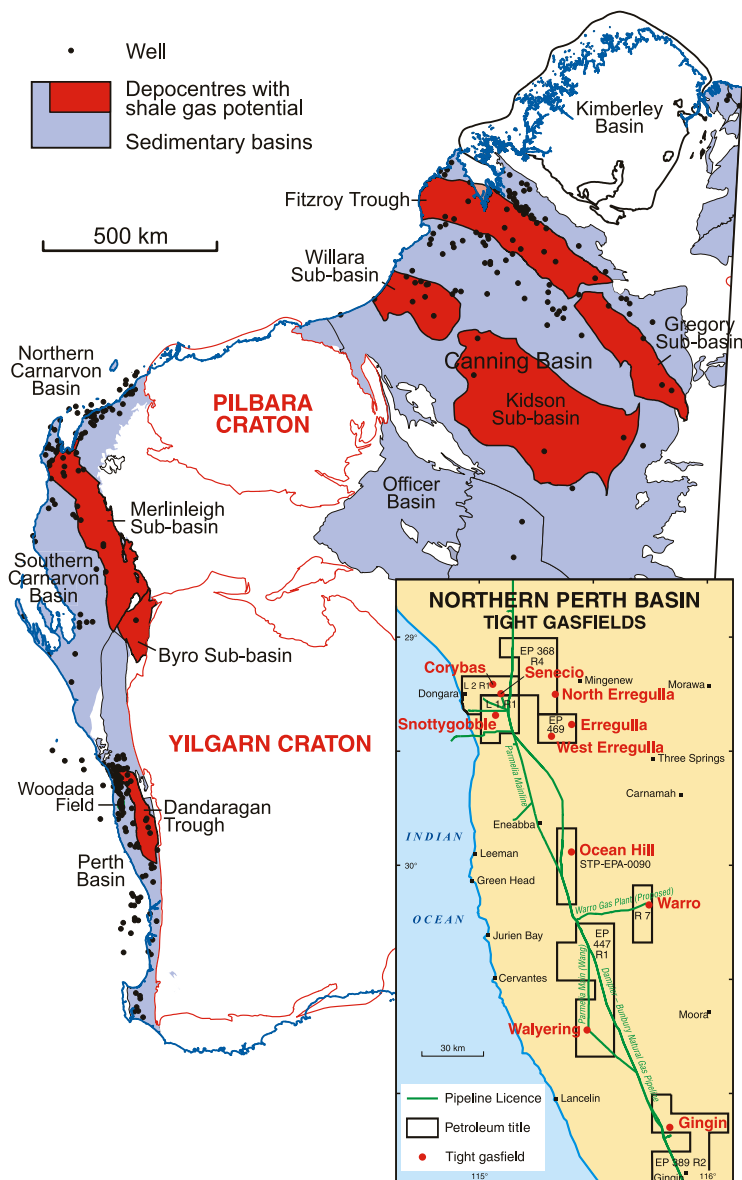


# INVESTMENT OPPORTUNITIES SHALE AND TIGHT GAS



## Unlocking tight gas in Western Australia

- Tight gas has enormous potential to deliver Western Australia an alternative energy supply.
- The Perth Basin is estimated to hold about 255 to 340 Gm<sup>3</sup> (9 to 12 Tcf) of gas, which is enough to meet Western Australia's domestic needs for up to 30 years.
- Conveniently, many of the tight gas resources in Western Australia are in areas where energy demand is the greatest.
- The Valhalla gas accumulation may also represent a new type of tight gas play in the Canning Basin.

### Extracting tight gas

Tight gas is found in rocks of very low permeability, and specialist techniques and equipment are required to extract it.

Using fracture stimulation technology, tight gas reservoir rocks can be made to fracture by applying high pressure, inducing the gas to flow into the wellbore and to the surface.

Fracture technology is widely used in many parts of the world.

## Shale Gas

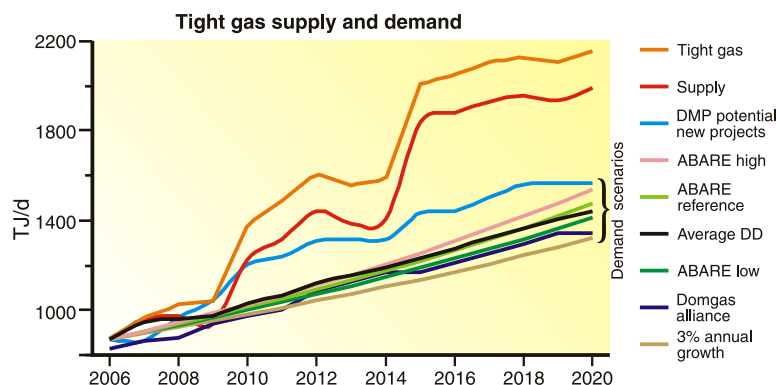
### Canning Basin

- Shale gas in-place is 22,200 Gm<sup>3</sup> (784 Tcf) in the Goldwyer Formation and 5,593 Gm<sup>3</sup> (194 Tcf) in the Laurel Formation Lower. Carboniferous Laurel Formation oil and gas-prone shales, which have sourced the Boundary, Lloyd, Sundown and West Terrace oilfields in the Canning Basin, have excellent shale gas potential.
- New Standard Energy's Nicolay 1 (2011) well was the first to target shale gas in the Canning Basin.
- The well Theia 1 (2015) by FINDER Shale Pty Ltd was the first to target shale oil in the State.
- Shale gas exploration is at a very early stage and much more work is required to delineate and commercialize such petroleum resources in the vast, under-explored onshore basins of Western Australia.

### Perth Basin

- Shale gas in-place is up to 6,314 Gm<sup>3</sup> (223 Tcf) total from the Kockatea and Carynginia Formations. The Irwin River and Cattamarra Coal Measures also show shale gas potential.
- AWE's Woodada Deep 1 (2010) and Northwest Energy's Arrowsmith 2 (2011) wells in the northern Perth Basin were successfully fractured and flowed gas.

The depocentres (in red) in the Canning, Southern Carnarvon, and Perth Basins contain potential shale gas targets. All depocentres have known petroleum systems; the Perth and Canning Basins have producing petroleum fields.



### The value of tight gas

The economic viability of tight gas has in the past been affected by low gas prices, and expensive field development and technology costs.

Increases in domestic gas prices, improvements in stimulation technology and the need for energy diversity and security have increased the potential for tight gas to be commercially extracted.

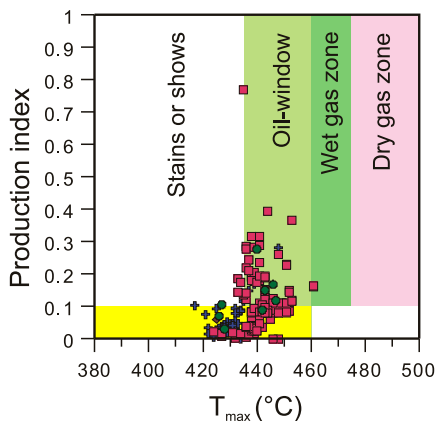
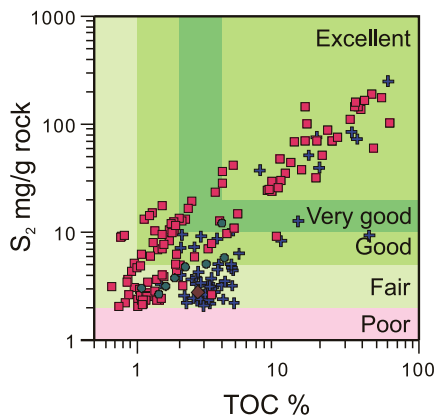
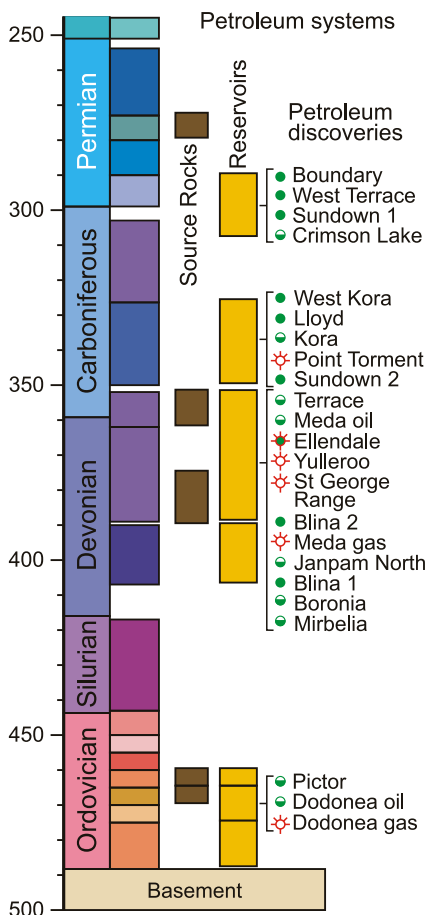
The Western Australian Government has also reduced the royalties rate for tight gas producers from 10% to 5%. The Government has recognised that start-up and operational costs for tight gas producers are very different to those of other petroleum producers.

### Technical and economic considerations

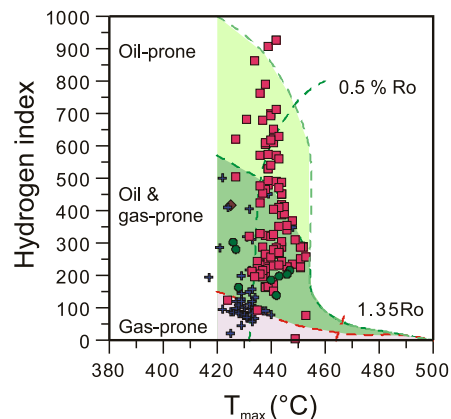
- Availability of technology in Western Australia (e.g. well stimulation, coiled tubing and underbalance drilling equipment)
- Cost of mobilising equipment to Western Australia: a large number of projects/wells is required in order to push down average cost
- Drilling and well stimulation
- Coordination to achieve economies of scale



# CANNING BASIN



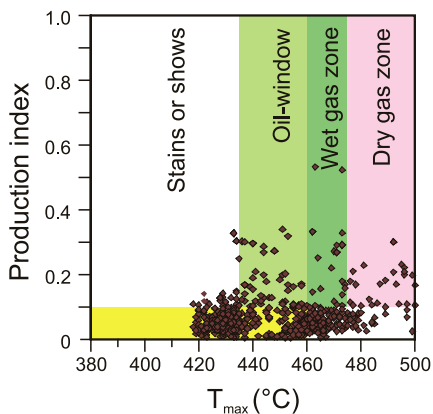
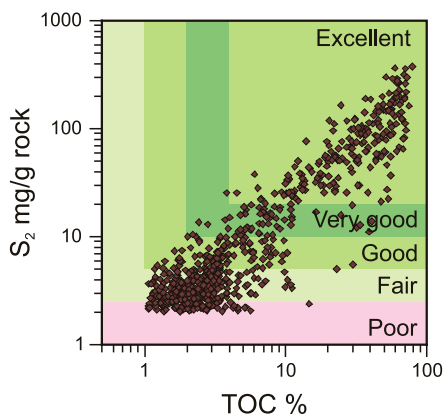
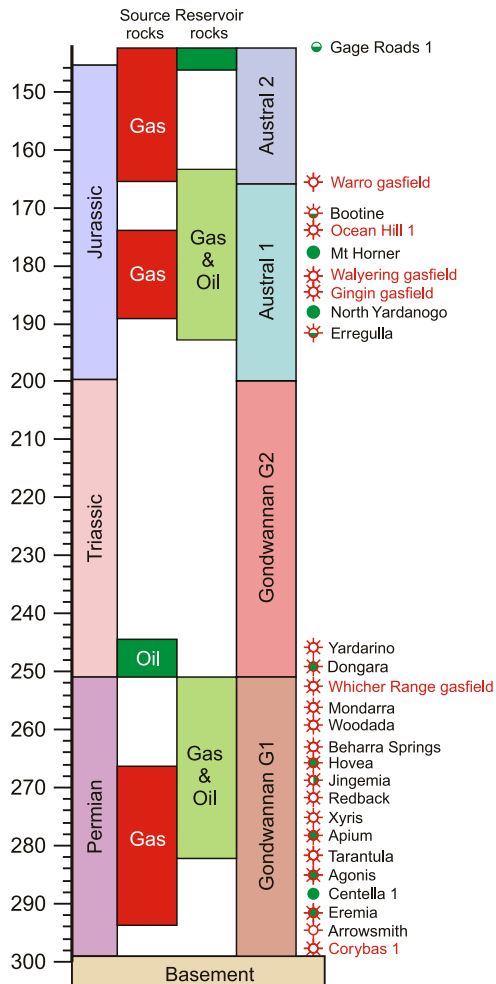
+ Permian      ♦ Lower Carboniferous  
 ● Devonian      ■ Ordovician



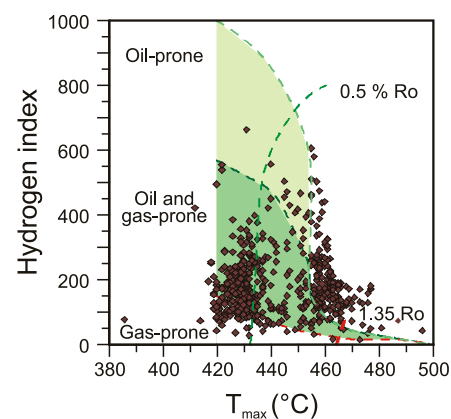
The Goldwyer Formation source and oil have been matched with source and oil from the Baltic, Michigan, Illinois, Williston, and Amadeus Basins, with kerogen predominantly derived from *G. prisca*.

The Devonian Gogo and Carboniferous Laurel Formations equated with the most prolific global marine oil-prone source-rocks of the Paleozoic.

# PERTH BASIN



+ Permian      ♦ Lower Carboniferous  
 ● Devonian      ■ Ordovician



The Permian Carynginia Formation (gas-prone) and Triassic Kockatea Shale (oil-prone) contain mature, organic-rich source beds and produced gas on fracturing. Commercial viability studies are underway.

The Perth Basin has the best infrastructure and market for shale-gas, and is the most actively explored basin in Western Australia.

