Deep-Water Reservoir Facies of the Late Jurassic Angel Fan, Dampier Sub-Basin, Australia*

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Abstract

The Angel Formation is a sand-prone, deep-water fan system that was deposited in the Dampier Sub-Basin on the NW Shelf of Australia. The Angel Formation hosts a number of oil and gas fields and is also a regional aquifer. Core (over 700 meters) from 15 wells were studied to define lithological facies and facies associations. The cores allowed the examination of the vertical facies variations and their correlation with wireline logs. Three facies associations have been recognized in the Angel Formation:

1. Massive Sandstones are subarkosic to quartz arenites that are fine to coarse-grained, bioturbated, and glauconite-rich. Bedding is mostly massive, with occasional lamination and disruption by dewatering features.
2. Heterolithic facies consist of a mixture of sandstone and shale which is commonly bioturbated. Trace fossils include *Chondrites*, *Zoophycus*, and *Terebellina*. Sandstone content in the heterolithic facies is variable, decreasing gradually basinward. Sandstone injection features are not uncommon.
3. The claystone facies consists of up to 10 cm thick beds of claystone, which are burrowed by *Chondrites*. Claystones are less common and thinner towards the proximal part of the fan (NE).

These facies were deposited in a slope to basin-floor fans system, supplied from a shallow marine shelf. Deposition was mostly by high-density turbidity flows, in water depths estimated to be 200 to 300 meters below sea level. Sandstone deposits are sharp based and gradually fine-upwards into laminated bedding. Occasionally beds have sharp indented tops with sandstone injection features. This suggests localized remobilization and modification of original sandstone geometries, which may impact upon reservoir performance.

Introduction

The Angel Fan is a Late Jurassic deep-water fan system that evolved as a series of stacked sand bodies. The fan is approximately 50 km wide and 100 km long and was deposited in the Dampier Sub-Basin on the NW Shelf of Australia (Figures 1 and 2). The fan sands form reservoirs in the Angel, Cossack, Dixon, Lambert, Legendre and Wanaea Fields and acts as regional but limited aquifer for the oil and gas fields in the Dampier Sub-Basin. This study is based upon 15 wells in the Angel, Wanaea, Cossack and Lambert fields.

Facies Associations

Examination of cores over 700 meters recognized three facies associations:

- massive sandstone
- heterolithic facies
- claystone facies

The cores allowed the examination of the vertical facies variations and their correlation with wireline logs. Massive sandstones mostly has flat base, contains dewatering structures and occasionally showing sharp top indented with some injected sandstones or gradational top with thin laminated sandstones. The Angel Formation in the Wanaea, Cossack and Lambert Fields has the attributes of slope and basin floor sandy fans supplied from

a shallow marine shelf. Deposition was mostly by high-density turbidity flows, in water depths estimated to be 200 to 300 meters below sea level.

Fan Architecture and Reservoir Quality

Fan architecture changes from a high net-to-gross, proximal fan system in the northeast to a moderate to low net-to-gross distal fan system in the southwest, suggesting a northeast source (e.g., net-to-gross changes from 0.890 to 0.315 in 30 km from Angel-1 to Madeleine-1). Individual sand bodies can be correlated relatively easily in the distal part of the fan (e.g., Wanaea-Lambert) where the sand bodies are layers separated by 4-10 m thick bioturbated heterolithics. However, correlation becomes increasingly difficult in the proximal fan (e.g., Cossack-Angel) where the sand bodies are commonly amalgamated and the bioturbated heterolithics are less than 2 m thick.

The sand bodies are sometimes connected through the heterolithics by sandstone injection, while some pinch-out due to topographic or structural control. Despite the down-fan reduction in connectivity and net-to-gross, the sandstones maintain good reservoir quality. The best reservoir quality is found in the massive sandstone facies that has high porosity and permeability values.

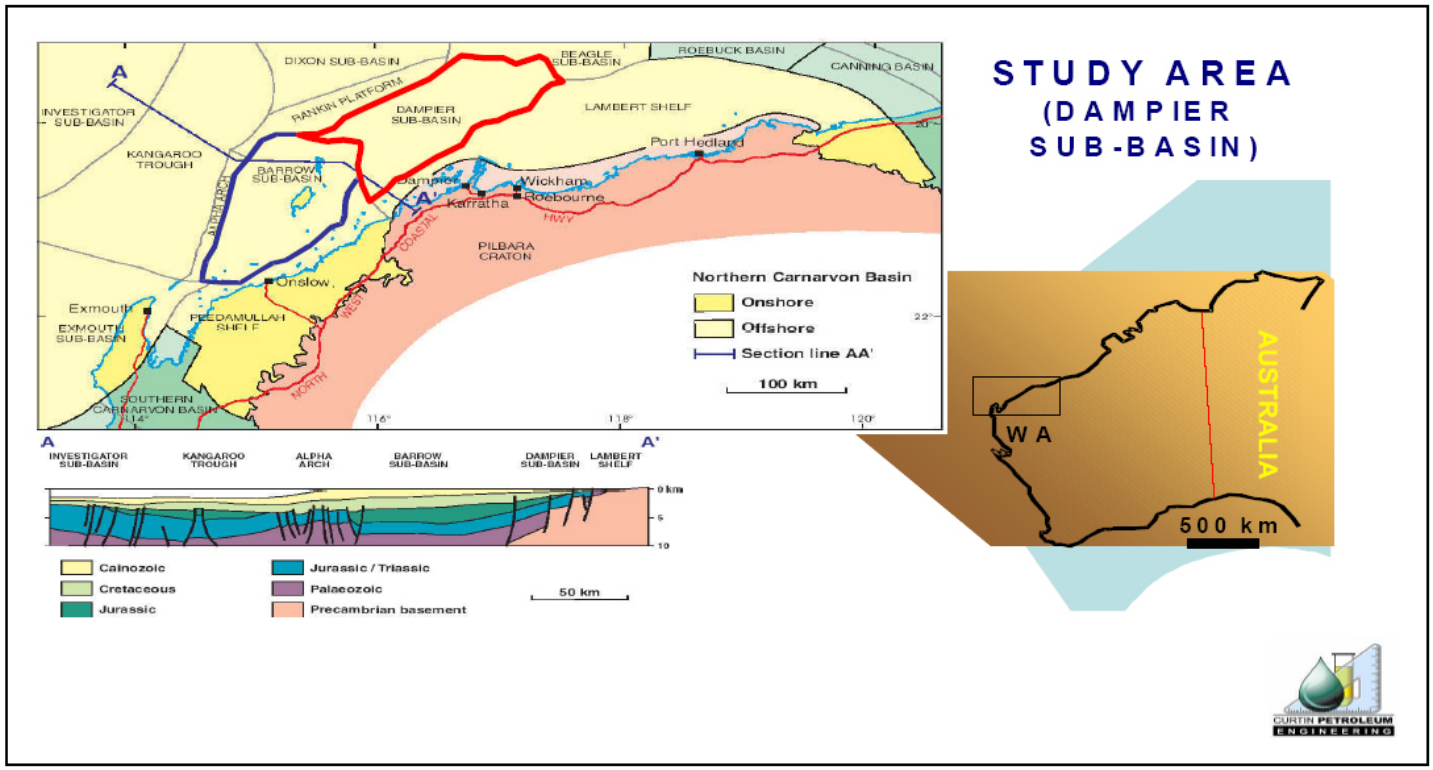

Figure 1. Dampier Sub-Basin, North West Shelf of Australia.

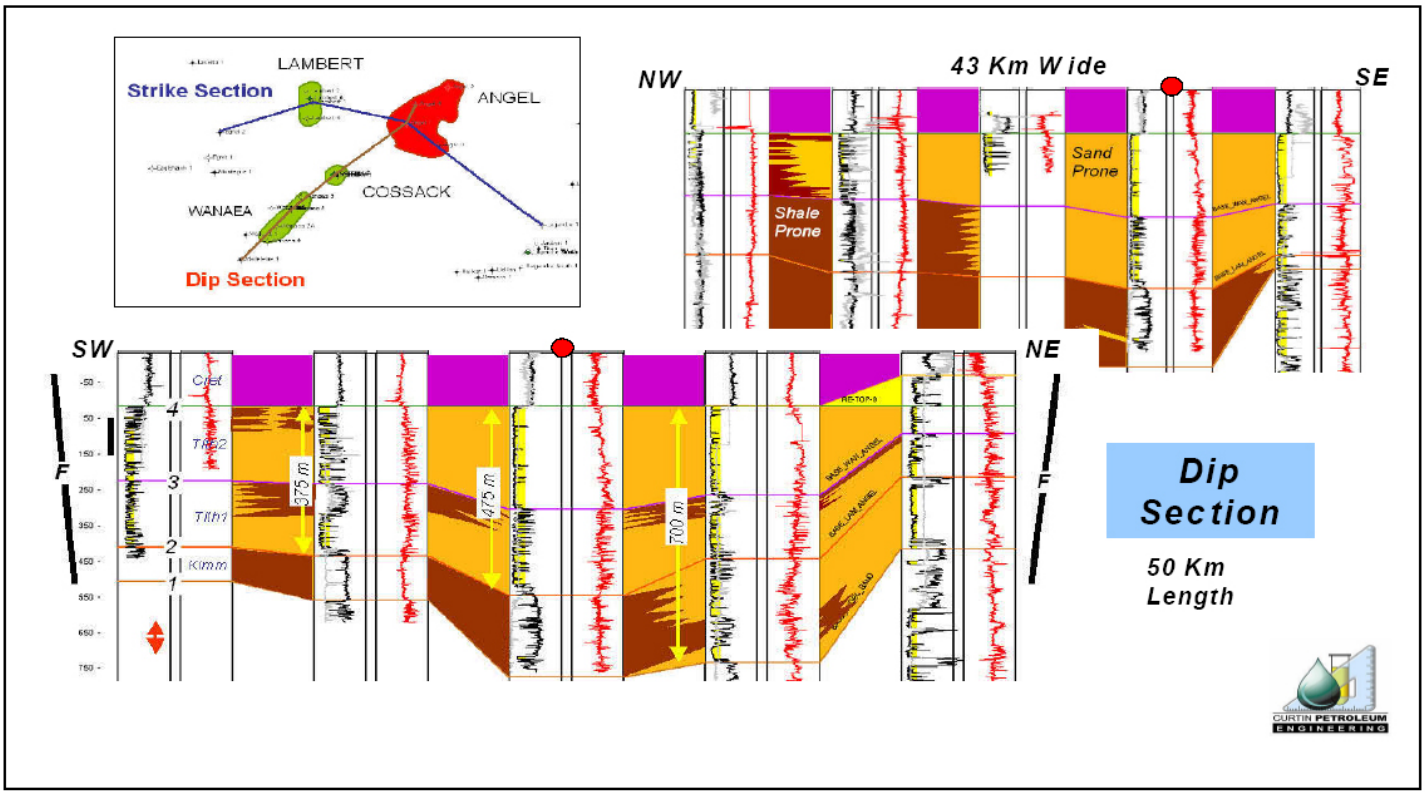

Figure 2. Angel Fan architecture.