10.1071/PVv2018n195p44

A new experimental extractive technology trial for Cooper Basin unconventional resources: alignment flow technology

Professor Raymond L. Johnson, Jr
Professor of Well Engineering and Production Technology
The University of Queensland
r.johnsonjr@uq.edu.au

Unconventional reservoirs in Australia's Cooper Basin consist of three main types of reservoirs: tight or basin-centred gas, shale gas reservoirs, and deep coal gas accumulations. Tight and basin-centred gas ('BCG') reservoirs are unlike conventional reservoirs.

Conventional reservoirs exist in traps or accumulations requiring exploration tools (e.g. drilling and seismic) to define reservoir boundaries or explore their presence. They have well interconnected porosity and high permeability, and have been pursued across Australia for oil and gas extraction since the 1950s. BCG reservoirs are a type of tight sandstone; gas reservoirs that have been stratigraphically or hydro-dynamically trapped and charged to pressures beyond normal hydrostatic pressures. This occurs either by internal maturation, unearthing or uplifting, or charging from underlying sediments. Tight or basin-centred gas reservoirs possess lower interconnected porosity and permeability and require hydraulic fracturing to be successful.

Shale gas reservoirs are highly layered, clay-rich, low permeability reservoirs that are generally self-sourced, have extremely low permeability, and require a horizontal wellbore and multiple-staged, hydraulic fracturing treatments to be successful. Deep coals are similar to coal seam gas reservoirs, deriving their gas from adsorbed gas and permeability primarily through natural fracturing in the coal. Whilst coals and shales in the Cooper Basin are not directly addressed by this paper, these interbedded coals and shales within sandstones, targeted for hydraulic fracturing, affect hydraulic fracture propagation (i.e. coals and shales have differing stress and rock-mechanical properties as compared to targeted lower permeability sandstones and siltstones in Cooper Basin reservoirs).

All of the above unconventional reservoirs were initially successfully developed in North America using vertical wellbores, and became highly profitable based on the successful experimentation and development of horizontal well technology, including multiple staged hydraulic fracture treatments, staged in clusters along the horizontal wellbore. Similar applications of North American technologies in Australia have had lesser success largely because of lower permeability values and a less favourable stress conditions (i.e. stress regime). North America is generally in an extensional, normal stress regime (i.e. vertical stress is much greater than the maximum horizontal stress, which is greater than the minimum horizontal stress). The Cooper Basin is in a compressional, strike-slip stress regime where the maximum horizontal stress is much greater than the vertical stress and greater than the minimum horizontal stress. In deeper sections of the Cooper Basin, the stress regime can become a reverse stress regime (i.e. vertical stress is less than or equal to the minimum horizontal stress and much less than the maximum horizontal stress).

A favourable stress regime is the predominant factor for the success of North America unconventional developments to date, and is particularly favourable to the hydraulic fracturing process. Conversely, the strike-slip to reverse stress environment adversely effects Cooper Basin hydraulic fracturing treatments. This is especially the case when such treatments originate from one of the less favourable well directions, being either vertical or horizontally oriented in the direction of the minimum horizontal stress (i.e. oriented to create fractures perpendicular to the wellbore orientation or 'transverse' fractures).

The Cooper Basin has a problematic stress environment that can be further complicated by the damaged stress cage resulting from wells drilled in a less favourable stress direction to the maximum horizontal stress and the presence of natural fracturing (Johnson et al., 2015). This complex stress environment can create a fracture complexity often manifested by a pressure differential associated with these fracture complexities in the near wellbore region, or near wellbore pressure loss (NWBPL). Developing an effective extractive technology to progress Cooper Basin unconventional resources has been elusive to date based on these complexities, and further research in this area was a key recommendation by the 2013 Chief Scientist and other ACOLA examination of the status and progress of unconventional resources in Australia.

Since the early 2000s, a number of experimental methods have been employed to counter high NWBPL observed during Australian hydraulic fracturing treatments. One experimental study showed that NWBPL in the Cooper Basin can be reduced by directionally perforating the well before fracturing in the maximum horizontal stress direction (Johnson and Greenstreet, 2003). Increasing fluid viscosity has cited by several authors as a means to manage NWBPL. However, increased polymer loadings can also severely impact post-treatment hydraulic fracture conductivity (Penny et al., 1996), leading to overall poor productivity. Others have used small mesh proppant slugs, acid spearhead treatments, and reducing the perforation length in Australian Basins where problematic NWBPL was encountered (Johnson and Greenstreet, 2003; Pitkin et al., 2012; Scott et al., 2013). Although achieving some localised success, these methods have proven ineffective at providing an overall solution to the development of an effective widespread extractive technology for Cooper Basin unconventional resources.

Recent published experimentation with wellbore orientation indicated that in two cases orientation of the drilled wellbore in the maximum horizontal stress direction reduced fracture complexities in the strike-slip stress environment (Bentley et al., 2013; Johnson et al., 2015). This was based on numerous North American studies of horizontal wells showing the benefit of alignment in the maximum horizontal stress direction to create less complex, fracturing along the horizontal wellbore. Based on this, and past research, it is hypothesized that a combined strategy of deviating the wellbore and aligning the perforations in the maximum horizontal stress direction will improve the hydraulic fracturing process in the Cooper Basin in two upcoming fracs for an operator in the Windorah Trough area of SW Queensland (ATP 927P – see Figure 1) by:

- lowering NWBPL and fracture complexity as a result of better alignment of the perforations and the resulting hydraulic fracture with the wellbore (all should be aligned along the preferable maximum horizontal stress direction);
- allowing better fracture containment within lower stress bounding coals through the use of lower viscosity fracturing fluids
- allowing implementation of recently graded particle injection as a means to improve natural fracturing using cleaner, lower-polymeric fluid technology; and
- improving flow to the wellbore through higher concentrations of localised proppant in the primary hydraulic fracture through effective proppant 'banking'.

The last three bullet points above are only achievable by effectively lowering NWBPL and creating a less complicated hydraulic fracturing environment in Cooper Basin fracturing treatments.

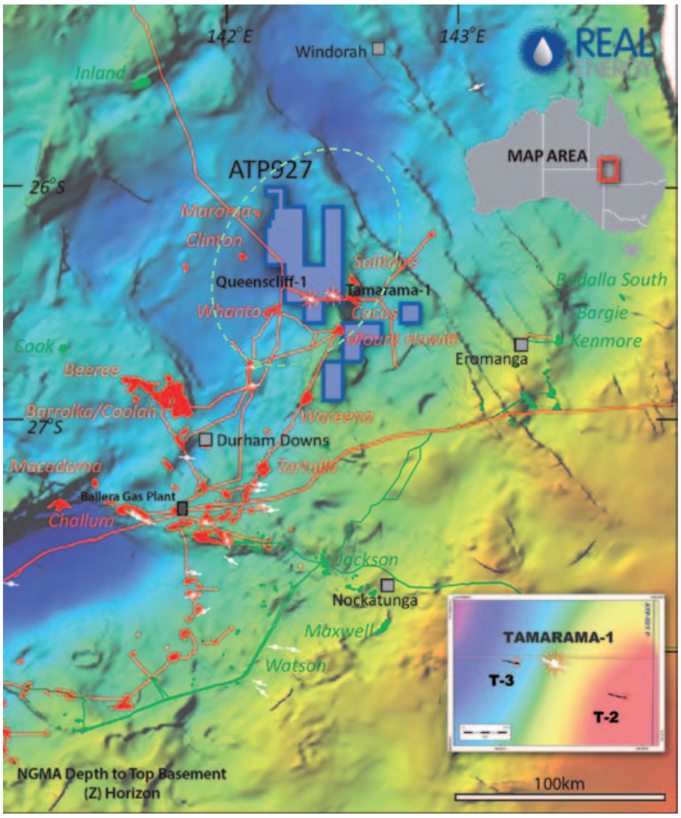

Figure 1. *Windorah Trough study area indicated in green dashed region with Tamarama 1 vertical and Tamarama 2 and 3 lateral wells (pictured insert) with well azimuth striking <10 degrees from the E-W trending maximum horizontal stress direction.*

This combined strategy, referred to as 'Alignment Flow Technology' or 'AFT', will be implemented in a series of experimental wellbores to be placed in an opportunistic area of the Cooper Basin – the Windorah Trough. It is believed that this area will benefit from this experimental technology based on past experiments demonstrating high stress, problematic wellbores, high NWBPL, and difficulty placing proppants (Johnson, et al., 2015, 2016). Further, this technology may provide a widespread solution for the Cooper Basin as an effective extractive technology for other unconventional resources in problematic stress environments.

Acknowledgements

The author wishes to acknowledge Scott Brown, Chief Executive Officer; Lan Nguyen, Non-Executive Chairman; and Terry Russell, Exploration Manager, Real Energy Corporation Limited for contributions and permission to publish.

References

Bentley, P. J. D., Megorden, M. P., and Jiang, H., 2013, *Improving Hydraulic Fracture Geometry by Directional Drilling in Coal Seam Gas Formation, SPE 167053*. Paper presented at the SPE Unconventional Resources Conference and Exhibition-Asia Pacific, Brisbane, Australia.

Johnson, R. L., Jr, and Greenstreet, C. W., 2003, *Managing Uncertainty Related to Hydraulic Fracturing Modeling in Complex Stress Environments with Pressure-Dependent Leakoff, SPE-84492*. Paper presented at the SPE Annual Technical Conference and Exhibition, Denver, Colorado.

Johnson, Jr, R. L., Abul Khair, H. F., Jeffrey, R. G., Meyer, J. J., Stark, C., and Tauchnitz, J., 2015, Improving fracture initiation and potential impact on fracture coverage by implementing optimal well-planning and drilling methods for typical stress conditions in the Cooper Basin, central Australia: *The APPEA Journal* 55, 403.

Johnson, R. L., Jr, Nguyen, L., and Russel, T., 2016, Next steps to crack the code on tight Permian Toolachee and Patchawarra sandstones of the Cooper Basin, southwest Queensland: *The APPEA Journal* **56**, 533.

Penny, G. S., Conway, M. W., Almond, S. W., Himes, R., and Nick, K. E., 1996, *Mechanisms and impact of damage resulting from hydraulic fracturing, GRI-96/0183*. Chicago, IL.

Pitkin, M. C., Wadham, T. H., McGowen, J. M., and Thom, W. W., 2012, *Taking the First Steps: Stimulating the Nappamerri Trough Resource Play, Paper SPE 160307*. Paper presented at the SPE Asia Pacific Oil and Gas Conference and Exhibition, Perth, Australia.

Scott, M. P., Durant, R., Woodroof, R. A., Stephens, T., Thom, W., and McGowen, J. M., 2013, *Investigating Hydraulic Fracturing in Tight Gas Sand and Shale Gas Reservoirs in the Cooper Basin, SPE 167073*. Paper presented at the SPE Unconventional Resources Conference and Exhibition-Asia Pacific, Brisbane, Australia.