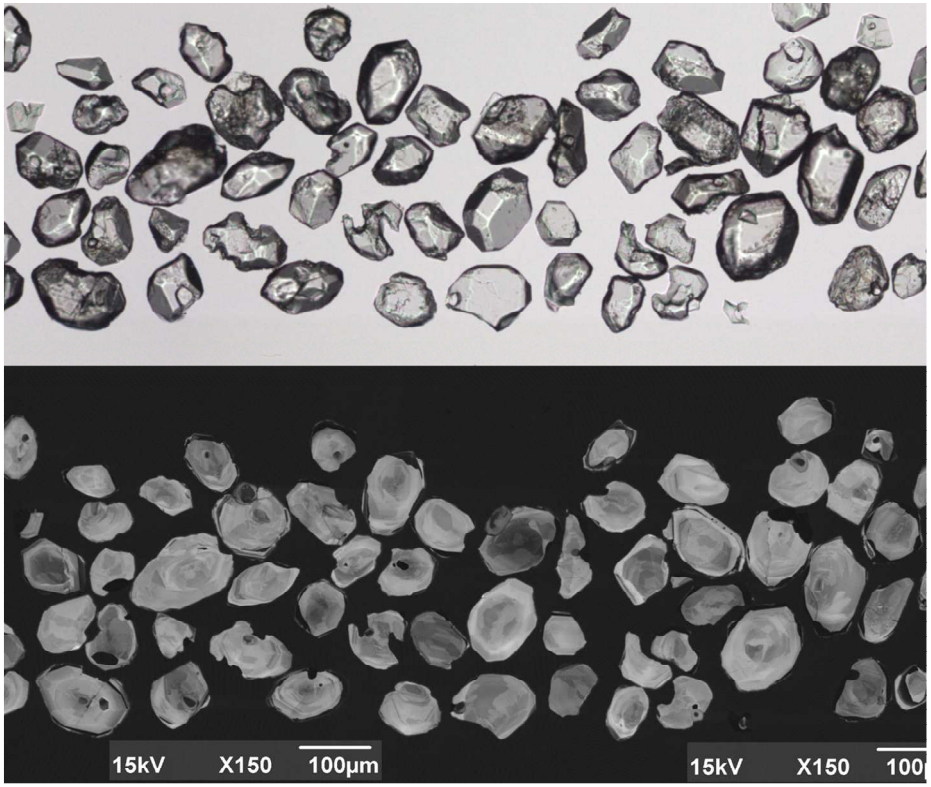


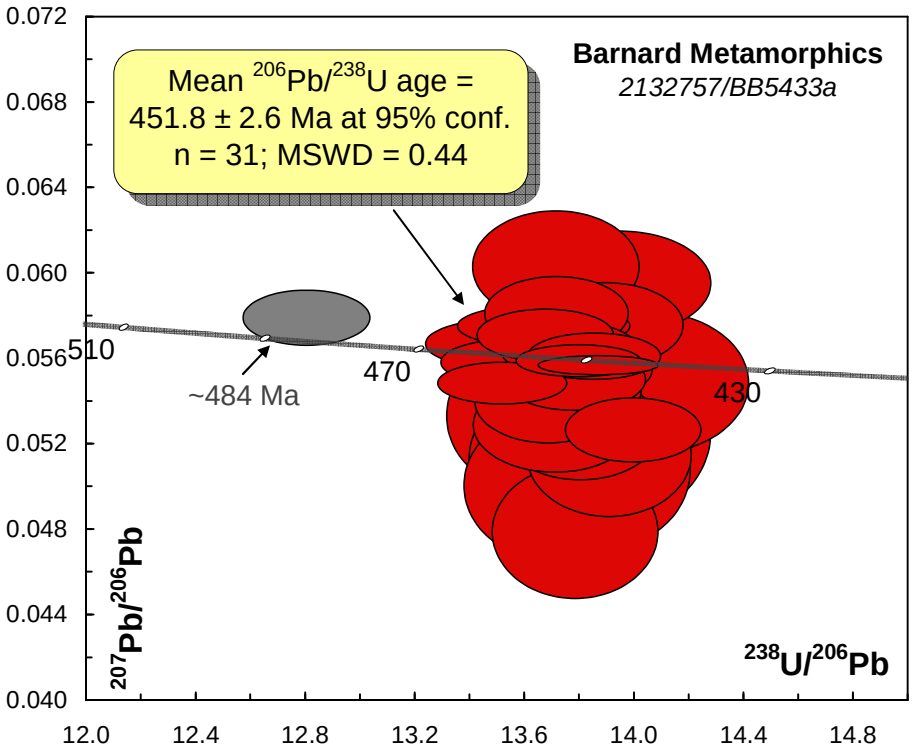


GA – GSQ Geochronology Project

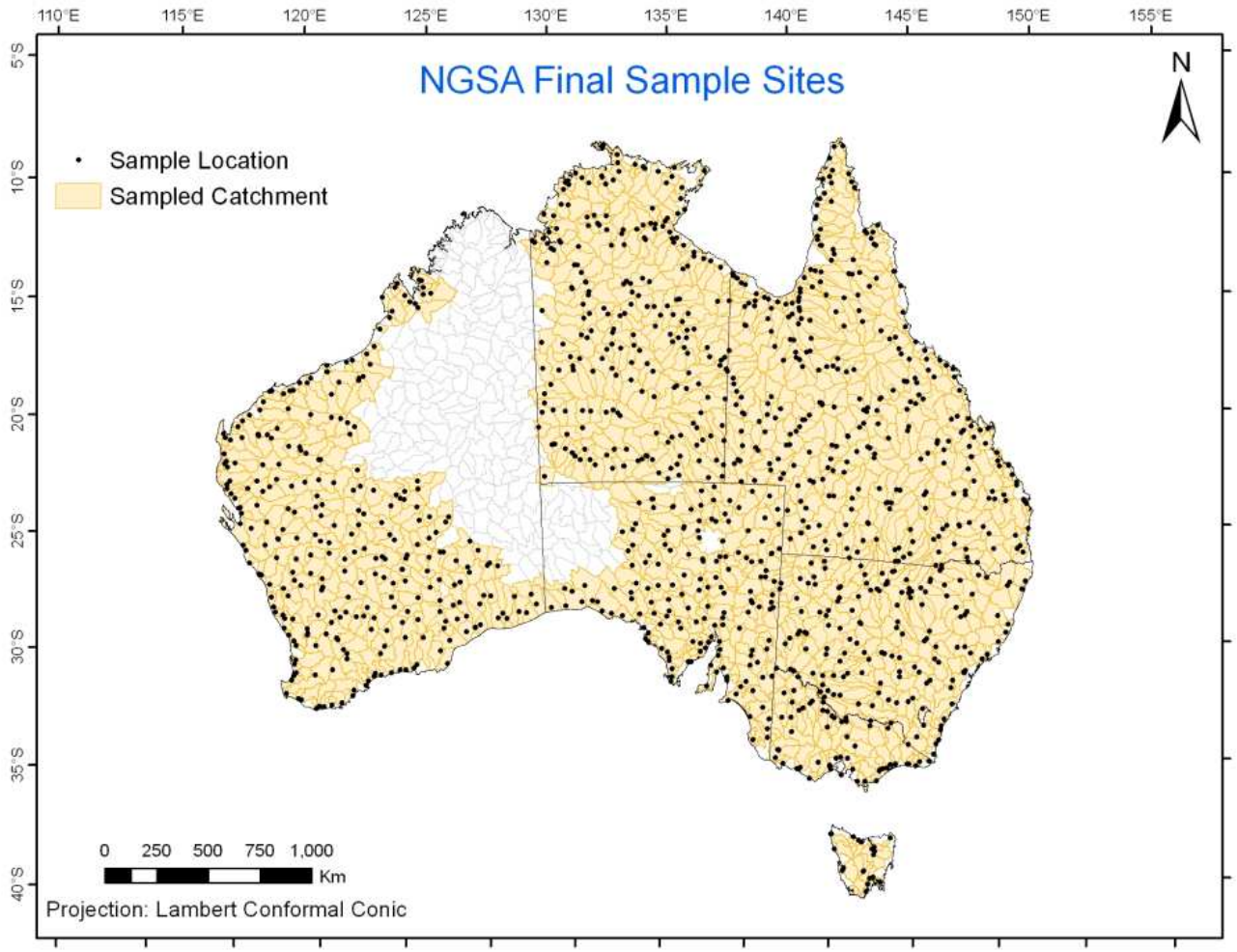
Barnard Metamorphics (2132757/BB5433a)

- Amphibolite
- Recrystallisation/Metamorphic age = 451.8 ± 2.6 Ma





National Geochemical Survey of Australia (NGSA)

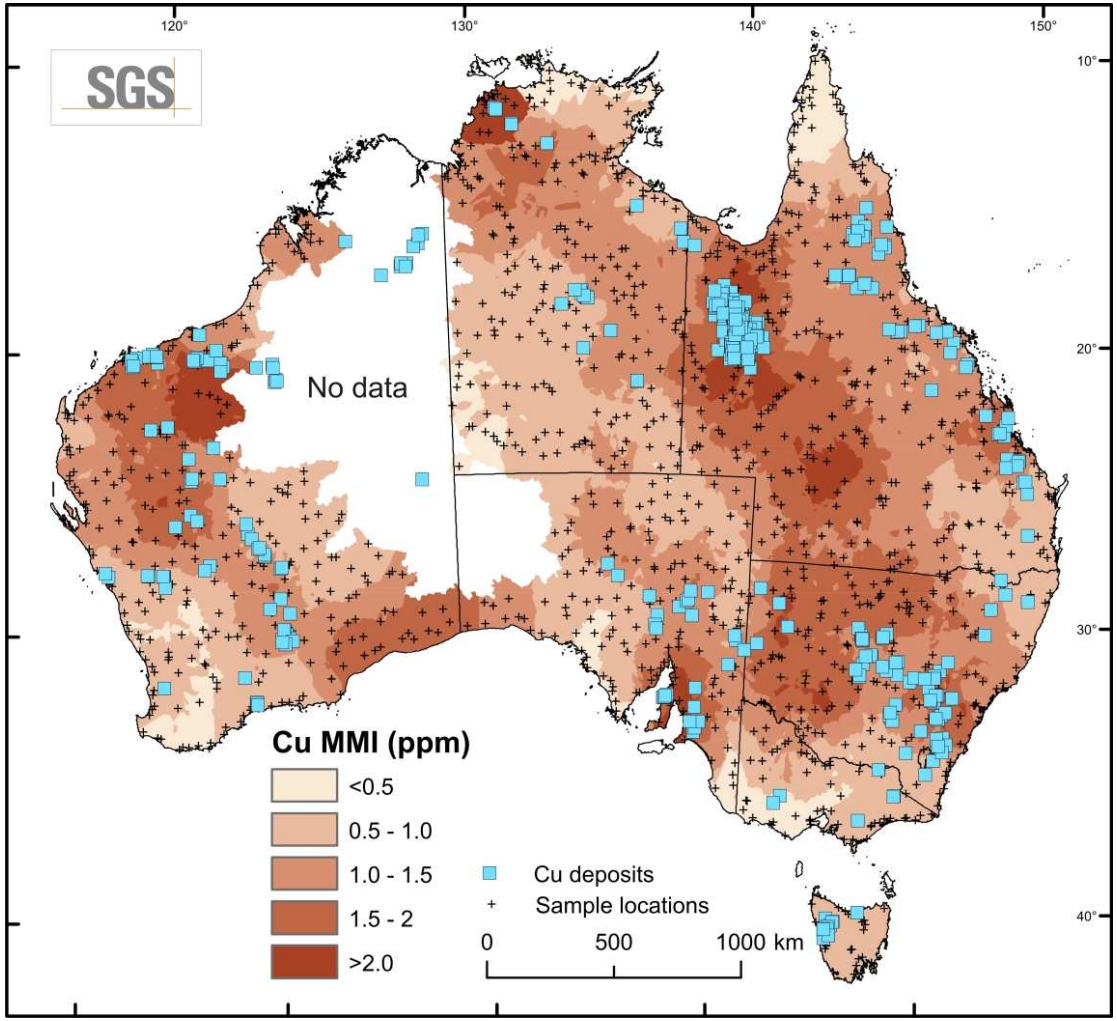


- Sampled transported regolith at outlets of 1187 catchments over mainland Australia
- Average density ~1 site/5500 km^2 (*similar to Foregs European Atlas*)
- Sampled at 2 depths (0-10 cm = TOS, and ~60-80 cm depth = BOS)
- Analyses for 60+ elements on 2 size fractions after total & aqua regia digestion
- Also analysed for 50 elements in TOS coarse fraction by Mobile Metal Ion^{TM} (partial) extraction
- Sampling finished (86% of intended total)
- Analyses finished
- Completed and released in June 2011

www.ga.gov.au/ngsa

Contact: Patrice.deCaritat@ga.gov.au

National Geochemical Survey of Australia (NGSA)



Cu concentration by Mobile Metal Ion™ overlain by major Cu mineral deposits
(Mann, Caritat & Prince, 2012, GEEA, *in press*)

Outline

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2. Examples of GSQ-GA collaborations:
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   - National Geochemical Survey of Australia (NGSA)

3. **National Unconventional Hydrocarbon Resource Assessment**

National Unconventional Hydrocarbon Resource Assessment

Outline:

1. Geoscience Australia's Role

2. GSQ collaboration

3. Unconventional Hydrocarbon Resource Assessment Methodology

Geoscience Australia's Role

National Resource Assessment Coordination:

- No unified national approach in the assessment of unconventional hydrocarbon resources in Australia
- Produce nationally consistent, geologically based, auditable and efficient resource assessments using an internationally benchmarked methodology
- Collaborate with the State and the Northern Territory government agencies and the United States Geological Survey (USGS)

GSQ Collaboration

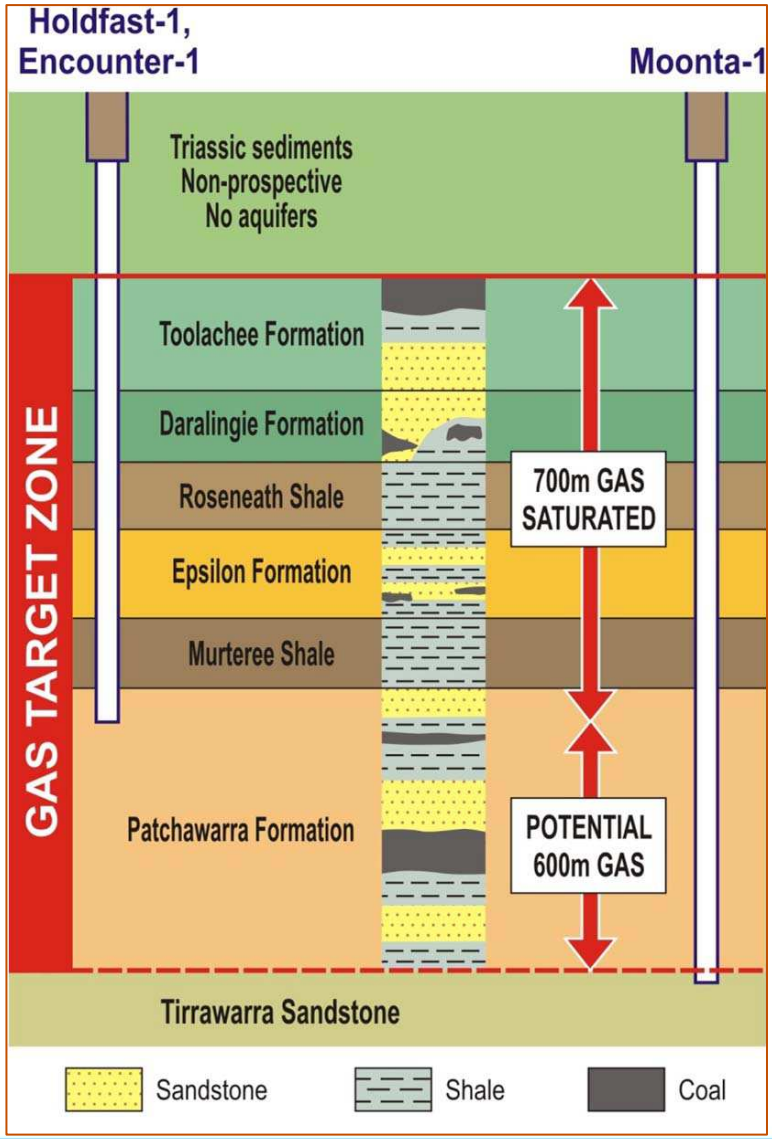
Three basins currently being examined:

1. Georgina Basin:
   - Qld + NT
   - Arthur Creek Hot Shale
   - GA leading the assessment with GSQ support

2. Eromanga Basin – Toolebuc Formation
   - Qld + SA +NT
   - GSQ leading with GA support

3. Cooper Basin – Basin Centred Gas Accumulation
   - Qld + SA
   - Toolachee, REM & Patchawarra, ?Tirrawarra, ?Merrimelia
   - DMITRE (SA) + GA leading with GSQ support

Cooper Basin: Basin Centred Gas Accumulation



Key Elements:

Abnormal pressure,

Multiple low permeability reservoirs,

Continuous gas saturation, and

No down-dip water leg

Heterolithic: Shale Gas, Tight Gas and CSG (Deep)

Beach Energy:

- Moonta-1 reported to be gas saturated throughout the target Permian zone
- Single-stage fracture stimulation of the Patchawarra Formation, flow a rate in excess of 750,000 scfd (Encounter-1).
- Multi-stage frac of the REM, flow rates >2 MMcfd, 2 tcf resource booked (Encounter-1, Holdfast-1)
- 300+ tcf estimated GIP

Santos:

- 3x stage fracture stimulation of the Moomba 191 Roseneath-Epsilon-Murteree (REM) section resulted in stabilised flow rate of 2.7 mmscf/d dry gas. (Australia's first commercialised shale gas)
- Moomba 77 fracced and flowing gas from coal (?VC50) in the Patchawarra Fm.

Modified from Beach Energy Presentation to Morgan Stanley Shale Gas and Oil Forum, 17 April 2012

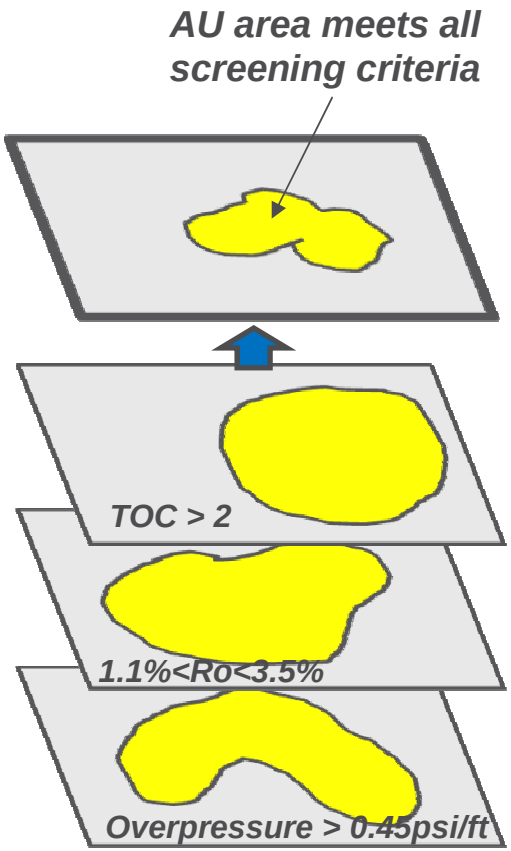
USGS Assessment Method

Productivity based method, not volumetric:

- Play or Assessment Unit (AU) defined by geological screening criteria
- The productivity of cells, represented by the drainage area of a well
- Well productivities from decline-curves: Estimated Ultimate Recovery/well (EUR)

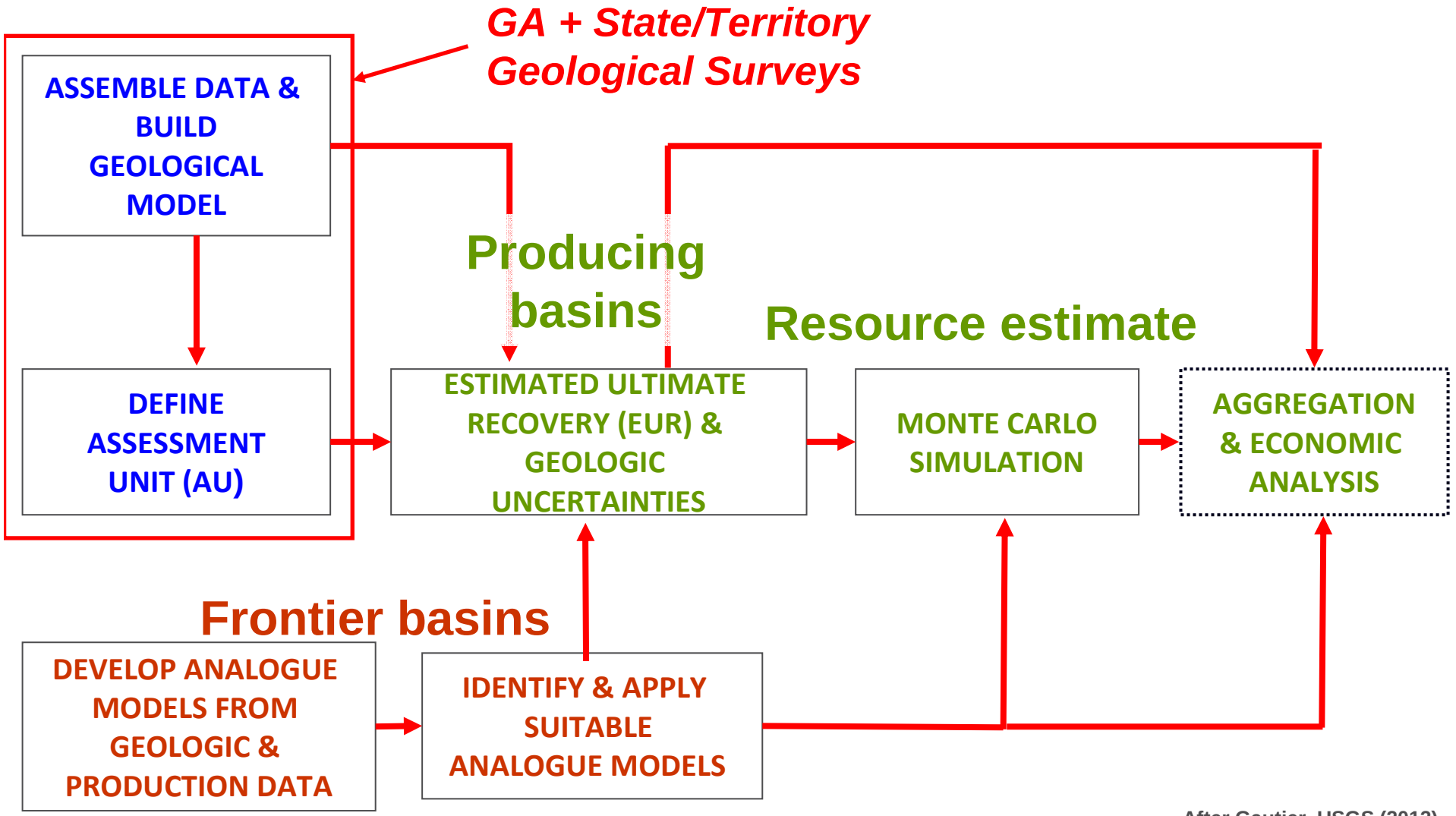
Probabilistic not deterministic:

- Parameters are evaluated as probability distributions
- Distributions are combined in a Monte Carlo simulation



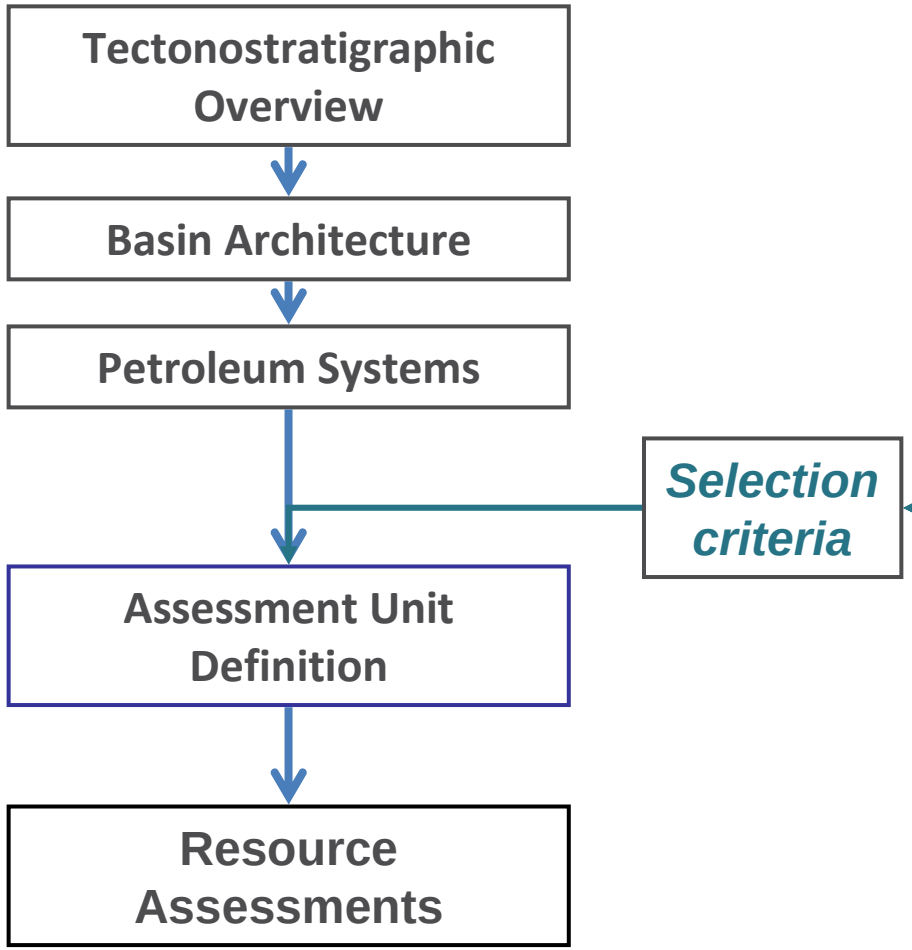
USGS Assessment Unit (AU)

USGS Assessment Workflow



After Gautier, USGS (2012)

Assessment Unit Definition



Selection criteria

OR

Criteria for highly productive gas shale:

- Total Organic Carbon (TOC) > 2 wt percent
- Thermal Maturity > 1.1% Ro (>1.5 % is better); < 3.5% Ro (reservoir quality)
- Net thickness > 15m
- Overpressured (>0.45 psi/ft)
- Type II or Type IIs kerogen (marine)
- Type I systems are possible
- Evidence of gas in matrix/organic storage

Criteria for tight gas reservoir:

- Thermal maturity > 0.8% Ro
- Low permeability matrix (< 0.1 mD)
- Abnormal pressure (mostly overpressure)
- Water production data
- Thick reservoir intervals (100's of meters)

Other play types?

Shale oil, CSG, hybrid?

Advantages

Quantifies the uncertainty around predicted resource volumes – potentially avoids overestimation associated with deterministic volumetric methods

Standardised and reproducible method – uses simple form-based user interface for inputs

Benchmarked against 'real-world' production data in North America and globally – mitigates uncertainties in geological and engineering controls on ultimate recovery

Total Petroleum System (TPS) and Assessment Units (AU)	Field type	AU probability	*Total undiscovered resources*							
			Gas (BCFG)				*NGL (MMBNGL)*			
			F95	F50	F5	Mean	F95	F50	F5	Mean
Devonian Shale-Middle and Upper Paleozoic TPS										
Foldbelt Marcellus AU	*Gas*	1.0	345	698	1,410	765	0	0	0	0
Interior Marcellus AU	*Gas*	1.0	41,607	76,078	139,106	81,374	1,497	2,982	5,938	3,255
Western Margin Marcellus AU	*Gas*	1.0	1,002	1,907	3,629	2,059	57	113	224	124
Total undiscovered resources			42,954	78,683	144,145	84,198	1,554	3,095	6,162	3,379

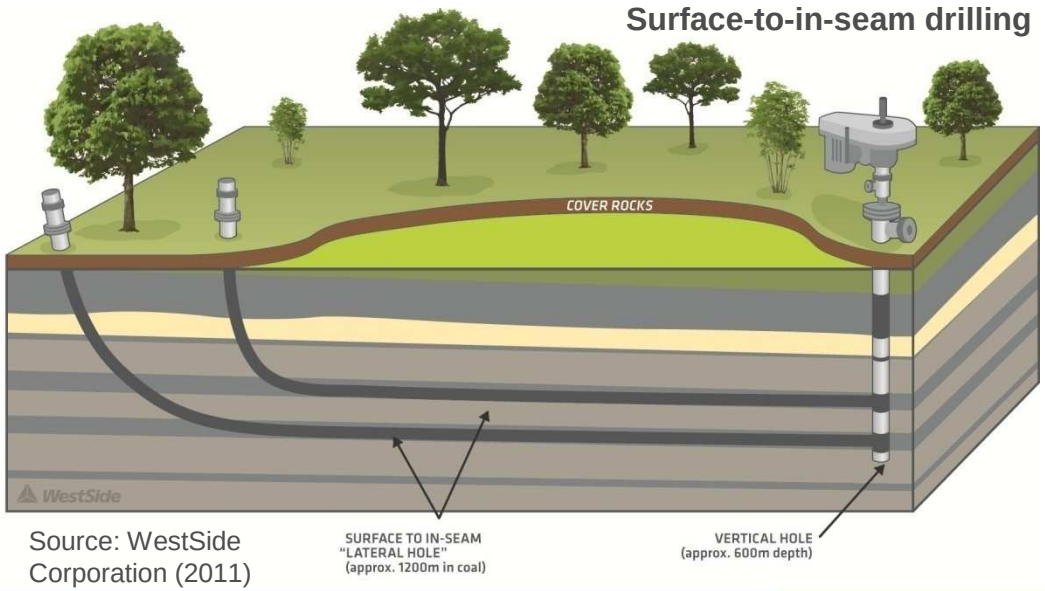
USGS: Assessment of Undiscovered Oil and Gas Resources of the Devonian Marcellus Shale of the Appalachian Basin Province, 2011

Limitations

Assessments do not consider future advances in production technology

Large data and labour requirements

- **North American production data may not always be the best analogues in Australia**



Source: WestSide Corporation (2011)

Outputs

Documentation

- GA record
- Fact sheet etc..

Delivery mechanisms:

- Web site download
- Conferences

Branding?

- Consistent look and feel
- Co-branding
  - USGS, GA, States

USGS
science for a changing world

National Assessment of Oil and Gas

Assessment of Undiscovered Oil and Gas Resources of the Devonian Marcellus Shale of the Appalachian Basin Province, 2011

Introduction

Using a geology-based assessment methodology, the U.S. Geological Survey (USGS) estimated a mean undiscovered natural gas resource of 84,198 billion cubic feet and a mean undiscovered natural gas liquids resource of 3,379 million barrels in the Devonian Marcellus Shale within the Appalachian Basin Province. All this resource occurs in continuous accumulations.

In 2011, the USGS completed an assessment of the undiscovered oil and gas potential of the Devonian Marcellus Shale within the Appalachian Basin Province of the eastern United States (fig. 1). The Appalachian Basin Province includes parts of Alabama, Georgia, Kentucky, Maryland, New York, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia. The assessment of the Marcellus Shale is based on the geologic elements of this formation's total petroleum system (TPS) as recognized in the Appalachian Basin Province. These elements incorporate the characteristics of the TPS as a petroleum source rock (source rock richness, thermal maturation, petroleum generation, and migration) as well as a reservoir rock (stratigraphic position and content and petrophysical properties).

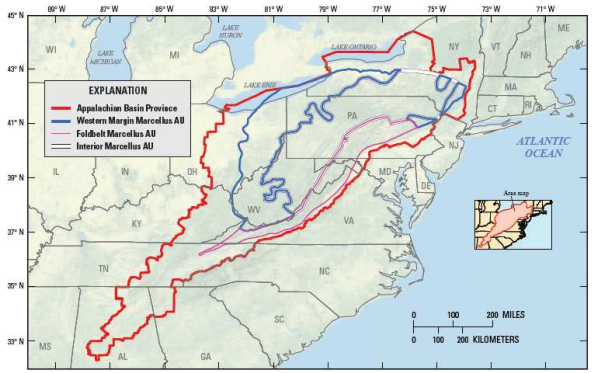


Figure 1. Map of the Appalachian Basin Province showing the three Marcellus Shale assessment units, which encompass the extent of the Middle Devonian from its zero isopach edge in the west to its erosional truncation within the Appalachian fold and thrust belt in the east.

U.S. Department of the Interior
U.S. Geological Survey

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Fact Sheet 2011–3092
August 2011

The Marcellus Shale is divided into three AUs within the formation's extent in the Appalachian Basin—the Western Margin Marcellus AU, which encompasses the western extent of the formation and west of the Appalachian Structural Front (ASF); the Interior Marcellus AU, which is the central extent of the trend and west of the ASF; and the Foldbelt Marcellus AU,which is east of the ASF. The total area of these three AUs extends from southern New York to northeastern Tennessee and from central Ohio to western Virginia and Maryland.

The Western Margin Marcellus AU includes the formation where it is less than 50 feet (ft) thick, ranges in depth from less than 2,000 ft to more than 9,000 ft, and contains strata that range in current levels of thermal maturity from pre-peak oil to past-peak gas. The Interior Marcellus AU contains the Marcellus Shale that is 50 feet thick or more, ranges in depth from less than 2,000 ft to more than 11,000 ft, and contains strata that range in current levels of thermal maturity from peak oil to past-peak gas. The Foldbelt Marcellus AU contains the Marcellus Shale within the Appalachian fold and thrust belt, ranges in thickness from a few feet to more than 350 ft thick, ranges in depth from outcrop to more than 11,000 ft, and contains strata that range in current levels of thermal maturity from peak gas to past-peak gas.

Table 1. Appalachian Basin Province assessment results.

[Results shown are fully risked estimates. For gas accumulations, all liquids are included as natural gas liquids (NGL). F95 represents a 95 percent chance of at least the amount tabulated; other fractiles are defined similarly. Fractiles are additive under the assumption of perfect positive correlation. AU, assessment unit; BCFG, billion cubic feet of gas; MMBNGL, million barrels of natural gas liquids; TPS, total petroleum system]

Total Petroleum System (TPS) and Assessment Units (AU)	Field type	AU probability	Total undiscovered resources							
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Marcellus Shale Assessment Team

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For Further Information

Supporting geologic reports on the Marcellus Shale resource assessment are in preparation. More information about the Marcellus Shale and other oil and gas assessments, the assessment methodology, and the TPS and assessment units can be found at the USGS Energy Resources Program Web site (*http://energy.usgs.gov/*).

Australian Government
Geoscience Australia

Many Thanks!

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