The Treachery Formation - a Complex Glacially-Influenced Reservoir, Blacktip Gas Field, Southeastern Bonaparte Basin, Western Australia*

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Introduction

The Blacktip Gas Field is located in the Southeastern Bonaparte Basin, offshore Western Australia. The field was discovered in 2001 by Blacktip-1, which encountered stacked gas-bearing sandstone reservoirs in the Triassic and Permian - Late Carboniferous section. Subsequently one appraisal (Blacktip-2) and two development wells (Blacktip P1 and P2) have been drilled (Figure 1). Production from the field commenced in 2009.

The Blacktip structure is an east-west-trending four-way dip closure with multiple seismic amplitude anomalies. The reservoir consists of stacked gas-bearing sandstone in the Lower Triassic Mt Goodwin Formation, and in the Permian - Upper Carboniferous Keyling and Treachery formations.

The Keyling and the Treachery formations are the primary reservoirs in the Blacktip Gas Field. These contain a series of stacked sandstones, separated by intraformational shales, extending over a 1000-m depth interval.

This study focuses on the Treachery Formation, which is composed of diamictite, sandstone, mudstone and siltstone, deposited in glacially influenced fluvial to shallow-marine environments. The regional framework and the stratigraphic interrelations of the Treachery Formation have been studied in details by Gorter et al. (2008).

The Treachery Formation was intersected by all wells drilled in the Blacktip Gas Field area. The Formation was cored in Blacktip-2, located in the western part of the field, and in Blacktip North-1, immediately north of the Blacktip Gas Field (Figure 1).

Facies Associations

The Treachery Formation is characterized by sharp lateral and vertical facies changes resulting in complex reservoir-seal architecture. Five main lithofacies associations have been identified from Blacktip-2, core 1 and 2, cut in the Treachery Formation (Figure 2).

Facies Association 1

This facies association contains moderately well sorted low-angle to horizontally bedded sandstone, with interbeds of very coarse-grained sandstone and occasional pebbles. These are interpreted to have been deposited in a braided fluvial outwash-plain or proximal delta-fan environments.

The sandstone has low (less than 5%) porosity in Blacktip-2 core, due to diagenesis, which has almost completely destroyed the primary intergranular porosity. However, in Blacktip North-1 (3.0 km to the north) the same facies have very good reservoir characteristics with core porosity up to 19% and permeability up to 1200 mD. Petrological study on samples from Blacktip North-1 core indicates that early diagenetic, grain-coating clays have preserved good intergranular porosity by inhibiting quartz overgrowth cementation.

Facies Association 2

This facies association consists of moderately to well sorted medium- to fine-grained sandstone with occasional silty streaks associated with soft-sediment deformation. The latter suggests relatively rapid subaqueous deposition and the possible presence of a minor slope. A coarsening-upward trend is observed, which could be indicative of progradation. A mouth-bar depositional environment is suggested for these sediments, based on the associations with overlying fluvial channels and underlying gravity flows.

The sandstone has core porosity ranging between 5 and 15% in both Blacktip-2 and Blacktip North-1 and constitute one of the best reservoirs in the Treachery Formation. Petrological analysis indicate higher permeability, associated with intergranular porosity preservation by authigenic grain-coating illitic clay.

Facies association 3

A series of fining-up cycles, consisting of fine- to very fine-grained sandstone, siltstone and minor claystone with occasional dropstones comprise this facies association. These are interpreted to be diluted turbiditic flow deposits that accumulated in lacustrine melt waters or brackish embayment in front of the ice sheet.

The sandstone is very thin and very fine-grained, with porosity up to 11%, but it has poor permeability due to diagenetic processes, such as quartz overgrowth cementation, grain-contact dissolution, and authigenic clay formation (Baker, 2010).

Facies association 4

This facies association consists of muddy siltstone, locally interlaminated with mudstone, showing soft-sediment deformation. These sediments are associated with mud settling out of suspension plumes. They could also represent distal turbidites. These sediments have very limited reservoir potential.

Facies association 5

A chaotic mixture, of various grain size clastics, ranging from claystone to very coarse sandstone and scattered ‘floating’ pebbles, comprise this facies association. The presence of pebbles in purely mudstone sections and presence of reworked sandstone lenses with signs of soft-sediment deformation suggest rapid deposition. These are interpreted as glacial sediments associated with the beginning of the ice retreat and melt-out diamictite deposition. These sediments have no reservoir potential.

Reservoir Characteristics

The sedimentological interpretation and routine core analysis suggest that within the Treachery Formation the best reservoir sandstone is in facies associations 1 and 2, deposited respectively in fluvial outwash plain or proximal delta plain and mouth-bar environments.

The primary sedimentary fabric is the major controlling mechanism for the reservoir distribution and quality. However petrological studies indicate a complex diagenetic overprint that significantly affects the primary porosity and permeability of the sandstone and further hinders reservoir-quality predictions. Good to excellent reservoir quality in the Treachery Formation is attributable to the presence of authigenic, grain-coating clay, which is best developed in Blacktip North-1. However, the lateral continuity of this clay-coated sandstone is not well understood, and it could be of limited distribution.

Conclusion

The study provides a better understanding of the complex facies interrelation and reservoir quality and distribution within the glacially influenced Treachery Formation. It could prove useful for optimizing reservoir performance and production from the Blacktip Gas Field.

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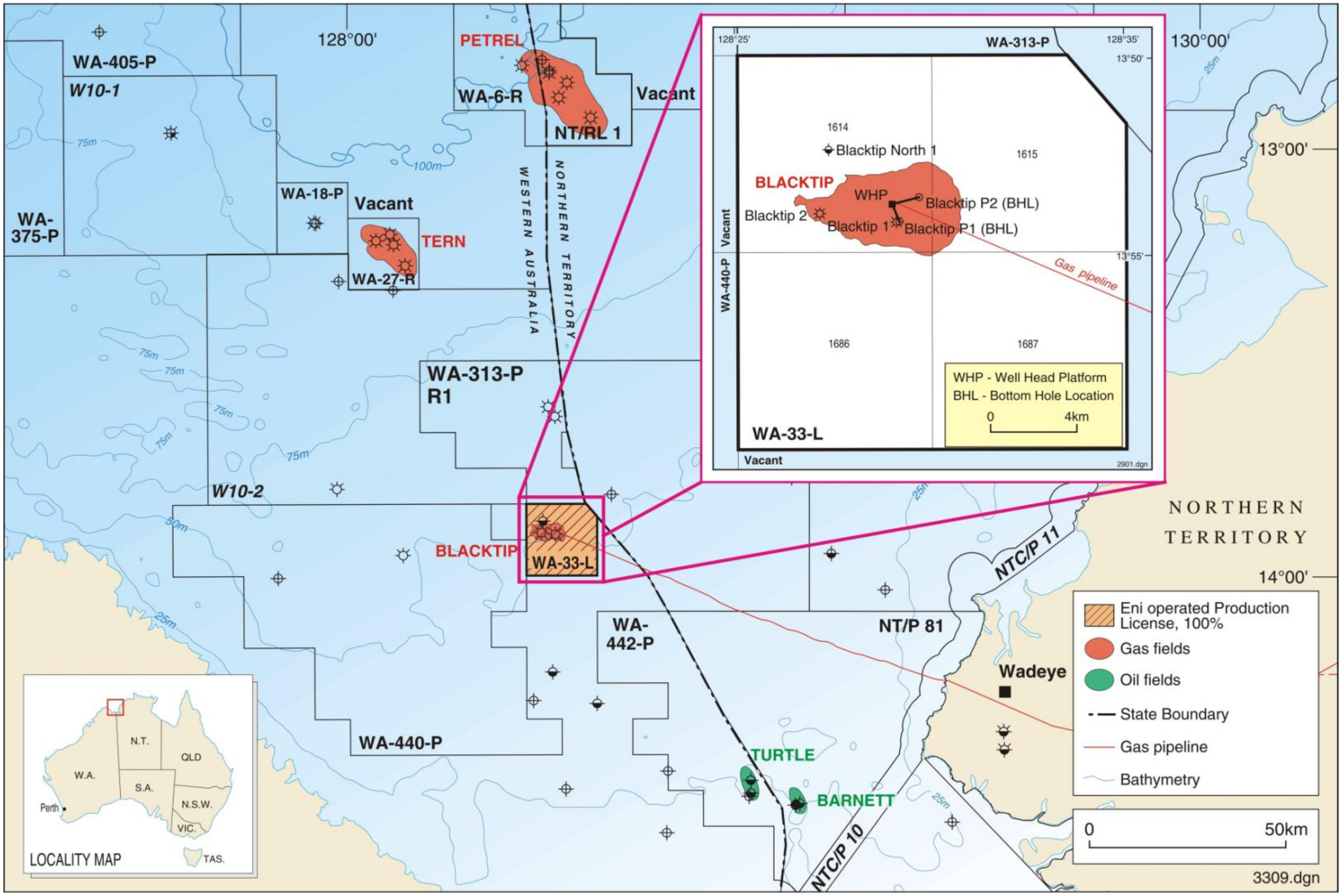

Figure 1. Blacktip Gas Field location map.

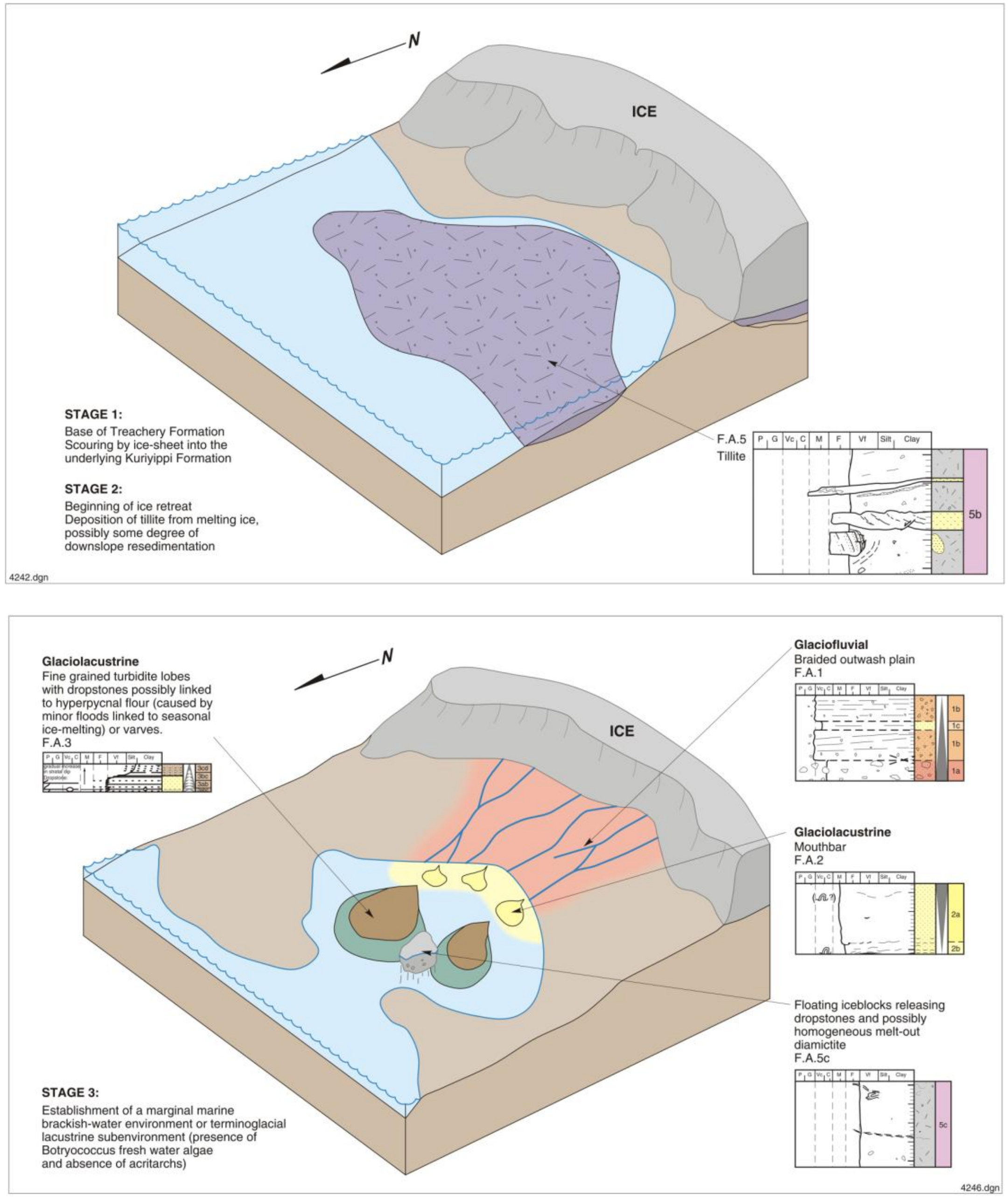

Figure 2. Schematic diagram of Treachery Formation depositional environments and facies associations.