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CORE DESCRIPTIONS OF TEN CONVENTIONAL CORES FROM THE LOWER BALONNE AREA, SOUTHERN QUEENSLAND, AUSTRALIA

Tobias H.D. Payenberg and Mark R.W. Reilly

CRC LEME OPEN FILE REPORT 166

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CONTENTS

LIST OF FIGURES

Executive Summary

Ten conventional cores from the St George region in southern Queensland, Australia were described in January 2003 to investigate the depositional environments and stratigraphic architecture of the Tertiary to Quaternary fill of the Dirranbandi Palaeovalley.

The Cretaceous Griman Creek Formation is considered the basement for the Dirranbandi Palaeovalley, which is filled with Quaternary sediment consisting of fluvial channel and floodplain deposits of meandering and braided rivers. Palynology data obtained from the cores prior to this study indicate an Early to Middle Pleistocene age for at least the top 60 m of section from some of the deeper holes (LB02 and LB 08 (Macphail 2004). This contrasts with an earlier interpretation that the Dirranbandi Palaeovalley was dominantly filled by Tertiary sediments (McAllister, 2000) and suggests the possibility that the entire fill might be Quaternary in age.

Determining the sediment architecture from core alone is very difficult. Although vertical variation in fluvial style exists in each well, it cannot be concluded from the core alone that fluvial style significantly changed within the Cainozoic Dirranbandi Palaeovalley. There is more evidence that suggests changes in fluvial style as a response to local accommodation and avulsion processes, since high sinuosity and low sinuosity channel sands are often interbedded.

Using typical width to thickness ratios of 100:1 for high sinuosity and 300:1 for low sinuosity river sands, some of the sheet-like sand bodies deposited by a low sinuosity river are in excess of 9 km wide. This has a major effect on connectivity of individual channel sand bodies and will most likely lead to a complex, interconnected porous and permeable network in the subsurface.

The coarsest channel sediments are found along a straight line through wells LB02, 03 and 08. This line parallels the modern Balonne River, and is offset approximately 20 km to the northwest. It is suggested that this area was the locus of maximum accommodation of the (Quaternary) Dirranbandi Palaeovalley, and that basement faulting has caused the main channels of the Palaeo-Balonne River system to flow along this trend.

1. INTRODUCTION

The National Centre for Petroleum Geology and Geophysics (NCPGG) at the University of Adelaide was contracted by Dr. Ken Lawrie (CRC LEME) to conduct core descriptions on ten (10) conventional cores from the St George region, southern Queensland. The cores were taken by the Bureau of Rural Sciences (BRS) on behalf of the CRC LEME in late 2002 as part of a major groundwater study in the lower Balonne River area around St George (Figure 1). Boxes containing slabbed Cainozoic rocks and mostly whole Cretaceous rocks are currently being stored at the Queensland Department of Natural Resources and Mines (QDNRM), St George office. The ten cores have an average depth of 60 metres each, and were cut from the ground surface upon commencement of the wellbore. Therefore all cores contain the present day soil profile at the top before penetrating older sediments. The cores are labelled LB 01 through to LB 10 and their location is shown in Figure 1.

The aim of this study was to describe the ten conventional cores to petroleum standards in order to get maximum information on facies, depositional environments and reservoir (sandstone) architecture. Some of the key questions are: How interconnected are the different sandstone bodies, and to what depth? Are there any stratigraphic intervals that are more clay (shale) prone or sand prone which could act as a regional aquifer or seal?

The core descriptions presented in Appendix I through to X have accompanying gamma-ray logs (provided by the CRC LEME). This was done to facilitate a better core to wireline log correlation and to improve wireline log response interpretations for future wireline log cross-sections.

2. GEOLOGICAL OVERVIEW

The St George study area is located approximately 500 km west of Brisbane, and is located above the Mesozoic Surat Basin, a part of the Great Artesian Basin. Outcrop of Cretaceous age surround the hills to the north of St George and are present in the subsurface. Cretaceous aged rocks from the Griman Creek Formation and possibly the Surat Siltstone (after Exon, 1976) were encountered in several of the investigated core. Because this study focuses on the Cainozoic sediments in this area, the Mesozoic rocks are considered basement. Nevertheless Mesozoic rocks are described in some detail in this report because they are not always easily distinguished from the Cainozoic rocks.

North of St George, the Maranoa River merges with the Balonne River, which flows (and is now dammed) past St George. Approximately 40 km southwest of St George, the Balonne River bifurcates into a series of smaller rivers (Narran, Bokhara, Ballandool and Culgoa rivers) to form a braided river system (McAlister, 2000). The rivers are part of the Condamine River system, and drain into the Darling River system in New South Wales. Underlying this present day fluvial network is a package of Cainozoic sediments in the Dirranbandi Trough (Senior, 1970). In this report this feature is referred to as the Dirranbandi Palaeovalley. The sediments contained in this palaeovalley are the focus of the groundwater study by the CRC LEME.

3. GRIMAN CREEK FORMATION IN OUTCROP

Two outcrops of the Griman Creek Formation were briefly visited during the core investigation phase to familiarize the authors with the outcropping rocks. Both outcrop localities were situated approximately 20 km east of St George on the road to Goondiwindi.

The first outcrop locality contained completely weathered and mottled sandstone. Sedimentary structures and the architecture of the original sediments were impossible to decipher. Outcrop exposure was around 7 vertical metres. The weathering, beyond recognition of the original stratification, was used by field trip leader Dr. Ken Lawrie to highlight the potential of encountering such an intense weathering profile in the basement of the Dirranbandi Palaeovalley. However, in all the cores that encountered Griman Creek Formation the weathering was never as intense as at this outcrop location.

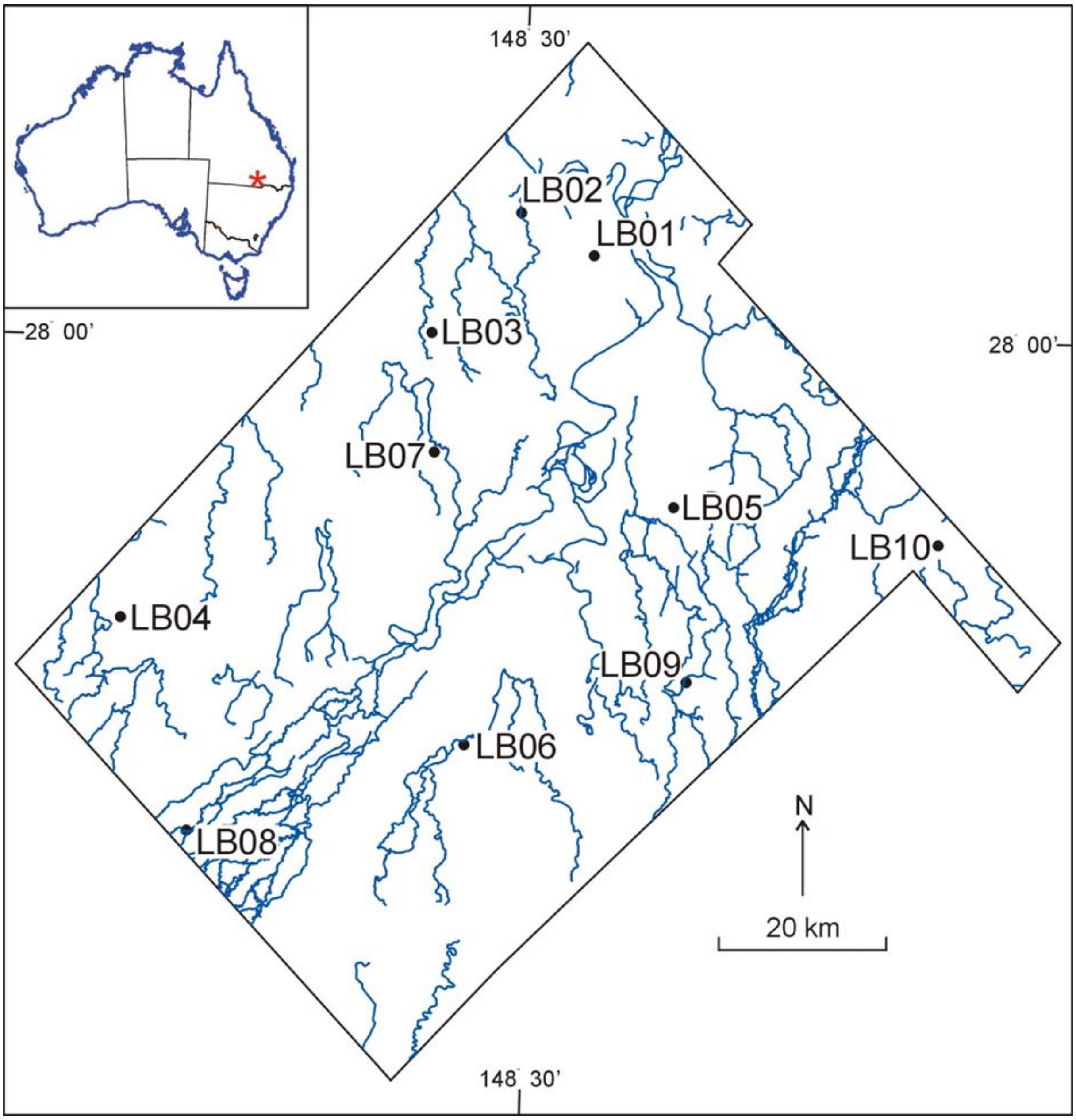

Figure 1 Location map of the 10 cores taken in the Lower Balonne area, central Queensland as part of the CRC LEME groundwater study.

At the second outcrop location, exposure of relatively fresh, less mottled and weathered Griman Creek Formation was encountered (Figure 2). Trough and planar cross-stratification were observed in the outcrop, together with larger scale accretion surfaces and scour cut-and-fill structures. The red coloured, commonly medium grained, well sorted arkosic sandstone was frequently interbedded with shale beds. Feldspar grains are often completely weathered into clay in the outcrop.

The high degree of weathering did not permit the identification of fossils or fossil traces, nor did it permit the detailed construction of stratigraphic architecture (Figure 2). While Exon (1976) interpreted the Griman Creek Formation to be terrestrial in origin, the high amount of shale interbeds within the outcrop could also point to a shallow lacustrine or shallow marine origin.

Figure 2. Griman Creek Formation outcrop about 40 km southeast of St George. The moderately weathered outcrop shows red, arkosic trough and planar cross-stratified sandstone interbedded with shale. The arkosic sandstone is characteristic for this formation, and enables the differentiation between the fluvial Cainozoic rocks and the Griman Creek Formation basement in the subsurface.

4. CORE DESCRIPTIONS AND INTERPRETATIONS

Descriptions of the cores were undertaken at the QDNRM field office in St George, Queensland. The ten cores were logged at a 1:50 scale; the composite core logs are presented in Appendix I through to X. A legend to the symbols used on the core logs is given in Figure 3. The logs show the detailed graphic core descriptions with gamma-ray logs, as well as an interpretation of the depositional environments for each of the cores. The purpose of this study was to look beyond the influence of the weathering and to interpret the original rock as opposed to the present-day weathering product.

Although the cores are surprisingly well preserved for such unconsolidated material, core conditions were commonly quite poor. This is mainly attributed to the removal of sandy intervals along the cores, typically 30cm in length every two to three metres. The complete slabs were removed for sampling by M. Turner prior to this investigation. The descriptions in this report are therefore based only on the remaining available material, and could have possibly been improved if the sampling had taken place after careful descriptions.

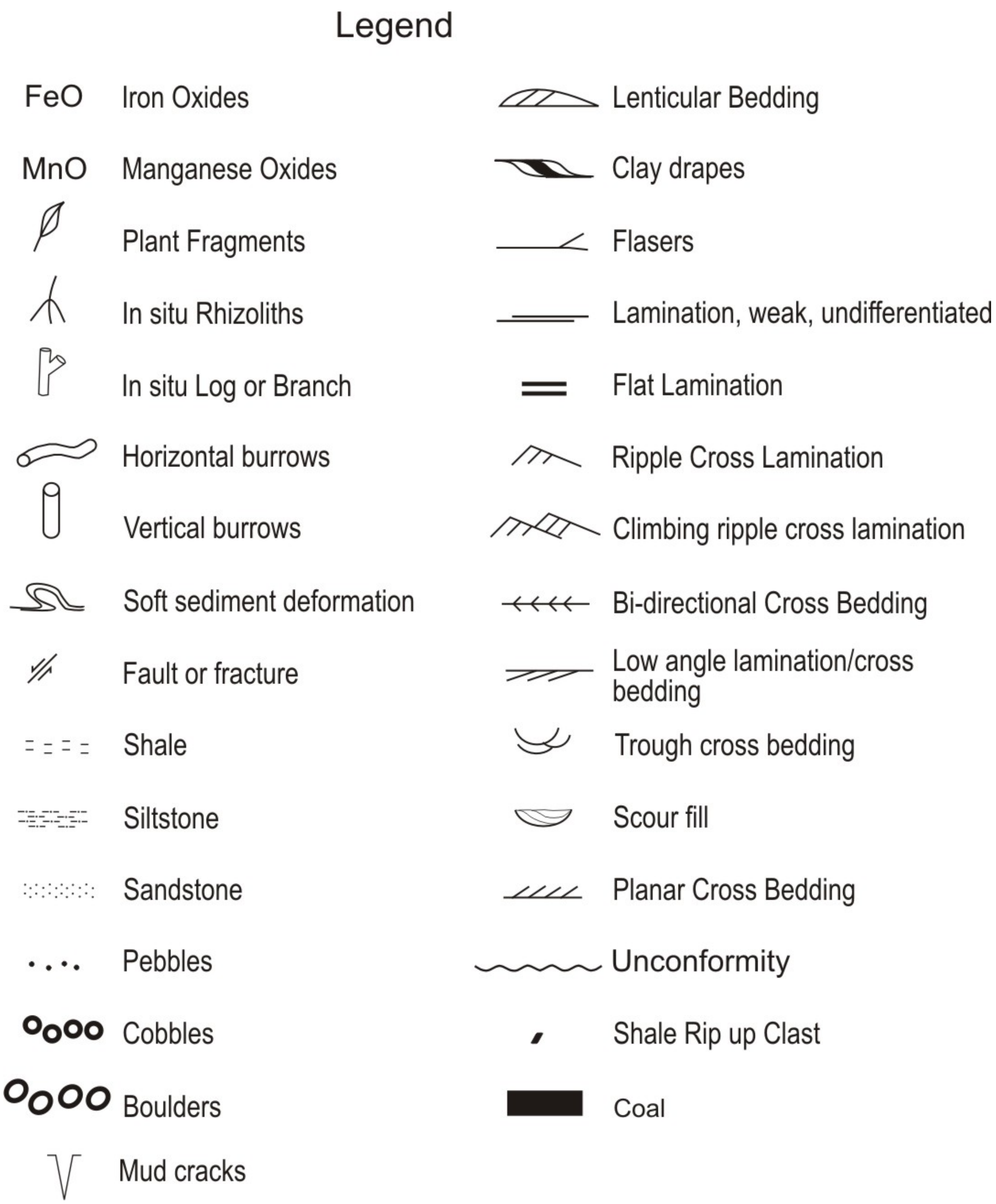

Figure 3. Legend to the symbols used in the core logs presented in Appendix I – X.

Below is a summary of the characteristic facies and depositional environments encountered in each core. A brief interpretation into the stratigraphic architecture is also attempted. However, it should be noted that without rigorous wireline logs cross-correlations and integration of all other geophysical and biostratigraphic data (e.g. Airborne EM and Palynology), the accuracy of this interpretation must be viewed critically. It should also be noted that the authors took several core samples for biostratigraphic analysis, to better constrain the age relationships within the cores. However, the results of these samples were not available at the time this report was prepared. As soon as the data becomes available it should be integrated with the data presented in this report and the stratigraphic model should then be revised as necessary.

4.1 Core LB 01

Well bore LB 01 is in the northern end of the study area, just north of St George (Figure 1). An exposure surface is located 3.5 m below the top of the core, where clay overlying this surface can be seen filling cracks of the underlying material (Figure 4). This material is clay-rich, with varying abundance of feldspar and quartz sand, and is interpreted to be the Griman Creeek formation. This puts the base of the Cainozoic succession in this well at only 3.5 m below surface (Appendix I). Due to time constraints while logging the core, it was decided that the Cainozoic interval be given preference over the Cretaceous rocks. Therefore core LB 01 was only logged to a depth of 8.4 m (Appendix I).

<u>8.4 m – 3.5 m</u>: This interval contains pale coloured fine-grained sandstone with silcrete nodules, which becomes less common up section. The core is increasingly brecciated and fractured towards the top, turning light yellow with dark manganese staining (Appendix I).

This succession is interpreted to be weathered Griman Creek Formation.

<u>3.5 m – 0.0 m</u>: This section consists of dark brown coloured, sandy clay with common charcoal fragments are around 1.5 m. Roots are common in this interval.

This succession is interpreted to be the present-day vertisol, a distal floodplain to the Balonne River (Appendix I).

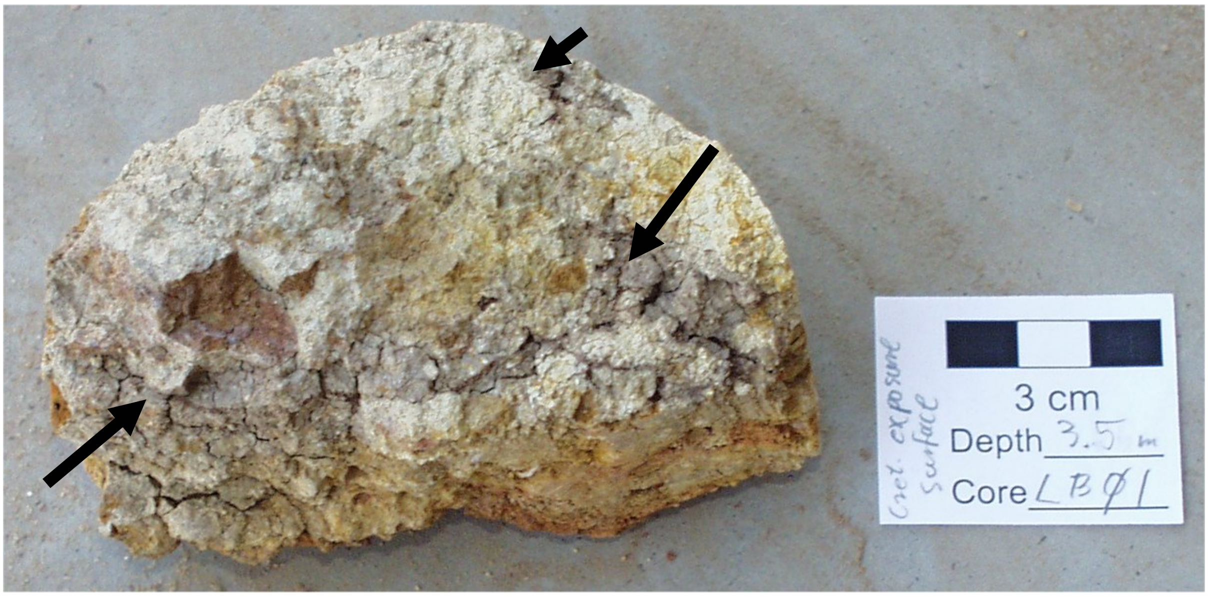

Figure 4. Cretaceous exposure surface showing overlying Cainozoic mudstone filling cracks in the underlying Griman Creek Formation.

4.2 Core LB 02

Core number LB 02 is located approximately 15 km northwest of St George, in the northern region of the study area (Figure 1). The core reaches a total depth of 59.6 m (Appendix II). One palynology sample from a depth of 56.1 m was taken prior to the commencement of this study. It indicates a freshwater, channel based environment of Early to Middle Pleistocene age (Mike Macphail, personal email to Dave Gibson 24/12/2002). This places the entire cored succession into the Pleistocene. Since this age is relying solely on one sample, an additional sample for palynological analysis was taken during this study at the depth of 48.0 m (LB01#1TP). In addition to this, a tree branch was sampled at 58.1 m with the intention of its origin being identified.

The interpretation of a freshwater channel environment is confirmed in this study. Within the total length of the core, four individual river channel systems can be identified, from 59.6 m to 47.0 m, 47.0 m to 27.8 m, 27.8 m to 17.8 m and 17.8 m to 2.6 m.

59.6 m – 47.0 m: This channel complex comprises at least four individual, sharp-based, coarsening-upwards successions each approximately 2 metres thick. The average sand grain size is medium-grained, and many pebble lags and mud rip-up clasts can be found within this interval. The sand is dominantly laminated and low-angle cross-stratified. The top metre of this interval contains sandy clay and is interpreted as channel abandonment sediment.

The abundant occurrence of coarse-grained sand beds and the common occurrence of pebble lags suggests this succession contains the main channel system of a very sandy, low sinuosity river.

47.0 m – 27.8 m: This interval is also marked by an average medium-grained sandy assemblage, but lacks the common pebble lags of the first channel system. There are frequent clay rip-up clasts in dominantly low-angle cross-stratified sand beds and carbonaceous content is locally high. At 33.8 m a medium- to fine-grained sandy succession of 1.5 m thickness grades upwards into sandy clay with rare root traces. This succession overlies a 50cm thick clay bed, and is interpreted as a final channel pulse within an overall abandoning channel succession.

Due to the lack of metre-scale, clearly fining-upwards successions, this channel system is interpreted either as a secondary channel system within an overall sandy low sinuosity river system, or as a pointbar succession of a high sinuosity river system.

27.8 m – 17.8 m: This 10 m thick interval consists of three individual fining-upwards cycles of very coarse- to medium-grained sand with an abundance of pebbles and clay rip-up clasts throughout. The top 80cm consist of mottled, pale grey to orange clay.

The high amount of pebbles and generally very coarse nature of the channel fills, together with the thickness of only a few metres for each fining-upwards cycle support the interpretation of a main channel succession within a low sinuosity river system.

17.8 m – 2.6 m: The upper succession in this core consists of a basal very coarse- to medium-grained sandy succession that grades into fine-grained sandstone (10.5 m) and then clay (6.5 m). It contains common occurrences of pebble and clay rip-up clast layers in its lower portion.

The general fining-upwards nature of this succession suggests a single fill of a channel of either high or possibly low sinuosity origin.

2.6 m – 0.0 m: This interval consists of light to dark brown, sandy and silty clay with rare modern roots preserved in it. It is either the modern day floodplain of the Balonne River, or a present-day vegetated portion of the underlying channel abandonment facies.

4.3 Core LB 03

Borehole LB 03 is located approximately 10 km west of St George (Figure 1). Core to a total depth of 59.5 m was recovered from this hole. No age dates are available for this core, and samples for further analysis were taken from the depth of 59.5 m (LB03#1TP), 58.65 m (LB03#2TP), 58.55 m (LB03#3TP) and 38.2 m (LB03#4TP). In addition Ken Lawrie took a sample (“coarse at top”) from a depth of 46.6 m. The core can be divided into four intervals, from 59.5 m to 58.5 m, 58.5 m to 38.8 m, 38.8 m to 21.5 m and 21.5 m to 0.0 m.

59.5 m – 58.5 m: Dark black clay, with fine-grained sand lenses comprise this interval.

The most likely depositional environment of this was a floodplain lake or channel abandonment lake such as an oxbow-lake.

58.5 m – 38.8 m: A series of metre-scale fining-upwards cycles of very coarse- to medium-grained sand with a few pebble lags characterise this interval. Low-angle cross-stratification and carbonaceous debris is common, especially in the lower portion. Clay rip-up clasts are more common towards the top. Overall this succession is fining-upwards and terminates with some clay and fine-grained sandy beds.

The general fining-upwards nature of this succession with individual fining-upward beds suggests a channel fill of low sinuosity or possibly high sinuosity origin.

38.8 m – 21.5 m: This interval is represented by an overall fining-upwards succession comprising medium- to fine-grained sand that grades into clay at the top (the top 2.5 m). The base of this succession is marked by a series of planar cross-stratified pebble and clay rip-up clast lags with a relatively high carbonaceous content.

The general fining-upwards nature of this succession suggests a single fill of a channel of either high sinuosity or less likely of low sinuosity origin.

21.5 m – 0.0 m: The lower portion of this interval is comprised of very fine- to fine-grained sand beds that overly a sharp, pebble base with very coarse- to coarse-grained sand. Planar cross-stratification is present close to the base of this succession, with the remainder of this interval appearing relatively massive. The top 11 metres contain a series of 50cm to 1 m thick fining-upwards sandy successions separated by metre thick clay beds. This clay-rich interval contains an abundance of carbonaceous material as well as present-day root traces. The top 2 m are a present-day, red soil with roots and is most likely a combination of weathered Cainozoic mixed with present-day floodplain deposits of the Balonne River.

This interval is interpreted as a complete channel fill, including abandonment facies, of a low sinuosity or high sinuosity river system.

4.4 Core LB 04

Core LB 04 comes from the western end of the study area and is located approximately 70 km west-southwest of St George (Figure 1). The core was taken to a depth of 61 m and has various degrees of weathering throughout. It can be divided into five intervals, from 61.0 m to 48.7 m, 48.7 m to 39.2 m, 39.2 m to 26.8 m, 26.8 m to 21.0 m and 21.0 m to 0.0 m.

61.0 m – 48.7 m: The lowest interval comprises coarse- to medium-grained sand in its lower part and fines upwards through fine- and very fine-grained sand into clay. Some root traces and carbonaceous material can be seen around 51.0 m to 52.0 m, otherwise the core appears massive.

The simple fining-upwards nature of this succession without any major energy changes suggests a single fill of a channel of either high sinuosity or possibly low sinuosity origin.

48.7 m – 39.2 m: This interval is a very low-energy succession and contains 3.5 m of very fine-grained, massive sand at the base and silty clay with rare sand lenses for the remainder of this succession. Clay filled fractures are common in this interval. Some charcoal fragments are located around 41.0 m and carbonaceous material is present towards the top.

Based on the very low-energy fill, this succession is interpreted as a floodplain deposits overlying a sandier crevasse-channel or crevasse-splay complex.

39.2 m – 26.8 m: Core from this interval shows a 5.0 m thick fining-upwards medium- to very fine-grained sandy succession overlain by a clay interval with 50cm thick sand beds. The sand beds are in faulted contact with the clay. Some mud cracks are present at around 32.2 m.

This succession is interpreted as a single channel fill overlain by floodplain clays. Due to the fact that the sand beds are in faulted contact with the floodplain clay, their original environment of deposition is out of context, but was most likely a floodplain crevasse-splay complex. This low-energy interval is interpreted to be first deposited in a distal high sinuosity channel and then on a distal floodplain.

26.8 m – 21.0 m: This interval contains one metre of massive fine-grained sand that is overlain by silty clay. Fractures are common.

This very low energy interval is interpreted as very distal floodplain overlying a sandy distal crevasse-splay sand.

21.0 m – 0.0 m: This interval is strongly mottled, and thus it is very difficult to interpret the original configuration. Very fine- to fine-grained sand of massive appearance dominates most of this interval with clay present between 17.0 m and 18.0 m and 6.7 m to 8.0 m. Modern root traces can be found to a depth of 12.5 m. The top one metre of the interval contains red, present-day soil with roots.

This interval was most deposited in a relatively low energy channel system.

4.5 Core LB 05

Borehole LB 05 is located approximately 15 km southeast of St George, and was drilled to a depth of 59.3 m. No age data exists from this core, and samples for future palynology analysis were taken at a depth of 45.75 m (LB05#1TP), 15.5 m (LB05#2TP), and 19.8-20.3 m (LB05#3TP). This core can be divided into four intervals from 59.3 m to 45.9 m, 45.9 m to 30.8 m, 30.8 m to 14.6 m and 14.6 m to 0.0 m.

59.3 m – 45.9 m: This basal interval comprises fine-grained, massive, clay-rich sand in its lower portion grading into three 2.5 m thick fine-grained sand to clay fining-upwards packages towards the top. Carbonaceous material can be found within the clay beds in the upper portion of this interval.

The fine grainsize together with the high amount of clay content within the sand beds, as well as within the interbeds, suggests deposition within a relatively low-energy, high sinuosity channel, followed by a channel abandonment facies or proximal floodplain facies.

45.9 m – 30.8 m: This interval shows a single fining-upwards succession grading from a trough cross-stratified pebble and very coarse-grained sand into massive, muddy and carbonaceous, very fine sand and then into carbonaceous clay. A strong fracture network exists throughout this interval.

This single fining-upwards succession is interpreted as a fill of a single (high sinuosity) channel with channel abandonment clay at the top.

30.8 m – 14.6 m: This interval consists of a 1.5 m thick massively looking medium-grained sand overlain by 14 m of weathered and fractured clay, with rare root traces.

The interpretation for this interval is floodplain crevasse splay sands overlain by floodplain clays. It is likely that, during this time, the floodplain developed into a lake that provided accommodation for the thick clay package. However, the presence of roots indicates such a lake must have been shallow.

14.6 m – 0.0 m: The lower 8 m of this interval consists of very coarse-grained sand at the base with pebble lags that fine upwards into medium- to coarse sand with pebbles at the top. This is overlain a mottled and burrowed clay that grades into a present day, 1 m thick dark brown soil.

This interval is interpreted as a relatively high energy channel fill complete with abandonment facies. The channel system is of high or possibly low sinuosity origin.

4.6 Core LB 06

Core LB 06 was taken approximately 55 km south of St George to a depth of 59.7 m. The core appears dominantly Cretaceous in age following the dominance of feldspar within the sandstone. Only the top six metres are interpreted to be of Cainozoic age. To verify this interpretation, samples for Palynology were taken from the depths of 58.6 m (LB06#1TP), 35.0 m (LB06#2TP), 17.9 m (LB06#3TP) and 4.7 m (LB06#4TP), and are awaiting analysis.

6.0 m – 0.0 m: This interval is represented by 2.0 m of coarse-grained silt overlain by 1.2 m of medium-grained sand, which in turn is overlain by 1.8 m of coarse-grained silt with the last metre consisting of dark-grey clay. The degree of weathering obscures sedimentary structures; iron oxide staining is found in the lower portion.

Due to the fine grainsize of this interval, it is interpreted as being deposited in a fluvial floodplain environment.

4.7 Core LB 07

This core was taken to a total depth of 57.0 m approximately 20 km west-southwest of St George. The core is very strongly weathered (mottled and bleached) from a depth of 33.2 m to 44.0 m, and only the grainsize can be estimated. Based on this, the core can be subdivided into six intervals, from 57.0 m to 48.0 m, 48.0 m to 33.2 m, 33.2 m to 30.8 m, 30.8 m to 20.4 m, 20.4 m to 7.5 m and 7.5 m to 0.0 m. No age dates are available in this core, and one sample was taken at a depth of 20.75 m (LB07#1TP) for further palynological analysis.

57.0 m – 48.0 m: This interval comprises a coarsening-upwards succession that grades over six metres from clay over silt and very fine-grain sand to fine-grained sand, and then continues as a very fine-grained sand until 48.0 m. Backfilled burrows are present at 52.0 m and possibly at 56.5 m. The sand is weakly laminated and has some clay rip-up clasts at around 54.5 m.

This coarsening-upwards succession is interpreted as a delta or crevasse splay building out into a floodplain lake.

48.0 m – 33.2 m: This interval comprises very fine-grained sand, but due to the mottled and leached nature of this core, no interpretation can be drawn from it.

33.2 m – 30.8 m: Overlying the mottled interval is a 50cm thick very fine-grained sand bed that is sharply overlain by 1.8 m of light-grey clay. The lower contact shows a burrow extending into the underlying mottled sand (Figure 5).

The lower sand bed is interpreted as a transgressive lag at the onset of a floodplain lake that accommodated the overlying clay.

30.8 m – 20.4 m: Over this 10 m interval, very coarse-grain sand with pebbles and trough cross-stratification grades into a low-angle cross-stratified, medium-grained sand, then into very fine-grained sand and then clay. Carbonaceous material is present within some sand beds.

This succession is interpreted as a complete channel fill with channel abandonment plug.

20.4 m – 7.5 m: This interval comprises stacked, centimetre to metre thick, fining-upwards, very coarse- to medium-grained sand beds. Pebble layers, clay rip-up clasts and carbonaceous material are rare, and some sand beds show planar cross-stratification.

This interval is interpreted as stacked fluvial channels of a low sinuosity river system.

7.5 m – 0.0 m: This interval comprises very fine- and fine-grained sand beds that are overlain by a present-day cracking clay soil. The sand appears massive and has a high clay content. At around 6.0 m a root system can be seen that is not associated with present-day vegetation.

The root system indicates deposition of this sand in a floodplain environment, possibly on top of a levee complex.

Figure 5. Burrow in core LB 07 at 33.2 m extending from a transgressive surface into the underlying, mottle sand.

4.8 Core LB 08

Core LB 08 was taken to a total depth of 69 m, approximately 70 km southwest of St George close to the edge of the study area. One earlier palynology sample from a depth of 62.3 m indicates a freshwater channel based environment of Early to Middle Pleistocene age (Mike MacPhail, personal email to Dave Gibson 24/12/2002). This would place the entire cored succession into the Pleistocene. The core can be subdivided into five broad intervals, from 69.0 m to 61.4 m, 61.4 m to 51.5 m, 51.5 m to 20.2 m, 20.2 m to 16.1 m and 16.1 m to 0.0 m.

69.0 m – 61.4 m: This interval contains 4.0 m of laminated, silty clay that is sharply overlain by 1.8 m of silt and then sharply overlain by 1.8 m of black clay. Several root traces are present at around 65.0 m (Figure 6).

The lower portion of this interval is interpreted as a palaeosol with root traces that is overlain by a flooding surface at 65.0 m and a transgressive surface at 63.2 m. The flooding surface indicates the onset of the transgression through coarser silts. Accommodation space was created by this transgression which created a lake and caused fine-grained sediments to be deposited.

61.4 m – 51.5 m: Sharply overlying the previous succession with an erosional surface is carbonaceous, coarse- to medium-grained sand that grades over 5.5 m into fine-grain sand and is overlain by 4.4 m of shale. A majority of the sand was lost during coring, but what remains appears mostly massive.

This succession is interpreted as a fluvial channel fill overlain by channel abandonment and floodplain clays. The fluvial channel appears of high sinuosity origin.

51.5 m – 20.2 m: Overlying another erosional surface is a succession of metre-scale sand beds that vary greatly in grain size from very coarse- to fine-grained. Shale rip-up clasts are common, while carbonaceous material is rare. Towards the top of this succession the sand beds become more laminated and occasionally planar cross-stratified. Pebble layers also appear towards the top of the succession. The top two metres of the succession consists of silty clay with occasional fine-grained sand interbeds.

This almost 30 m thick interval is interpreted as a succession of sand deposited by a low sinuosity river system that is overlain by channel abandonment or floodplain clays.

Figure 6. Root trace in core LB09 at a depth of 64.7 m.

20.2 m – 16.1 m: This interval comprises medium-grained sand that gradually fines upwards into clay over 4 m. A pebble layer marks the lower boundary of this succession. The sand is laminated and occasionally carbonaceous. A sand-filled, lined burrow is present at 19.7 m. The shale bed at the top contains root traces.

This interval is interpreted as a single channel fill succession complete with floodplain abandonment clay.

16.1 m – 0.0 m: Overlying a thick pebble layer is a 7.0 m thick succession of coarse- to fine-grained, 0.5 m thick sand beds that commonly contain pebble beds. The sand beds are typically laminated or planar and trough cross-stratified. Clay rip-up clasts are common, some with a diameter of up to 8cm. The upper 8.9 m comprise low-angle laminated and planar cross-stratified, medium-grained sand that grades upwards into carbonaceous, fine-grained sand with roots, and then into clay with charcoal fragments and roots. The top 1.0 m of the core shows a black soil overlain by coarse gravel from a road (the well was drilled next to a road).

This interval is interpreted as a relatively high-energy channel sand deposited in a low sinuosity river channel followed by a lower energy channel succession with channel abandonment plug that is likely to have originated in a more high sinuosity river channel.

4.9 Core LB 09

Core LB 09 was taken approximately 45 km south-southeast of St George to a total depth of 60.0 m. The lower portion of the core to a depth of 32.0 m is Cretaceous in age based on the feldspar content within the sandstone and the degree of lithification. There is also a discreet palaeo-regolith horizon present on top of the Cretaceous section which indicates prolonged exposure and supports the interpretation (Figure 7). Since there is no age date available for this core, a sample for palynological analysis was taken as close to the bottom of the non-Cretaceous section as possible at a depth of 30.8 m (LB09#1TP). This sample will help to verify the age of the overlying interval. The non-Cretaceous section can be divided into five intervals, from 32.0 m to 19.2 m, 19.2 m to 17.0 m, 17.0 m to 12.2 m, 12.2 m to 6.8 m and 6.8 m to 0.0 m.

32.0 m – 19.2 m: This interval contains a 1.5 m thick succession of reworked regolith overlain by 8.0 m of fining-upwards, medium- to fine-grained sand. The base of the sandy succession is erosional and has a pebble layer that contains potch (poor-quality opal). The sand is dominantly massive and partly interbedded with clay. Overlying this sandy succession is 3.0 m of sandy clay.

This interval is interpreted as the fill of a channel of possibly high sinuosity origin complete with channel abandonment or floodplain clays. The reworked regolith at the base of the succession is interpreted as the onset of renewed accommodation following the exposure of the cretaceous section.

Figure 7. Ironstone regolith surface developed on top of the Cretaceous in core LB 09 at 31.7 m. The Ironstone bed indicated prolonged exposure of the surface prior to burial by younger fluvial sediments.

19.2 m – 17.0 m: This short interval features a very fine-grained, trough cross-stratified sand overlying an erosional surface that grades upwards into laminated silts and clays. The clay at the top of this succession is truncated by another erosional surface.

The fine grainsize and the fining-upwards nature of this succession supports the interpretation of a crevasse channel fill on a floodplain environment.

17.0 m – 12.2 m: Coarse- to fine-grained, metre thick sand beds with pebble layers dominate this interval. The sand is occasionally low-angle cross-stratified, and contains a few clay rip-up clasts. The sand is overlain by a 10cm thick clay bed.

This succession is interpreted as a series of shallow channel fills deposited in a low sinuosity river.

12.2 m – 6.8 m: Overlying very coarse-grained pebbly sand is a succession of metre thick, fine-grained sand beds with occasional pebble layers. The sand is dominantly massive, but the lower, very coarse-grained bed is low-angle cross-stratified and contains clay rip-up clasts. The very top 20cm of this succession contains clay with root traces. The roots extend a metre down into the fine-grained sand.

This succession is interpreted as a channel succession deposited in a low sinuosity river.

6.8 m – 0.0 m: Following an erosional surface is a 10cm thick pebble bed overlain by a fining-upwards medium- to very fine-grained sand. The sand is massive and contains several root traces. Clay content increases up-section. The top one metre consists of brown vertisol silty clay.

This interval is interpreted as a single, low energy channel fill following a strong scour even (possibly an avulsion event).

4.10 Core LB 10

Core LB 10 was taken from a well situated approximately 55 km east-southeast of St George (Figure 1). The complete core contains Cretaceous Griman Creek Formation except for the top two metres, which consist of Quaternary vertisol silts and clays. The weathering of the Griman Creek Formation is exceptionally strong, and a reconstruction of the original composition and environment of deposition of the top portion of the core was not possible. A present-day root can be found at a depth of 3.0 m within shale of the Griman Creek Formation.

The silt and clay of the vertisol in the top two metres is interpreted as very distall floodplain sediments of the Quaternary Balonne River.

5. DISCUSSION

5.1 Age of fill of the Dirranbandi Palaeovalley

In the report by McAlister (2000) the age of the fill of the Dirranbandi Palaeovalley is interpreted to be Tertiary to Quaternary. However, this interpretation is based on lithostratigraphic recognition and "intuition", and is not confirmed by any subsurface age dates.

Prior to the commencement of this study, palynological sampling of the cores returned a bottom of hole age of core LB 02 and LB 08 of Early to Middle Pleistocene age (Macphail 2004). Although these cores do intersect basement, a significantly thicker portion of the Dirranbandi Palaeovalley now appears to be of Quaternary age than that thought by McAlister (2000). While logging these cores, there was no strong indication of any compositional change or of a change in fluvial style in sediment overlying the Griman Creek Formation. Since there is no evidence of Tertiary-aged sediments in the cores so far, it could be suggested that the Tertiary was a time of general tectonic quiescence, and that the Dirranbandi Palaeovalley is dominantly filled with Quaternary sediment.

The additional sampling of the cores for palynological analysis should resolve some of these age differences. Based on the new age dates, the interpretations presented in this report should be adjusted accordingly.

5.2 Stratigraphic architecture from cores

Thicknesses of the sandstone filled channels together with the identification of the fluvial style (high or low sinuosity) can result in an estimation of the width of the channel (sandstone) body based on statistical width to thickness ratios. Payenberg and Lang (2003) suggest that high sinuosity meandering fluvial rivers produce sand bodies with a width to thickness ratio of typically 100:1, while low sinuosity braided fluvial rivers produce sand bodies that are at least 300:1 in width to thickness ratio. This suggests that low sinuosity braided rivers usually produce a laterally more extensive sand sheets compared to high sinuosity meandering rivers. For example, the thickest braided succession identified in this study is in core LB 08 and measures 30 m thick. Based on the above width to thickness ratios, that sandbody should be at least 9 km wide. Using such width to thickness ratios combined with a proper identification of the fluvial style can greatly benefit subsurface correlation and architecture determination.

Even without direct core control it is possible to determine the fluvial style from wireline logs. To aid in this determination, all the core logs presented in Appendix I to X are complimented and depth-matched with the downhole gamma-ray logs. Clean sand appears with a very low gamma-ray count while shale has a very high gamma-ray count. Fining-upwards successions from coarse-grained sand to clay, for example, show on the gamma-ray log as a trace with gradually increasing gamma-ray count. This is termed a “bell curve” or “bell shape”. Single bell curves most likely indicate a high sinuosity channel origin, while several metre short, stacked bell curves, or zig-zag curves suggest a more low sinuosity braided or anastomosing environment. A thorough integration of the core data with the wireline logs should aid in the constructing of a sound subsurface architecture model.

The overall coarsest grain size in the (Quaternary) Dirranbandi Palaeovalley channel sands can be found in wells LB 02, LB 03 and LB 08 (average coarse-grained sand) while wells LB 04, LB 05, LB 07 and LB 09 contain on average medium- to fine-grained sand and cores LB 01, LB 06 and LB 10 contain mainly floodplain fines of very fine-grained sand, silt and clay. Since well LB 02, 03 and 08 are on a relatively straight line, is can be suggested that the Quaternary Palaeo-Balonne River might have had its main channel located along this line, which is situated approximately 20 km northwest and parallel to the present-day Balonne River. Coarse-grained river sediment located along straight lines or lineaments are commonly basement fault controlled, but needs further investigation in this area.

6. CONCLUSIONS

The ten cores from the St George area, southern Queensland penetrate Quaternary sediments of the Dirranbandi Palaeovalley overlying the Cretaceous Griman Creek Formation. The Quaternary sediments consist of fluvial channel and floodplain deposits originating in low and high sinuosity rivers. Although vertical variations in fluvial style exist in each well, it cannot be determined from the cores alone if fluvial style changed throughout the Dirranbandi Palaeovalley within the Cainozoic. It much rather appears that fluvial style is a response to local accommodation and avulsion processes, something that can be verified with good wireline correlations.

Based on standard width to thickness ratios, some of the sheet-like sandstone bodies deposited by braided river channel systems are at least 9 km wide, if the river is not too strongly basement controlled. This will have a major effect on connectivity of individual channel sand bodies and can lead to a complicated network of heterogeneous, continuous porous sandbodies which are capable of conducting surface waters deep into the subsurface.

The coarsest sediments are found along a line parallel to the modern Balonne River, but approximately 20 km to the northwest. This area appears to have been the region of maximum accommodation. Basement faulting commonly causes the main channels of river system to flow along such lineaments.

7. RECOMMENDATIONS

To gain a better understanding of the subsurface geometry and connectivity of the sand bodies the following are suggested:

- Examination of the palynology samples taken during this study and integration with the core data;
- Use of the core to wireline correlation to constrain subsurface wireline correlations;

- Identification of the fluvial style of the channel sandstones in wireline logs and the use of width to thickness ratios to constrain correlations;

- Integration of any other geophysical data, such as Airborne EM data, with the subsurface wireline interpretations.

8. REFERENCES

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