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Research paper

A comparison of North American shale plays with emerging non-marine shale plays in Australia

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ABSTRACT

Geological and petrophysical parameters are critical in evaluating the production potential of prospective shale gas plays and their economic viability for commercial development. However, based on the US experience, these characteristics can vary widely. Furthermore, the non-marine shale plays of the Cooper Basin, South Australia are distinctively different from the marine shale plays in the US. Non-marine shale may consist of higher clay content and, thus, may be less responsive to hydraulic fracturing due to the increased ductility. Conversely, the availability of sufficient amounts of quartz and siderite may counteract this effect and maintain brittleness. In this study, the mineral, total organic and gas content, thermal maturity, Poisson's ratio and Young's modulus data obtained from the Roseneath and Murteree formations of the Cooper Basin have been compared with US shale formations. The results show that the formations compare well in terms of thickness, thermal maturity, Young's modulus and Poisson's ratio, but not in clay mineral content and formation temperature and values for TOC, porosity and gas-in-place are comparatively lower. To determine whether such plays are economically viable will require technical, as well as economic, analysis of the hydraulic fracturing process, including the potential for horizontal and vertical well development or basin centred gas developments. A shale play that has unfavourable prospects may have upfront infrastructure and major capital costs that outweigh the potential receipts from gas production.

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1. Introduction

Globally, there is widespread interest in exploiting shale gas resources to meet rising energy demands, maintain energy security and stability in supply and reduce dependence on higher carbon sources of energy, namely coal and oil (ACOLA, 2013; EY, 2013; Johnson and Boersma, 2013; Rogers, 2011). However, extracting shale gas is a resource intensive process and is dependent on the geological and petrophysical characteristics of the source rocks, making the development of certain formations uneconomic using current technologies. Therefore, evaluation of the in situ properties of shale formations, together with technological advancements, is critical in verifying the economic viability of such formations (Weijermars, 2013). Although studies have been conducted mainly on US marine shales, there are substantial deposits of non-marine shale formations in China and Australia (Chou, 2013; Zou et al., 2010). Currently, the responsiveness to hydraulic fracturing of non-marine shales compared to US marine shales is not clear (Tang et al., 2014). This paper provides an evaluation of non-marine shale gas development potential using well testing data from the Cooper basin, South Australia.

2. Significance of shale gas

In Australia, current conventional gas production is predominantly based on the offshore resources, with onshore resources becoming severely depleted (Fig. 1) (Stevens et al., 2013). Liquid hydrocarbon resources are not substantial enough to provide security of supply and independence from imports from an increasingly unstable Middle East, and coal is falling out of favour due to its high carbon emissions and other environmental impacts (Jaramillo et al., 2007; Leather et al., 2013; Stevens, 2014). Therefore, there is an increasing interest in unconventional natural gas resources, as gas is a relatively cleaner fuel compared to coal and these resources appear to be widespread in many regions of the country (Govt, 2012; Leather et al., 2013). Similar situations exist in other parts

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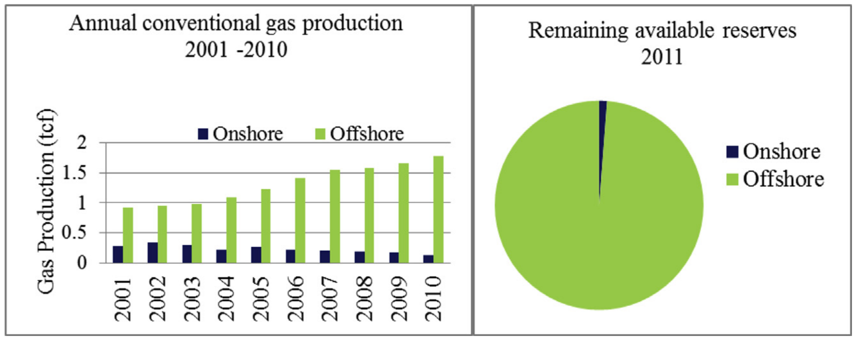

Figure 1. Conventional Australian gas production and remaining reserves (Australia, 2010; Stevens et al., 2013).

of the world (KPMG, 2011). Furthermore, the US experience has shown that production costs of unconventional natural gas can be lower in comparison to other fossil fuel resources (Stevens, 2012).

Globally, technically recoverable shale gas reserves are estimated to be around 25,300 Tcf (more than 45% in the US) (Boyer et al., 2011; Stark et al., 2012). Already in the US, natural gas prices have decreased steadily compared to oil and coal, as illustrated in Figure 2. This is mainly due to the shale gas boom driving down the cost of natural gas production. The US is already planning to export this excess amount of natural gas to maintain the stability of natural gas markets (Ker, 2013). This unconventional natural gas revolution is leading the US towards energy independence, with shale gas predicted to contribute a greater than 50% share of natural gas production by 2040, as illustrated in Figure 3. However, it is not yet certain whether the US shale gas success story can be replicated elsewhere. This is mainly due to differences in shale geology, as most of the formations in the US are marine in origin, which naturally consist of low clay contents, enabling the permeability of the reservoir to be increased effectively by hydraulic fracturing (Cardott, 2012). In addition, other factors, such as the availability of infrastructure, a high gas price, a vibrant service industry, favourable regulations and private mineral rights, have also contributed to the US shale gas boom (Stevens et al., 2013).

Whether greenhouse gas emissions from shale gas production are comparable to those from the conventional gas production is still open to debate (Burnham et al., 2011; Howarth et al., 2011; O'Sullivan and Paltsev, 2012) and the issue remains one of concern. However, natural gas driven power stations produce 50% less greenhouse gas emissions compared to coal fired power stations producing similar energy content (OGP, 2012) and by switching to gas, the US has been projected to reach its carbon abatement targets (C2ES, 2013). Furthermore, shale gas production consumes less water than coal extraction (Jenner and Lamadrid, 2013).

2.1. Shale sedimentology

Shale formations have the potential to generate hydrocarbons and store them within low permeable networks. In the shale network, gas generation can be either biogenic or thermogenic. Biogenic gas generally forms at depths less than 1000 m, but can be preserved in reservoirs at depths as large as 4500 m (Deshpande, 2008). During diagenesis, shales undergo recrystallization, compaction, cementation, and lithification. These processes contribute to the dual functionality of shale reservoirs as source and storage reservoirs, with low porosity and permeability.

Shale formations can be broadly classified as either marine or lacustrine in origin. Marine shales originate from deep coastal sedimentation systems, whilst lacustrine shale systems originate from deep lake-based inland environmental systems. By inception, marine shale has a higher quartz content compared to lacustrine shale, and lacustrine shales usually have higher clay contents.

3. The nature of shale formations

3.1. US shale formations

All commercially operating US shale plays are of marine type (Fig. 4) (Boyer et al., 2011). Marine shales are composed of marine mudrocks, which are best described as depositions in muddy coastlines, near shore, mid-shelf mudbelts, open-shelf mud blankets, basinal slopes and basinal floors (Pashin et al., 2011). These

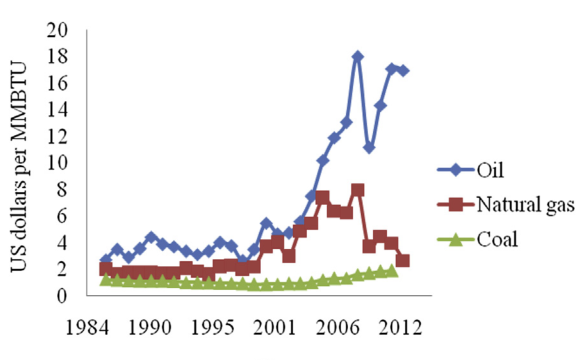

Figure 2. Price comparison of oil, natural gas and coal (EIA, 2015).

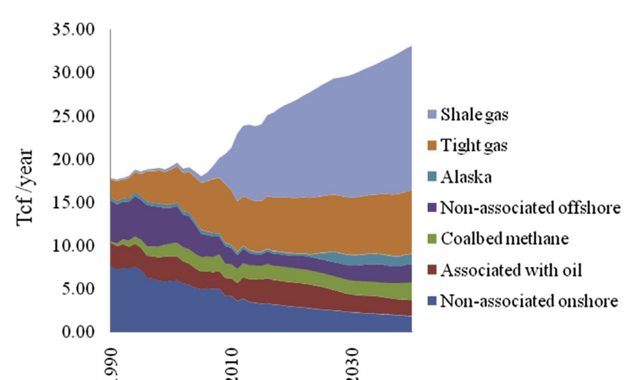

Figure 3. Projected increase of shale gas use in US (EIA, 2014).

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