A re-evaluation of a fractured carbonate reservoir from the Perth Basin, Western Australia

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SUMMARY

This ongoing research evaluates a fractured carbonate reservoir in the Beekeeper Formation, Perth Basin, focused mainly on the Woodada Field. Previous reports identified a fractured carbonate system as the main hydrocarbon reservoir in the Woodada Field, yet there is no published detailed documentation of reservoir development. The aim of this research is to evaluate the depositional and diagenetic characteristics of the Beekeeper Formation, its fracture system development and their combined impacts on carbonate reservoir quality.

This study employs multi-method geological analyses. Subsurface core description, standard microscopy, and acetate peel analyses have been conducted, while scanning electron microscopy, cathodoluminescence petrography, stable isotope geochemistry and fluid inclusion analyses are planned for the coming months.

Preliminary results show that the carbonate of the Beekeeper Formation consists of packstone, rudstone, packstone-rudstone, floatstone-packstone and packstone-grainstone. The development of the Beekeeper Formation was affected by tectonic activity. The level of influence of tectonic processes, versus diagenesis and primary sedimentary facies on the development of fracture systems, pore system generation and reservoir quality is still being studied in detail. It is anticipated that this ongoing study will increase our understanding of the Woodada Gas Field and fractured carbonate plays in general.

Key words: Fractured carbonate reservoir, Beekeeper Formation, Woodada Gas Field, Perth Basin.

INTRODUCTION

The gas-producing Woodada Field is located in the Perth Basin, Western Australia. The field was discovered in 1980 with production commencing in 1982 and now is shut-in on care and maintenance (Crostella, 1995). Fourteen wells were drilled in the Woodada Field, of which seven were productive on the 31st December, 1993 (Crostella, 1995). This gas field contains volumetric reserves up to 3.3 x10^9 m^3 (DME, 1994). Gas production from this field comes mainly from a fractured limestone reservoir known as the Beekeeper Formation, of Upper Permian age (Crostella, 1995). Even though this fractured limestone reservoir is considered as the main hydrocarbon play in the Woodada Field, the details of its deposition, diagenesis and fracture system development have not been published. The Woodada Gas Field is strongly influenced by tectonic activity, with the field associated with folding and large-scale faulting close to the Abrolhos Transfer Zone (Figure 1; Crostella, 1995). Numerous gas-bearing sub-vertical faults and fracture systems are noted for the area (Figure 2; Crostella, 1995). To better understand the fractured carbonate system of the Beekeeper Formation, detailed analyses of available core is underway from wells associated with the Woodada Field. Wells with core are Beekeeper-1, Woodada-2, Woodada-3, and Woodada-14.

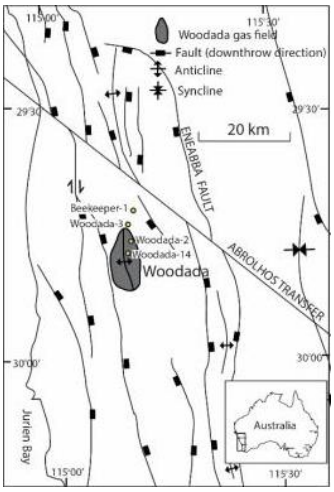

Figure 1. Simplified geological map of the Woodada Gas Field showing main structural features (modified from Mory and Iasky, 1996).

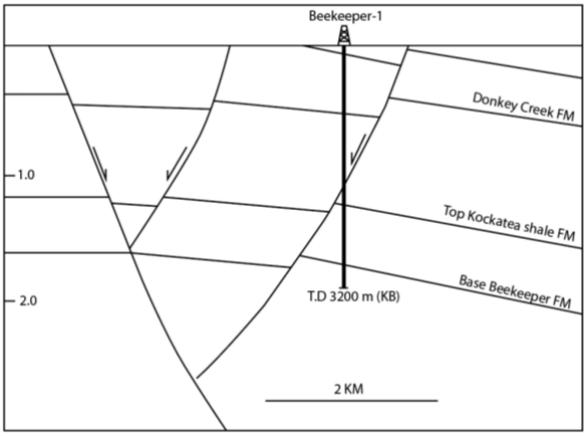

Figure 2. A geological section interpreted from seismic line P81-110 showing extensive normal faults in the vicinity of Beekeeper-1 well (After Lane, 1981).

This re-evaluation of 'legacy' data from the Perth Basin is anticipated to advance our understanding of fractured carbonate reservoirs and contribute to increased awareness of petroleum system development in the vicinity of the Woodada Field. Showing similarities with the Cody Formation of the Carnarvon Basin (North West Shelf) and the Pearce Formation of the Timor Sea (Gorter and Davies, 1999) this study is expected to have regional and global applicability.

METHODS

Available core data of the Beekeeper Formation in the Woodada Gas Field and the vicinity is being studied from four wells (Beekeeper-1, Woodada-2, Woodada-3, and Woodada-14) using an integrated geological approach. Sedimentary core descriptions, standard microscopy, and acetate peel analyses have been completed. Other analyses planned for the coming months include scanning electron microscopy, cathodoluminescence petrography, stable isotope geochemistry and fluid inclusion analyses. A total of 48.43 m of core (20.97 m from Beekeeper-1, 8.63 m core from Woodada-2, 10.88 m core from Woodada-3, and 7.95 m core from Woodada-14) is being detailed for sedimentary textures, fabrics, components, diagenesis and fracture systems. Acetate peels were made on almost all sections of the core, focussed particularly on fractured sections. The core was very lightly acid etched, flooded with acetone, before covering with acetate sheet and peeling off the acetate to take a surface "impression" of the core. Standard microscopy was undertaken on 22 thin sections from Beekeeper-1 using a polarizing microscope. Acetate peel and thin section analyses when combined with sedimentary log analysis can provide important information about the carbonate facies characteristics and their depositional environment. This study focussed on the diagenetic features and the paragenetic relationships of relative fracture timing, their cementation compared with diagenetic timings of the wallrock in the Beekeeper Formation.

PRELIMINARY RESULTS & INTERPRETATION

The fractured carbonate reservoir of the Beekeeper Formation consists mainly of packstone, rudstone, packstone-rudstone, floatstone-packstone and packstone-grainstone with bryozoa, crinoids and brachiopods as their main components. The main diagenetic processes affecting the development of this carbonate reservoir are micritization, syntaxial overgrowth cementation, granular-blocky calcite cementation, mechanical and chemical compaction, recrystallization, replacement, and multi size and multi-episode fracturing with some cementation of fractures.

The Beekeeper Formation is well known for fractures with fracturing inferred as the key porosity type in the main reservoir unit in Woodada gas field (Cadman et al, 1994; Mory and Iasky, 1996). The porosity of the Beekeeper carbonate is up to 15% and the permeability is 134 md in the Woodada Gas Field (Cadman et al, 1994). Fracture systems in the Beekeeper Formation post-dated primary depositional features including some compaction of the wallrock (Figure 3). Fracture development is mainly of inferred tectonic origin on the basis of these paragenetic timings together with offsets along fractures, common sub-vertical fracture orientations and multiphase fractures cementation (Figure 3 & Figure 4). The occurrence of numerous multi-size and multi-episode fracture systems in the studied cores suggests the importance of tectonic activity in the development of this fractured carbonate reservoir (Figure 3 & Figure 4). The fracture systems in the studied cores are fully/partially infilled with calcite, suggesting the importance of fracture systems as conduits for circulation of fluid and subsequent diagenesis in the Beekeeper Formation within the Woodada Field (Figure 3 & Figure 4).

The preliminary results also show that primary sedimentary and secondary diagenetic processes play major influential roles in fractured carbonate reservoir development in the Beekeeper Formation. The degrees of influence of tectonic activity, primary sedimentary and secondary diagenetic processes on the development of fracture systems, porosity-permeability heterogeneities and reservoir quality of the Beekeeper Formation is still being studied in detail.

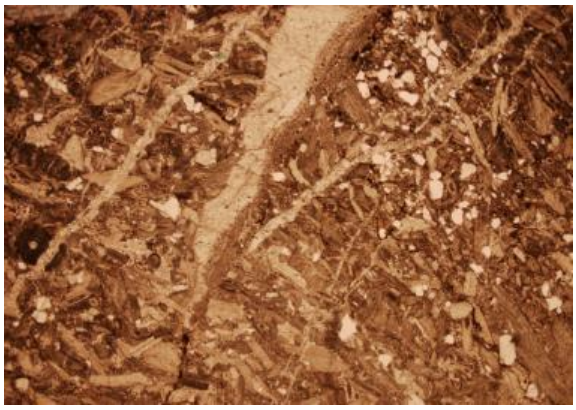

Figure 3. A thin section photomicrograph from Beekeeper-1 (from 2819.08 m) showing multi-episode fracture systems. Fractures post-dated other main features. Horizontal field of view is 2 cm.

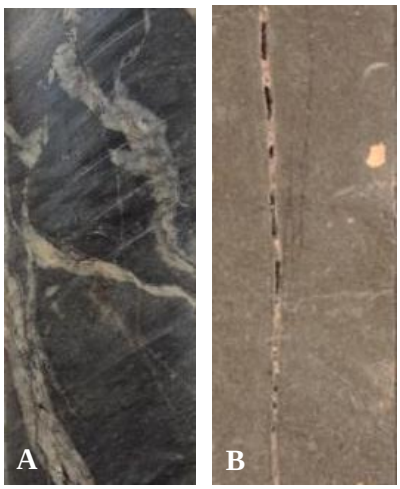

Figure 4. Core photograph showing fracture system fully/partially filled with calcite from (A) Beekeeper-1, and (B) Woodada-3. Horizontal field of view for each core image is 4 cm.

CONCLUSIONS

The Beekeeper Formation from the Perth Basin, Western Australia provides a good example of a fractured limestone reservoir. Tectonic activity, sedimentary and diagenetic processes play an important role in the development of this reservoir. The results from this study will enhance our

understanding of the Woodada Gas Field and other fractured carbonate reservoirs.

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