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Shale gas in Australia: a great opportunity comes with significant challenges

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Introduction

The term ‘shale gas’ is misleading as it includes gas hosted in tight siltstone, sandstone or limestone reservoirs, as well as shales. These non-shale reservoirs are always in close spatial association with the organic rich source rock, often being interbedded with it. It is probably more correct to use the term tight gas; however, the current usage is likely to persist.

Australia could have shale gas resources several times bigger than the existing conventional gas resource base, which is currently estimated at approximately 5300 BCM (190 TCF) by Geoscience Australia (GSA, 2011). The Australian Government currently has no estimate of potential shale gas resources. The US Department of Energy (EIA, 2011) estimated Australian shale gas resources to be 400 TCF. The quantum of this estimate is supported by an Australian study conducted by Advanced Well Technologies (AWT) in conjunction with DSWPET, which estimates resources of 600 TCF. Therefore, in the climate of:

- diminishing Australian self-sufficiency in liquid hydrocarbons,
- the rising cost of offshore gas,
- the worldwide push for carbon abatement, and
- the presence of very large Asian growth economies hungry for gas resources,

there appears to be a real opportunity for large scale development of Australian shale gas resources.

While there are significant technical differences between the shale gas plays in the USA and Australia, it is too early to tell if the technical differences are showstoppers. There are significant differences in the commercial landscape also. The lack of capacity in Australia has led to much higher costs for drilling and fracture stimulation than in the USA. The size of the domestic gas market is much greater in the USA and its existing infrastructure allows for production to come onstream quickly. In Australia this infrastructure is not present in most areas and the domestic market cannot support another large gas development.

Despite these differences, the author’s analysis of the current state of the Australian shale gas industry sees no real showstoppers to its development. Similar technical and environmental hurdles have been overcome in the USA. Also extractive industries in Australia such as iron ore and coal seam gas have overcome similar commercial/capacity issues. The gas markets in Asia seem to want more and more gas supporting an industry based on export of gas rather than domestic demand.

Perhaps the greatest challenge this opportunity faces is political. There is a public, hence political, perception that all gas sources have the same ‘gasland’ problems. These perceptions can be changed. First, the petroleum industry and the Governments need to understand the potential size of the gas resource and the possible strategic opportunity for Australia. Also, these parties need to recognise that the shale gas resources are often located away from areas of high social and environmental impact. Once these factors are understood by these parties, factual information about the environmental impact of shale gas plays in comparison with coal seam methane (CSM) and other alternative gas supplies can be factored into gas resource planning.

It is noted that recent efforts have been made by WA operators and the Australian Petroleum Production and Exploration Association (APPEA) to develop a code of practice for fracture stimulation.

What is shale gas?

Shale gas is defined for this article as natural gas trapped in fine grained sedimentary rocks that contain significant amounts of source material, which has generated the gas and stored some of it. The natural gas can contain significant quantities of liquid hydrocarbons. Shale gas reservoirs are essentially source pods that also store natural gas.

The reservoir sections may be homogenous or have shales interlaminated with other lithologies such as sandstones and or limestones and siltstones. All shale gas reservoirs have very low permeability. For example, the Barnett Shale in the USA is a highly silicious, organic rich shale with an average permeability of approximately 4 nanodarcies. Natural gas is stored in these reservoirs as both sorbed and free gas.

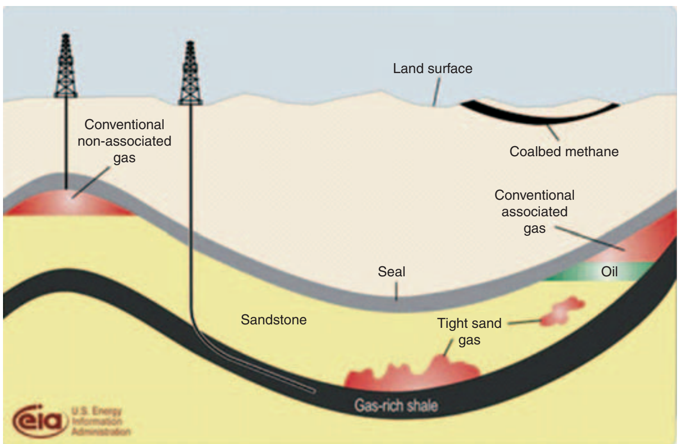

Fig. 1. *Habitat of shale gas plays.*

As shale gas plays are sourced by the reservoirs themselves and hydrocarbon migration plays little to no role in the accumulation process, the size and extent of these plays can be significantly greater than most conventional reservoir plays. Shale gas accumulations can be described as continuous gas accumulations as defined by the United States Geological Service (USGS) in their regional Resource Assessments (Pollastro, 2007). Figure 1 is a representation of one type of hydrocarbon system with a shale gas accumulation and indicates that the continuous accumulation can cover a significant proportion of a sedimentary basin.

Lessons from the US shale gas revolution

Perhaps the first lesson to be learnt from the shale gas industry in the USA is the size of the gas reserves that have been discovered. It is estimated by INTEK Inc. (2010) that reserves of the top seven shale gas plays in the USA could be greater than 700 TCF. The areal extent of the Barnett Shale play in Texas is estimated to be 10 000 km^2 (2.5 million acres) and contains 26 TCF of recoverable gas (USGS estimate), while the Marcellus shale in eastern North Amercia covers 140 000 km^2 (34 million acres) and could recover as much as 84 TCF of gas (USGS, 2011).

The shale gas revolution in the USA has changed the gas industry there greatly, but this revolution came about through innovation and persistence, not following the conventional rule book. The application of innovative completion techniques, horizontal drilling, microseismic and massive fracture stimulation, has unlocked very large volumes of gas. This did not happen overnight and the successful innovations were not pioneered by the major oil companies. The cracking of the code for the Barnett shale took approximately 20 years of constant trial by George Mitchell's team at Mitchell Energy to overcome on a consistent basis a multitude of 'problems'. To quote Dan Steward, the author of *The Barnett Shale Play* (Steward, 2007),

> *At Mitchell, and within the industry in general we've learned that through an integration of technologies and disciplines many of these obstacles can be overcome, and I believe will continue to be overcome in the future. The play was, and still is, dependant on intelligent, open minded, energetic professionals from all specialities.*

So perhaps the second lesson to be learnt from the US experience is that commercial success may not come easily and that it won't come unless we are prepared to innovate and experiment.

According to many of the participants in the US industry, another important lesson coming out of the US experience is that no two plays are alike and that while the drilling and completion techniques may look similar, in detail they can be significantly different. With that in mind, the following are considered common factors for successful shale gas plays in the USA:

- reservoir thickness is greater than 30 m (100 ft);
- target zones are well bounded mechanically for fracture stimulation;
- thermal maturity of the source material is in the dry and wet gas windows;
- average gas content is greater than 3.12 m^3/tonne (100 scf/tonne);

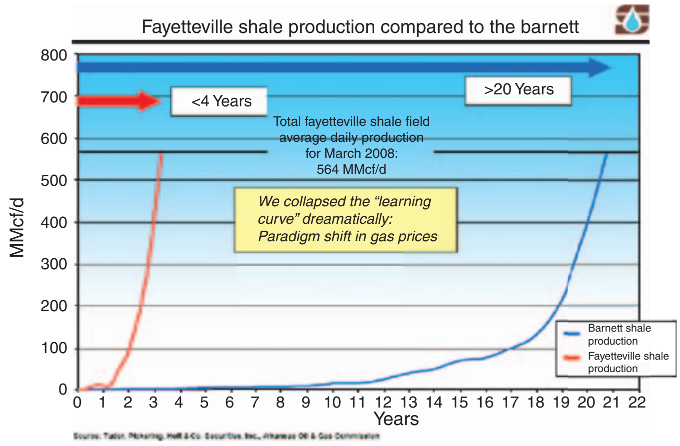

Fig. 2. *Comparison of learning curves in US shale gas plays (from South West Energy website).*

- clay content is less than 40%;
- the rock is brittle;
- the rock fabric and stress regime are aligned to enhance fracture density and connectivity;
- good lateral continuity in commercial reservoir conditions; and
- access to infrastructure and drilling and completion capacity.

It is believed there will be similar requirements for success in Australia.

Following the breakthroughs in commercialisation of the Barnett Shale play, the time between identification of the resource and the establishment of the commercial drilling and completion techniques in other shale plays, such as the Fayetteville and the Haynesville, has occurred much faster. According to South West Energy their solution to the commercialisation of the Fayetteville play took just five years (see Figure 2). So while each play represents an individual challenge to commercialise, the learning period can be successfully reduced by experience gained from precedents in other shale plays.

The success of the shale gas plays in the USA is also attributed to development of a manufacturing model for development. The development of the shale gas play in this mode can drive down cost considerably but involves the utilisation of large amounts of specialised machinery and people (see Figure 3).

It is not within the scope of this paper to outline all the lessons of the shale gas experience in the USA and certainly there are important ones not discussed here. However, the clear message

Fig. 3. *Fracture stimulation of a shale gas well in the USA.*

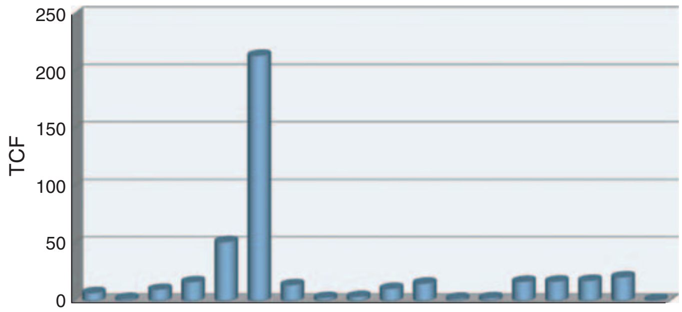

Fig. 4. *Size of potential shale gas plays in Australia (from The Australian Shale Gas Atlas, 2010). This study showed that Australia has shale gas plays ranging in size from 700 km² (175 000 acres) to 200 000 km² (49 421 000 acres) widely scattered across the Australian continent. They range in age from PaleoProterozoic (1600+ ma) to Cretaceous (150 ma).*

is that if a company is prepared to be innovative and patient the reward can be very large. This is demonstrated by the billions of dollars paid by the major petroleum exploration and production companies to acquire acreage in US shale plays established by the early movers such as XTO and Chesapeake.

So in summary, the lessons from the USA are that the key ingredients for success are not all related to just finding a gas saturated shale, but that innovation, patience, industrial capacity, and capital are also necessary.

The shale gas opportunity in Australia: current resource estimates

The US Department of Energy has estimated that Australia may have as much as 396 TCF of recoverable shale gas, ranking it fifth behind China (1275 TCF), the USA (862 TCF), Argentina (774 TCF), Mexico (681 TCF) and South Africa (485 TCF).

A separate study, *The Australian Shale Gas Atlas* by AWT International and DSWPET (2011), has identified 20 potential shale gas plays (see Figure 4) with an estimated recoverable resource of 603 TCF gas and 27 billion BBL oil. The estimated size and number of potential plays in Australia is roughly equivalent to that present in the US where 33 plays have been discovered with an estimated resource of 862 TCF.

Differences between US shale gas and Australian shale gas

While the size and distribution of the potential resource describes a very large opportunity for gas development in Australia, there are some significant differences between the USA condition and that in Australia.

The differences between the Australian and US shale gas plays that can be identified at this time are both technical and commercial and include the following:

1. Source material

While some of the older plays in Australia have source material that is marine (Type I and II) in origin, similar to all the USA plays, Australia is rich in non-marine source rocks (Type II and III). Little is known about whether this will enhance or reduce the gas storage capacity and or fraccability when compared with the marine shale gas plays in the USA.

2. Stress regime

The dominant stress regime in onshore Australian basins (strike slip) is different from that dominant in the USA (normal). As with the source material it is yet unknown whether this will be a blessing, have no effect, or be a curse.

3. Industrial capacity

Currently there is very little drilling or fracture stimulation capacity available in Australia capable of executing the types of programmes used for shale gas in the USA. Presently one large scale frac would consume all the shale frac capability for Halliburton in Australia. Similarly, the number of rigs capable of long horizontal wells at depth is very limited. This lack of capacity means that presently the costs of appraisal are much higher than in the US.

4. Access to infrastructure

The large domestic market for gas in the US is fed by a very large distribution system that covers most areas. As new production comes on it can access this infrastructure quickly and relatively cheaply. This is obviously not the case in Australia.

There is no doubt that as the shale gas plays in Australia mature more differences will become apparent.

Challenges to shale gas play commerciality in Australia

There are significant technical, commercial and political challenges facing the development of shale gas plays in Australia.

Presently there is not enough information available on the shale plays in Australia to be certain what the technical challenges will be. Suffice to say there are likely to be many. The most likely technical challenges are considered to be:

- finding the areas with sufficient gas storage capacity; and
- stress conditions in relation to horizontal drilling and fraccing.

Based on the experience of the USA shale gas industry, technology should be able to overcome these likely challenges, but only time will tell.

The commercial hurdles are related to drilling and fracture stimulation capacity. Currently Halliburton has one shale frac spread available in the whole of Australia. There is a similar shortage of drilling rigs and experienced people who can design and execute the drilling and completion programmes required. In the current phase of exploration in Australia, capacity is not as critical as for the appraisal and development stages. The creation of a manufacturing mode of development is vital to reduce unit costs and provide the steep production ramp up required to maintain commerciality. Again experience, this time with the Australian coal seam gas industry, indicates this capacity can be created in Australia if the demand requires it.

Currently there is a significant ground swell of anti-shale gas development that is present in many parts of the world. Often, and wrongly, shale gas development is seen as the same as the coal seam gas development with the same risks. Such is the concern that presently there is a moratorium on shale gas development in some USA states and in France and South Africa.

Risks attributed by the public to shale gas development, whether correct or not, include:

- chemicals that are used in fraccing may be dangerous and might contaminate groundwater;
- poorly cased wells allow gas to escape into underground aquifers used for human or agricultural purposes;
- waste water returning to the surface during production can be contaminated with salt and radon and may pollute land or streams;
- water used for fraccing depletes a scarce resource;
- exploitation for shale gas can damage amenity and landscape value and competes for agricultural or cropping land; and
- hydraulic stimulation might trigger earthquakes.

It is the author's opinion that all these 'risks' can either be shown to be unfounded or managed and a successful development plan executed. However, until the case is put to the public in a way that can be understood, there will be significant roadblocks to some developments.

An effort initiated by WA operators and supported by APPEA to develop a Code of Practice is a significant and important step toward achieving this (SPE News, December 2011).

Acknowledgements

The author thanks AWT for permission to use parts of *The Australian Shale Gas Atlas* in this paper.

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