

Queensland's unconventional petroleum potential

Shale oil and gas, tight gas and coal seam gas

July 2015

Overview

Queensland has a series of stacked sedimentary basins ranging in age from Paleoproterozoic to Quaternary (see Table 1 and Figure 1). Many of these basins are likely to be prospective for unconventional petroleum.

Exploration for conventional petroleum began in earnest in 1960, targeting basins across Queensland. Petroleum discoveries were made in the Bowen, Surat, Cooper and Eromanga basins. These basins have become the state's key petroleum-producing regions, serviced by processing facilities and major transmission pipelines.

The successful development of unconventional petroleum resources was pioneered in North America. High gas prices drove research and development of horizontal drilling and hydraulic fracturing which have become critical in producing natural gas from low permeability reservoirs. Further application of this technology led to commercial production of natural gas and oil from tight sandstone and shale formations in many basins across North America.

Significant coal seam gas (CSG) reserves have been discovered in the Bowen and Surat basins in eastern Queensland. CSG is now the dominant sector of Queensland's petroleum industry. Combined proved and probable reserves, as at 31 December 2014, were 1144 million cubic metres with estimated production in 2014 of 8984 million cubic metres. This represents almost 90 per cent of gas production in Queensland and 9 per cent of reserves. Growth in production and reserves in these basins will continue because CSG is the feedstock for a developing export liquefied natural gas (LNG) industry, based at Gladstone. The first cargo was exported in January 2015.

For more information on conventional petroleum and coal seam gas activity in Queensland, please see the 'Queensland's Petroleum and Coal Seam Gas' brochure.

There are many examples from the history of petroleum exploration in Queensland of hydrocarbon shows within source rocks and tight reservoirs. In some areas, hundreds of wells have penetrated intervals which have consistently recorded oil or gas shows over shale or tight sandstone intervals. These shows were largely ignored in the search for conventional petroleum reservoirs due to the lack of technology to extract oil and gas.

Exploration for shale oil and gas, tight gas and basin-centred gas has begun in Queensland, with recent exploration being focused on the Isa Superbasin and Georgina, Cooper, Bowen and Eromanga basins.

A review of petroleum systems studies has highlighted formations with source rock potential across Queensland that may have potential for shale oil or gas. Further assessment of the geological setting and characteristics is required to determine their potential as viable exploration targets.

Coal seam gas

Exploration for CSG in Queensland began in the late 1970s. Since then, all of the state's coal-bearing basins have attracted exploration activity. During the mid-1990s, reserves were defined in Permian coal measures in the Bowen Basin, and commercial production started from the Dawson River CSG field near Moura in 1996. From 2000, the Surat Basin became the focus of CSG exploration when large CSG reserves were discovered in the Jurassic Walloon Coal Measures. Commercial production in the Surat Basin commenced in 2006.

Greenfields exploration for CSG has focused on the Permian coal measures of the Galilee Basin, Cretaceous coal measures of the Eromanga, Maryborough and Styx basins, and the Tertiary coal measures of the Nagoorin Graben, Hillsborough and Duaringa basins. Exploration is also occurring on deep coal seams within the Permian interval of the Cooper Basin.

Tight gas and basin centred gas

Tight gas resources have long been known in Queensland. The adoption of new drilling technology resulted in renewed exploration for tight gas resources in the sandstones in the Permian Tinowon Formation of the southwest Bowen Basin in the early 2000s. In the past, exploration for conventional petroleum in many areas of Queensland has identified regions and formations with promising gas shows, but the reservoirs were evaluated as too tight.

These basins include the Georgina, Adavale, Galilee, Cooper, Maryborough and Laura basins (Table 2).

Re-assessment of the petroleum potential of these basins, with improved drilling and completion technologies in mind, has already begun. Recently, exploration for tight gas resources has targeted the Georgina and Cooper basins.

Shale oil and shale gas

Shale oil and gas exploration is still at a very early stage in Queensland. Several formations have been identified as possible shale gas targets (see Table 2). To date, exploration for shale gas and oil in Queensland has focused on shales in the Isa Superbasin, and Georgina, Cooper and Eromanga basins.

The Geological Survey of Queensland (GSQ) has been conducting a regional assessment of the Toolebuc Formation

in the Eromanga Basin to assess its shale oil or shale gas potential. The Toolebuc Formation is spatially extensive and relatively shallow, making it an easy exploration target. While current work suggests that there is a play fairway in the central Eromanga Basin, further exploration and research is required to determine the full potential of the Toolebuc Formation as an economic shale gas or shale oil target. For more information on this project, see the Toolebuc Formation brochure available from GSQ.

Table 1: Ages of sedimentary basins with unconventional petroleum resource potential

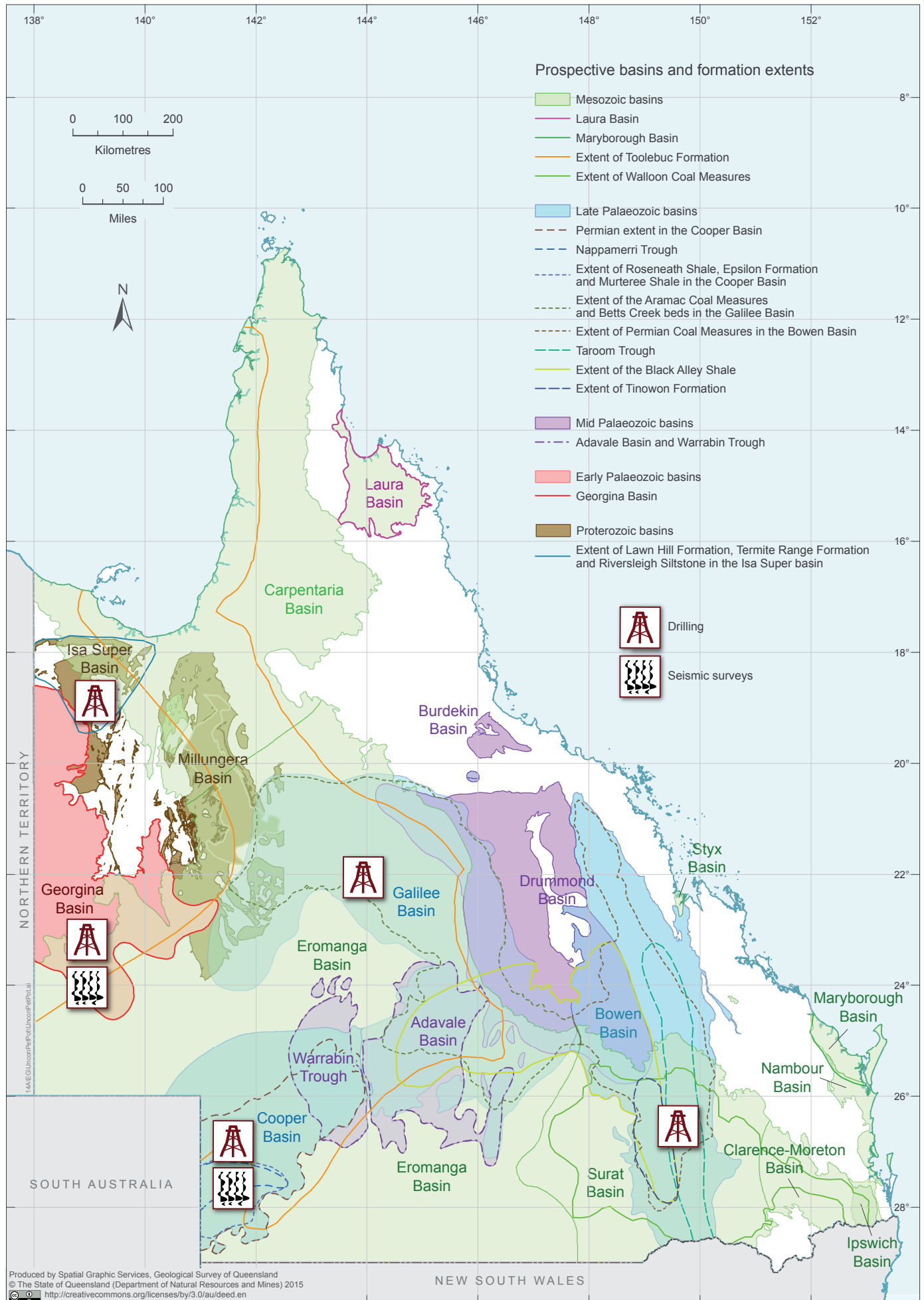
Basin	Age	Basin	Age
Laura Basin	Middle Jurassic to Early Cretaceous	Bowen Basin	Early Permian to Middle Triassic
Maryborough Basin	Late Triassic to Cenozoic	Galilee Basin	Carboniferous to Triassic
Eromanga Basin	Early Jurassic to Late Cretaceous	Adavale Basin	Early Devonian to Late Carboniferous
Surat Basin	Late Triassic to Middle Cretaceous	Georgina Basin	Neoproterozoic to Ordovician
Cooper Basin	Late Carboniferous to Middle Triassic	Isa Superbasin	Paleoproterozoic to Mesoproterozoic

Table 2: Summary of attributes — unconventional petroleum target formations in Queensland

Basin	Formation	Environment	Thickness (m)	Top Depth (m)	TOC (%)	Rv (%)	Resource Target
Laura Basin	Dalrymple Sandstone	Fluvio-deltaic	329 to 527 m	442 to 592 m	0.91 to 12.90%	0.81%	Shale gas or tight gas
Maryborough Basin	Maryborough Formation	Marginal marine to estuarine	up to 2245 m	Outcrop to 865 m	approx. 1.5%	up to 2.88%	Shale gas or tight gas
Maryborough Basin	Tiaro Coal Measures	Fluvio-lacustrine	6 to >430 m	Outcrop to 592 m	Coal	up to 3.02%	CSG or shale gas
Eromanga Basin	Winton Formation	Fluvio-lacustrine	400 to 1000 m	Outcrop to 1060 m	Coal	0.3 to 0.5%	CSG
Eromanga Basin	Toolebuc Formation	Restricted marine	20 to 45 m	Outcrop to 1640 m	0.2 to 26.1%	0.35 to 0.55%	Shale oil or shale gas
Eromanga Basin	Birkhead Formation	Fluvio-deltaic to lacustrine	up to 580 m	Outcrop to 2180 m	0.75 to 6.3%	up to 1%	Shale gas
Eromanga Basin	Westbourne Formation	Fluvio-lacustrine	70 to 130 m	Outcrop to 2046 m	0.51 to 2.18%	0.7 to 0.87%	Shale gas
Eromanga Basin	Poolowanna Formation	Fluvio-lacustrine	up to 165 m	370 to 2450 m	0.6 to 17.9%	up to 1.2%	Shale gas
Surat Basin	Walloon Coal Measures	Fluvio-lacustrine	up to 507 m	Outcrop to 1660 m	Coal	0.35 to 0.6%	CSG
Cooper Basin	Toolachee Formation	Fluvio-lacustrine	20 to 50 m	1360 to 2950 m	up to 7.2%	up to 2.4%	Shale gas or tight gas
Cooper Basin	Roseneath Shale	Lacustrine	20 to 80 m	1360 to 2530 m	1.0%	1 to 4%	Shale gas
Cooper Basin	Epsilon Formation	Prograding delta	30 to >60 m	1370 to 2625 m	3.7 to 7.5%	0.6 to 1.6%	Tight gas
Cooper Basin	Murteree Shale	Deep, freshwater lacustrine	Average of 50 m, up to 80 m	1370 to 2680 m	2.50%	1 to 4%	Shale gas
Cooper Basin	Patchawarra Formation	Fluvio-lacustrine	up to 550 m	1375 to 2990 m	Coal	up to 3.6%	Shale gas or tight gas
Bowen Basin	Bandanna Formation	Deltaic	up to 173 m	Outcrop to 2900 m	Coal	approx. 0.9%	CSG or tight gas
Bowen Basin	Baralaba Coal Measures	Fluvial	up to 556 m	Outcrop to 2982 m	Coal	0.55 to 2.1%	CSG
Bowen Basin	Moranbah Coal Measures	Fluvial	up to 760 m	Outcrop to 790 m	Coal	>1.1%	CSG
Bowen Basin	Black Alley Shale	Marine to lacustrine	up to 350 m	45 to 2030 m	0.29 to 10.18%	0.52 to 0.98%	Shale gas
Bowen Basin	Tinowon Formation	Deltaic	50 to 70 m	890 to 2830 m	–	0.52 to 0.98%	Tight gas
Galilee Basin	Aramac Coal Measures	Fluvial and peat swamp	31 to 272 m	757 to 1600 m	Coal	0.39 to 5.2%	CSG or shale gas
Galilee Basin	Betts Creek beds	Fluvial and peat swamp	50 to 210 m	approx. 900 m	Coal	0.70 to 8.75%	CSG or shale gas
Galilee Basin	Lake Galilee Sandstone	Fluvial	85 to 287 m	1055 to 2734 m	–	up to 1.77%	Tight gas
Adavale Basin	Log Creek Formation	Marine shelf	>755 m	approx. 3100 m	up to 1.55%	1.4 to 1.6%	Shale gas or tight gas
Adavale Basin	Lissoy Sandstone	Nearshore, shallow marine to restricted marine	up to 470 m	approx. 2760 m	–	1.4 to 1.6%	Shale gas or tight gas
Adavale Basin	Cooladdi Dolomite	Lagoonal to back reef	up to 85 m	approx. 2500 m	–	1.4 to 1.6%	Shale gas or tight gas
Georgina Basin	Arrintheta Formation	Carbonate and siliciclastic shelf	138 to 835 m	64 to 726 m	up to 9.6%	up to 0.6% [§]	Shale gas or tight gas
Georgina Basin	Inca Shale	Marine	up to 133 m	Outcrop to 3216 m	up to 2.82%	CCAI* of 1 to 1.5	Shale gas or tight gas
Georgina Basin	Thorntonia Limestone	Peritidal to restricted shallow marine	13 to 104 m	Outcrop to 1960 m	up to 8.7% in NT wells	–	Shale gas or tight gas
Georgina Basin	Beetle Creek Formation	Marine	27 to >172 m	Outcrop to 1018 m	0.19 to 1.51%	CCAI* of 1 to 1.5	Shale gas
Georgina Basin	Georgina Limestone	Tidal shallow marine	>33.2 to 759 m	Outcrop to 2457 m	EOM [†] up to 2000 ppm	TAI [‡] of 2.25 to 2.50	Shale gas or tight gas
Isa Superbasin	Lawn Hill Formation	Mid to outer shelf	up to 2200 m	Outcrop to 2000 m	up to 7%	–	Shale gas
Isa Superbasin	Termite Range Formation	Turbidite fan	up to 1300 m	Outcrop to 2500 m	up to 8%	–	Shale gas
Isa Superbasin	Riversleigh Siltstone	Mid to outer shelf	up to 2900 m	Outcrop to 4500 m	up to 8%	–	Shale gas

[§] Analysis only from PGA Bradley 1, *Conodont Colouration Alteration Index, [†]Extractable organic matter, [‡]Thermal Alteration Index, TOC – total organic carbon, Rv – Vitrinite reflectance, NT – Northern Territory
Note: Statistics quoted in this brochure were compiled by the Department of Natural Resources and Mines, 2013–14.

Figure 1: Queensland basins — unconventional petroleum potential



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The Cooper Basin

The Cooper Basin is Australia's premier onshore conventional petroleum province with many fields producing oil and gas. These fields have well established infrastructure including processing plants and major transmission pipelines servicing Adelaide, Sydney and Brisbane, making this area one of the premier locations for exploration and development of deep gas.

Recent exploration drilling within the Nappameri Trough in the Queensland portion of the Cooper Basin intersected over 1.3 kilometres of Permian rocks likely to be gas saturated and overpressured, suggesting the presence of a significant new gas resource in the Cooper Basin in Queensland. The interval predominantly comprises sandstones, shales and coals that form a 'hybrid' type play with multiple shale gas, tight gas and deep coal seam gas targets. Collectively, this sequence may represent a basin-centred gas play. Other deep troughs in the Cooper Basin may also present targets for tight gas drilling.

The Roseneath-Epsilon-Murteree (REM) interval within the Cooper Basin has specifically been targeted by shale gas exploration.

Following successful drilling in the South Australian portion of the Cooper Basin, recent exploration drilling in Queensland intersected over 450 metres of REM within the Nappameri Trough that is likely to be gas saturated and over-pressured, suggesting potential for significant shale gas resources is also present within Queensland.

Cooper Basin Industry Development Strategy

The Cooper Basin has a mix of attractive gas and oil targets as well as significant pipeline infrastructure into the Eastern Australia Gas Market.

A Cooper Basin Industry Development Strategy has been developed to facilitate both exploration for, and development of, the gas and oil in this remote part of the State. Key elements of this strategy are:

- releasing new areas for exploration in the Cooper Basin during 2015 and beyond
- making more high quality geological and geophysical data available to industry online
- negotiating a Memorandum of Understanding between Queensland and South Australia identifying opportunities to encourage investment and facilitate cross border operations
- delivering more practical and flexible tenure arrangements for industry
- developing a Cooper Basin Water Strategy to protect local water users and ensure responsible and productive use of water resources in the Basin
- undertaking regular community and stakeholder engagement sessions in the Cooper Basin.

Data availability

Many basins with unconventional petroleum potential have not been the major targets for conventional petroleum exploration and production in Queensland. As a result, there are limited analysis data available, and the data presented in Table 2 are only approximate. Well completion reports, analytical results (where available) and wireline-log data are available from the GSQ.

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