Cooper Basin Electrofacies Mapping Project
South Australia

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EXECUTIVE SUMMARY

Wireline logs from approximately 830 wells have been analysed using in-house script known as *ElectroFacies*. 42 wells were further analysed using a manual approach to specifically target anomalous results. Preset cut-off values were used to analyse the thickness and percentage of electrofacies for the following formations of the Cooper Basin sequence: Patchawarra, Epsilon, Daralingie, Toolachee and Nappamerri Formations. Cut-off values were determined from careful calibration of core facies and log signatures for four electrofacies: coal, clean sandstone, silty or muddy sandstone, and siltstone/shale. A series of isolith and isopach maps, first produced in 1998 by McLean and Hill, have been further developed by X. Sun and B. Camac (2004) to include recent data and specifically correct anomalous readings. These maps have been produced for sandstone, silty or muddy sandstone, shale/siltstone and coal for the formations analysed. These are intended to provide a general guide for interpretation of Cooper Basin lithofacies distribution and palaeogeography, leading to improved prediction of reservoir, source and seal rocks.

Calibration of log motif and core lithofacies analysis recognises several electrofacies and sequences indicating deposits of delta-mouth bars, delta plain, coal swamp, point-bar, braided channel, crevasse splay, floodplain to lake. The Daralingie or Epsilon Formation in many wells has typical log motifs of smooth to serrated funnel shape indicating coarsening-upward deltaic distributary mouth bar. The Patchawarra or Toolachee Formation has typical bell shape gamma log motifs representing meandering point-bar deposits along with smooth and serrated cylinder shape indicating braided channel deposits. Electrofacies and sequences generally reflect changes in porosity and permeability. This is distinctive in the gamma log, as the clay content in sandstone increases, porosity decreases slightly but permeability decreases dramatically. Based on integration of porosity and permeability, lithofacies and log-shape pattern, the recognised electrofacies can be used as templates for geologists or engineers to help predict sand trend, palaeogeography of the southern Cooper Basin and assist evaluation of reservoir quality.

The resultant data are available as digital grids, exported from Petrosys Mapping software. The grids are created with 250 x 250 cell size, using the minimum curvature algorithm. The co-ordinate datum is GDA 94.

INTRODUCTION

The Cooper Basin is an intra-cratonic basin of Permo-Triassic age and extends from the north-eastern corner of South Australia into south-western Queensland. The study area is in the southern Cooper Basin, occupying about 30,000 km^2. The Cooper Basin is Australia's largest onshore hydrocarbon producing basin, where many research projects have been carried out. However, no regional study of electrofacies has been published although Thorton (1979) did a brief regional study of palaeogeography of the Cooper Basin. Depositional environments of the studied formations have been interpreted as fluvial, deltaic and lacustrine environments by various authors (Kapel, 1966; Gatehouse, 1972; Battersby, 1976; Stuart, 1976; Thornton, 1979; Williams, 1982; Stuart *et al*., 1988; Mackie *et al*., 1995; Williams, 1995).

A series of sand, shale and coal isolith maps had been generated by using wireline logs for about 400 wells in a regional coverage of about 22,500km^2 in the Cooper Basin (the Cooper Basin Folio, 1998;

McLean & Hill). This study aims to further develop the existing maps of lithofacies of major formations of the Cooper Basin sequence to improve description of the facies composition and lateral facies variation in the basin. Log analysis has been carried out on more than 800 wells. Mud type (KCl) has been taken into consideration along with the normalisation required for older gamma ray logs.

Porter (1976, 1990), Porter & Croker (1972), Morton (1989), Rezaee & Lemon (1997) and Khaksar & Griffiths (1998, 1999) have carried out petrophysics of Cooper Basin reservoirs in South Australia from the point of view of porosity and permeability and Vshale calculated from wireline logs. Khaksar & Mitchell (1995) applied the thin bed log analysis method of Bateman (1990) to overcome the common problem of under-estimation of thin sands within the Patchawarra Formation in the Toolachee Field. However, since the study is at a regional scale, these petrophysical study results have been only generally considered.

CONCEPTS OF ELECTROFACIES AND ELECTROSEQUENCES

Serra (1970) defined electrofacies as “the set of log responses, which characterises a bed and permits it to be distinguished from the others”. He also pointed out that all log responses indicate the quantitative (log values) as well as qualitative (characteristics of curves – log motif) aspects, which are therefore the component elements of the electrofacies. “An electrofacies may be defined as a depth interval exhibiting more or less constant log responses, while an electro-sequence may be defined as a depth interval within which one or more characteristics vary in a continuous fashion – known as a ramp. Such an interval must have a thickness, which is greater than the vertical resolution of the devices that respond to this characteristic. The breakup into electrofacies can be done visually, either manually or using an interactive terminal, or automatically using an appropriate computer program. (Serra, 1986, p.76).

METHODOLOGY

Two main methods have been used in this study. The first is a log-pattern method that identifies several typical wireline log curve shapes representing different facies (qualitative electrofacies). A similar study has been carried out by Mackie *et al*. (1995) who interpreted six facies from detailed facies analysis of 580m of cores, together with log motif analysis of 135 wells, from the Toolachee Formation in the Moomba and Big Lake area. The most common idealised log curve shapes (Serra, 1986, 1989) of gamma and sonic logs herein are recognised by calibration with many lithofacies interpreted by Williams (1982, 1995) from core samples. The integration of log motif and core lithofacies analysis results in recognition of several electrofacies and sequences representing depositional environments varying from delta-mouth bars, delta plain, coal swamp, point-bar, braided channel, crevasse splay, floodplain to lake.

The other method was to study wireline log values to decide quantitative electrofacies (different lithology). For the chosen wells, digital gamma-ray and sonic logs were used to determine the thickness of certain facies over specific formation intervals. Formation intervals were taken from the Petroleum Exploration and Production System (PEPS) database. In-house script known as *ElectroFacies* (the EF subroutine is reproduced in **APPENDIX 1**) was used to test the logs against preset cut-off values over the specific intervals given. For each formation in each well this returned a cumulative thickness for each of coal, sandstone, and siltstone/shale facies. Hill & McLean (1998) used in-house script known as *ElectroFacies* to test the logs against preset cut-off values over the specific interval given. A uniform cut-off value of 100 API units to distinguish sandstone and siltstone/shale facies was set, suggested by Thornton (1998, 1979). The cut-off value they used for coal is equal or greater than 120 microsec/ft while Thornton (1998, 1979) pointed out that a value of at least 100 microsec/ft is used to recognise peaks of sonic logs of coal intervals. Porter (1976) suggested very rough gamma log values for pure shale being 160 API, and clean sandstone being 20 API. However, the cut-off values are too general, for example, sandstone may be under-estimated resulting in missing thin beds of sandstone (e.g. in Andree 2) and thin coals are not counted. Khaksar & Mitchell (1995) revealed that this conventional cut-off (100 API units) underestimates the true gross sandstone thickness by up to 36% for the Patchawarra Formation in the Toolachee Field. They used the Binary Lithology Method (BLM) of Bateman (1990) to reduce underestimation of sandstone thickness from 36% to 3%. The gamma ray values for sandstone and siltstone/shale in the BLM are not simple cut-off values. For this regional study, it is difficult to use the BLM for every well. For the environmental effects such as mud type of KCl which elevates gamma ray values should be corrected. For example, gamma value elevated 15-19 API in Strzelecki 16 comparing with nearby Strzelecki 1. Thickness values of different lithologies change significantly from KCL (2%) uncorrected to corrected, for example, in Pelican 1, a comparison is shown in Table 1. Average 20 API has been corrected for all wells drilled with KCl mud.

Table 1 Comparison between KCl uncorrected (above) and corrected (bold) in Pelican 1

Formation	Total	Sand	Silty/muddy sandstone	Siltstone /Shale	Coal
	Thickness (ft)	Thickness (ft)	Thickness (ft)	Thickness (ft)	Thickness (ft)
NAPPAMERRI GP	491.5	44	201	246.5	0
NAPPAMERRI GP	**491.5**	**102**	**271**	**118.5**	**0**
Toolachee Fm	131.5	48.5	42	27	14
Toolachee Fm	**131.5**	**63.5**	**36**	**18**	**14**
Patchawarra Fm	680.5	124.5	277.5	227.5	51
Patchawarra Fm	**680.5**	**202.5**	**341**	**86**	**51**

We examined widely distributed wells including about 37 wells with cores and 45 wells that are mainly from wells studied by John Morton (1990) to see if there are suitable cut-off values for the whole basin. In fact, beds of less than 25-inch (60 cm) thickness will be registered on the sonic log, but a true velocity will not be recorded (Rider, 1986).

WIRELINE LOG VALUES (QUANTITATIVE ELECTROFACIES)

Mackie *et al*. (1995) used a gamma ray cut-off value of 100 API in Moomba 3, this missed thin sands of the proximal crevasse splay or channel abandonment. Similarly, it also missed thin sand layers of small channels, inter-distributary bay, delta plain and channel-levee as shown in core 3 of Gidgealpa 6 in (Thornton, 1979).

Resistivity logs especially MSFL can be used as reference logs to define boundaries between shale/siltstone and sandstone, because they have higher resolution than gamma logs. General cut-off values of gamma logs are determined from calibration among lithology from cores and cuttings, and wireline logs of about 82 wells. **Table 2** shows gamma ray values corresponding to different lithologies from three wells. These cut-off values are chosen from intervals with more or less uniform lithologies (not frequent interbeds). Those anomalous values are due to “shoulder” effects (gradational transition of gamma values) are deliberately omitted. Four quantitative electrofacies are differentiated by the following cut-off values:

	Gamma Ray (API)	Sonic (µsecs/ft)
Coal	not applicable	≥ 115
Clean sandstone	≤ 80	
Silty sandstone/coarse siltstone	> 80 and < 130	
Silty shale	> 130	
Carbonaceous mudstone/shale	>145	

Table 2 Gamma Ray values of three wells

Well	Formation	Core	Depth (driller) (log) ft	Electrofacies	Gamma value API
Burke 1	Toolachee	1	7025-7042.5 (-3)	Sst, shaly lamina. downwards	63-94; 103-128
		1	7042.5-7059.5 (-3)	Shale, silty, micac.	131-159
		1	7059.5-7070 (-2)	coal	24-86
	Toolachee	1	7070-7085 (-2)	Coaly shale, lam. sst	105-155
	Toolachee	2-3	7185-7199.25	Fine, med. to very coarse sst, pebbly	30-52
	Toolachee	3	7199.25-7212 (-1)	Shale, coal, min.sst	131-138; 70-105
	Toolachee	3	7212-7216	Fine, well-sorted sst	73-89
		3	7216-7220	Coal, sh, silt, sst	97-143
	Toolachee	4	7253-7278	fine, massive sst, minor sh. lam.	50-94; basal congl. (38-40)
	Daralingie	4	7278.5-7312 (-0.5)	shale & siltstone	130-158
				Coaly shale	110-130
				Sandy shale	126-
				Shaly sst	96-111

Well	Formation	Core	Depth (driller) (log) ft	Electrofacies	Gamma value API
Cowralli 2	Patchawarra	1	9558-9585.5 (+2)	Sst, fine to medi. Pebble at 9578.7 ft(+2)	29-69; 80 45
		1	9585.5-9593 (+2)	Siltstone, min. sst	54-97; 113
		1	9593-9602 (+2)	shale	125-152
		1	9602-9606 (+2)	siltstone	109-124
		1	9606-9613(+2)	shale	130-152
		1	9613-9616(+2)	Sst interlaminated with siltstone	86-123
Por. & per.					good indicator

Well	Formation	Core	Depth (driller) (log) ft	Electrofacies	Gamma value API
Gidgealpa 52	Patchawarra	1	7240-7240.8 (+10)	fine sst	45-55
		1	7240.8-7244.1 (+10)	shale	128-134
		1	7244.1-7246.4 (+10)	Shale, lam. of sst	112-121
		1	7246.4-7251 (+10)	Sst, shale laminae	71-100
		1	7251-7253 (+10)	Coal	63-96
		1	7253-7260 (+10)	Shale	112-153
			7260-7263 (+10)	Sandstone, pebbles	91-104
			7263.8-7264.4	coal	104
			7264.4-7271.8	Shale, min. sst lam.	50-106
			7271.8-7284	Sst, thin shale lam.	18-93
			7284-7299.6 (+9)	Coal, carbon. sh.	29-200
			7299.6-7319.4 (+9)	Siltstone, shale, v.min. sst laminae	117-161
			7316.1-7316.5 (+9)	coal	130

Serrated cylindrical log indicates existence of thin shale interbeds (1 – 3ft or 0.3-0.6 m) within the sandstone. If no cores are cut, lithologies are assumed from mud log information, e.g., it is quite reliable to decide shale above and below the coal bed, especially if it is carbonaceous mudstone/shale, as their gamma values are normally greater than 140 API.

Despite the following complications in using uniform cut-off values, clean (reservoir-effective) sandstone won't be missed except if they contain labile fragments, muddy matrix (e.g. Big Lake 29, core 2, over the interval of 9669-9671 ft) or a lot of carbonaceous material.

1. It is impossible to have a uniform cut-off value where frequent thin interbeds occur, gamma value for shale is lower than normal (<130, sometimes even less than 100 API), such as over the interval 5796-5803 ft in Wancoocha 3. Another example is that gamma values vary from 110 to <130 API for stacked cyclic beds comprise dark shale, medium dark siltstone, pale siltstone and very fine pale sandstone over the interval 7336-7346 ft in Toolachee 9.

2. For mixture of coal, sandstone and shale, gamma ray values can be less than 130 API for shale.

3. Sandstone with minor shale laminae, gamma ray values are normally low, which will severely influence porosity and permeability.

4. Where shale is predominant and has minor sandstone laminae, gamma value is high, and contains small kicks (spines).

5. Cut-off values are not quite the same in different formations for example, sandstone or silty sandstone have higher gamma values in the Nappamerri Formation than in other formations.

6. Conglomerate containing shale or siltstone clasts, sandstone rich in clay matrix, will show very high gamma ray values. For example, 143-210 API values were recorded from conglomerate over the interval 9662-9670 ft in Big Lake 29, and it contains argillaceous matrix and mica.

7. Coals need to be greater than 0.98 ft (0.3m) thick, and sandstone greater than 1.9 ft (0.6 m) to be identified on the logs.

8. Most wells have been drilled on structural highs. Fairly uniform cut-off values have been used for these wells. . Several wells such as Kirby 1, 2, Burley 1, 2, Big Lake 1 and Kanowana 1 are located either on the flank or in the Nappamerri Trough area. Gamma ray values for shale in the Roseneath and Murteree Shales in McLeod 1, Burley 1 & 2 and Kirby 1 are much lower than those drilled on structural highs (**Table 3**). In these cases, different cut-off values were used.

Table 3 Cut-off values for wells from Nappamerri Trough

Well	**Gamma Ray Cut-off value**		**Comments**
	Clean sand API	**Shale API**	
Burley 1	<40	>65 >75	Thin sandstone can be > 40 API; shale is about 60 API in core 1, 8798-8819ft. Try two cut-off values
Burley 2	80	125	
Kirby 1	80	110	Shale can be 100 APIor less
Kirby 2 (KCl mud)	100 95	150 130	115 API or less for shale e.g. in Toolachee Fm, core 2; try two cut-off values
McLeod 1	85	120	Can vary

WIRELINE LOG PATTERN (QUALITATIVE ELECTROFACIES)

Rao (1998) stated "electrofacies is best interpreted by considering a sand body geometry and orientation and the character and distribution of the associated electrofacies. With sufficient well control, high resolution palaeo-geomorphic maps can be made using log curve shapes and sand body geometry to interpret depositional environments within genetic increments of strata." He used log motifs representing channel sand and over-bank mud facies to reconstruct depositional environments and predict distribution of channel-type reservoir sands.

Several general log motifs were recognised and described in (Selley, 1996), and their descriptive terms are followed herein. For Cooper Basin data, only in the Toolachee Formation in the Moomba and Big Lake area, Mackie *et al*. (1995) recognised five facies from detailed core facies analysis of cores (580m thick), together with log motif analysis of 135 wells. The facies include complete channel sands, abandoned channel sands; crevasse splay sands, shale and coal. Typical log motifs for all major Cooper Basin formations are recognised, and named as several electrofacies listed below

COMPREHENSIVE INTERPRETATION

Log motifs and corresponding values are discussed together in this section. Because Cooper Basin strata were mainly deposited in fluvial depositional system, typical log-pattern (motif) can be used as general diagnostic of different environments within the fluvial system. Lithofacies from cores, scale of facies successions can further constrain interpretation of particular depositional environments. We also can use facies models to do further interpretation.

Fluvial environment typically comprises point-bar, levee, over-bank or flood-plain and other elements. Generally meandering channel sand bodies are composed of superimposed channel/point bar units. A general bell shape often serrated, for each sedimentary sequence is obtained on logs, which reflects a general fining upward sequence (Serra, 1989) for meandering stream and the same is observed in the log facies of the Cooper Basin. Point-bar sandstones and distributary channel sandstones exhibit similar sharp base, gradational top and bell-shaped gamma ray log signatures. They can be differentiated from each other by their textures and their position in a vertical sequence. Distributary channel sandstones are much finer grained sediments and often do not have lag deposits. They contain more argillaceous sediments than point bar deposits this may be represented by their being more serrated log shape (gamma value can be up to 140 for serrated portion). A typical point bar log signature is seen in Strzelecki 3, facies changes vertically from lag deposit (basal lag, reworked from the underlying Warburton Basin), very coarse sandstone, coarse sandstone, fine sandstone, and finally siltstone, shale and coal. Serrated cylindrical log motif is observed in some wells, such as in Fly Lake 4, core 2, over the interval of 8860-8900 ft).

Deltaic environment mainly comprises distributary channels, delta-mouth bars and crevasse splay or delta plain. Deltaic deposits are common within the Epsilon, Daralingie and Patchawarra Formations (Stuart, 1976; Thornton, 1998, 1979; Moore & Castro, 1984). Several typical electro-log shapes including funnel shape indicating coarsening upward sequence resemble those recognised by Serra (1989) and Williams and Moore (1983). The Daralingie or Epsilon Formation in many wells such as in Moomba 45 and 47 has typical log motifs of smooth to serrated funnel shape indicating coarsening-upward deltaic distributary mouth bar.

Lacustrine environment is characterised by low energy sedimentary deposits and the absence of marine fauna (Selley, 1996). Low energy conditions result in the deposition of fine-grained sediments, shales and siltstones. Two thick lacustrine deposit packages in the Cooper Basin are the Murteree and Roseneath Shales, but other thin lacustrine deposits intercalated with fluivio-deltaic deposits of the Patchawarra Formation. The gamma log shape is typically irregular, with value of 160, for the thick lacustrine deposits of the Murteree and Roseneath Shales in many wells except some wells in the Nappamerri Trough such as McLeod 1, Burley 1 & 2 and Kirby 1. However, the gamma log shape normally display several spikes within a cylinder for the lake deposit intercalated within channel fills, and the values vary from 120 to 140 such as core 3, Fly Lake 2 described by Williams (1995). In Wirrarie North 1 & 2, the Roseneath Shale is relatively sandy. There is a sandstone about 10 feet thick within the shale, which is funnel shaped log motif representing upward coarsening distributary mouth-bar deposit in Wirrarie North 2. It may also well be due to interbedding with the underlying Epsilon Formation.

Clean sandstone (quantified electrofacies, ≤ 80 API gamma value) can represent several different facies such as fluvial channel, point-bar, crevasse splay, distributary channel bars and delta prograding mouth bar etc. However, detailed log motifs can help differentiation of facies, especially where core evidence is available. Combination of qualitative (log motif) and quantitative (log values) electrofacies allows recognition of following detailed electrofacies. Vertical facies successions interpreted from cores by previous workers are calibrated to log signatures herein. Williams (1995) identified about 3 major vertically stacked fluvio-lacustrine facies from cores of the Patchawarra Formation these facies correspond to the wireline logs very well (Table 5a,b). In these serrated cylinder log motifs, representing channel sandstone and lag deposit dominated, thus gamma value is normally low, about 30-40, or possibly 60. The serrated portion of the gamma log indicates shale and mudstone of the crevasse splay deposit. High value (>120 API) of the gamma log above the coal or below the channel deposit indicates shale and siltstone of lake and swamp infill deposit.

Table 5a Williams vertical facies for core 3, Fly Lake 2 and corresponding log motifs and values

Gamma log API	**Sonic µs/ft**	**Log curve shapes**	**Facies, environment**	**Main lithology**
~ 40	130-140	Spike	Coal swamp	coal
Sandstone: ~ 28-51 Shale: 110-142	75-80	Serrated cylindrical Serrated spikes	Lake cut by distributary channels, upward-fining crevasse channel fill, compound bar	Sandstone with thin interbedded shale. Upward fining channel sandstone sequence.
129-155 90-112	~ 65	Slightly bell	Interdistributary bay, low energy	shale, siltstone. thin sandstone interbedded with sitlstone

Table 5b Williams vertical facies for core 4, Fly Lake 2, and corresponding log motifs and values

Gamma log API	**Sonic µs/ft**	**Log style**	**Facies, environment**	**Main lithology**
~ 20	130-140	Spike	Coal swamp	coal
120-135	~65	Slightly funnel	Upward-coarsening subcycle of abandonment fill at top of classic upward-fining (see the underlying)	Shale, sandstone interbedded with siltstone.
41-79	70-85	cylinder with slightly serrated, slightly bell at base	Compound channel fill sequence with multistorey bar forms and vegetated bar tops.	Sandstone

			Upward-fining from channel lag base.	
130-160	~ 75-115	Slightly narrow funnel	Two upward coarsening subcycles interrupting coal swamp	shale, siltstone, thin sandstone and coal.
120-129		Small peak		thin sandstone within shale
~ 20-30	130-140	Spike	Coal swamp	Coal and shale

POROSITY AND PERMEABILITY OF DIFFERENT ELECTROFACIES

Porosity and permeability vary in sandstones of different electrofacies. For example, porosity and permeability change from 10.7% (porosity) and 0.1-365mD in clean sandstone (gamma value: 39-74 API) to 2.9-8.1% and 0.005-0.035 mD in sandstone with minor shale laminae (gamma value: 91-121 API) facies from the Daralingie Formation in Moomba 45. A similar case occurs in Tirrawarra 16, porosity and permeability are excellent in thick clean sandstone (channel facies) over the interval of 9130-40 ft of the Patchawarra Formation, but are much poorer in thin sandstone interbedded with siltstone and shale (crevasse splay sand facies) over the intervals of 9140-50 ft and 9160-9170 ft. Another similar case is in Wancoocha 3, in the upward fining sequence over the interval of 5796-5812 ft, porosity decreases slightly but permeability decreases dramatically from 14md to 52-367 mD. This thick clean sandstone gradually changing upwards into thin sandstone interbedded with siltstone and shale, indicates distributary channel bar prograding into bay or lake fill. A similar case is in Moomba 73, core 1, a complete channel sandstone facies (gamma value 30-50 API) has porosity (6.4-11.3%; av. 8%) and permeability (0.077-22 mD, av. 6.78 mD); a possible abandoned channel or crevasse splay sandstone facies (gamma value 50-80 API), has porosity (1.6-5.8%; av. 4.6%) and permeability (0.005-0.103 mD, av. 0.067mD);

CONCLUSIONS

Preliminary conclusions can be derived form the current study.

1. Cut-off values for sandstone and shale vary from area to area; meaning that at least several wells in one area or field needs to be examined to determine suitable cut-off values. Several electrofacies can be broadly recognised by their gamma values: clean sandstone (<80 API) indicating channel sand deposit, sandstone with minor siltstone/shale (80-100 API) representing crevasse splay sands, siltstone/shale with minor sandstone laminae (100-125 API) indicating distal crevasse splay facies, and siltstone/shale carbonaceous shale (130-200 API) representing flood plain, lake and coal swamp.

2. Electrofacies can be classified into:
    a. Lithological, sandstone, siltstone/shale and coal as Mackie *et* al. (1995) did for the Toolachee Formation, Moomba 6;
    b. Depositional environment related, e.g. as Mackie *et* al. (1995) did for several Moomba wells. This method is more significant for interpretation of palaeogeography and prediction of channel facies and sand trends.

3. Electrofacies should be studied quantitatively (log values) and qualitatively (characteristics of curves – log motifs) aspects. All electrofacies together with their thickness should be integrated to reconstruct palaeo-environments. For example, the Daralingie Formation in many wells has typical log motifs of serrated funnel shape indicating coarsening-upward deltaic distributary mouth bar.

4. Many wells containing the Nappamerri Group should be re-examined for subdivision.

5. Correct well correlations are integral to electrofacies mapping and reconstruction of the palaeogeography.

6. Data from many wells drilled using KCl mud, indicate that gamma ray values have been elevated by approximately 20 API.

7. Sonic values for some thin coals may be as low as 70 microsec/ft, such as in Moomba 26.

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APPENDIX 1:

Electrofacies sub-routine

```
;================================================================
; ELECTROFACIES SCRIPT
;-------------------------------------------------------------------------------
INPUTLOG GR
INPUTLOG DT
;
REAL GROSS
REAL TSST, FSST
REAL TCOAL, FCOAL
REAL TSHALE, FSHALE
REAL DTCOAL
REAL GRSST
REAL STEP
;
LOOP
BATCH
IMPORT
;
STEP=#DEPTH_INC( STEP )
GROSS=0.0
TSST=GROSS
FSST=GROSS
TCOAL=GROSS
FCOAL=GROSS
TSHALE=GROSS
FSHALE=GROSS
;
:NEXT
READROW :GOEND
IF(#ANULL(DEPT))THEN
  GOTO :NEXT
ENDIF
GROSS=GROSS-STEP
IF(DT>DTCOAL)THEN
  TCOAL=TCOAL-STEP
  GOTO :NEXT
ENDIF
IF(GR<GRSST)THEN
  TSST=TSST-STEP
  GOTO :NEXT
ENDIF
TSHALE=TSHALE-STEP
GOTO :NEXT
:GOEND
IF(GROSS<=0.0)THEN
  GOTO :SKIP
ENDIF
FSST=TSST/GROSS
FCOAL=TCOAL/GROSS
FSHALE=TSHALE/GROSS
PRINT GROSS
PRINT TSST, FSST
PRINT TCOAL, FCOAL
PRINT TSHALE, FSHALE
PAUSE
:SKIP
ENDLOOP
```