

# Premier Oil Australia Pty Ltd

## Yolla Field

### Yolla-2

Sedimentological interpretation of  
Formation Micro-Scanner (FMS)  
images

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## SUMMARY

This report presents processed and interpreted FMS images from the intervals, 1860-1951m, 2750-2948 m and 3000-3080 m within well Yolla-2. The studied succession within Yolla-2 is of Palaeocene-Eocene age, and is characterised by low structural dips, typically in the range 3°-5°, as is listed below.

<b>Study Interval 1860-1951 m</b>			
Zone I	1860-1905	3.4°/189°	Fracture / unconformity bound at 1905m
Zone II	1905-1918	???	Non-quantified dip change within fracture zone
Zone III	1918-1951	4.2°/198°	Fracture bound at 1918 m
<b>Study Interval 2750-3080 m</b>			
Zone I	2750-2815 m	4.2°/224°	Change in shale dip at base sandstone 2815m
Zone II	2815-2830 m	4.7°/128°	Fault bound at 2830 m
Zone III	2830-3000 m	5.6°/262°	
Zone IV	3000-3006 m	8°/080°	Fault or unconformity in zone 2990-3000 m
Zone V	3006-3027 m	3°/175°	Fault /fracture bound at circa 3027 m.
Zone VI	3027-3080 m	4.4°/299°	

Lithofacies identified from FMS images have been calibrated with cuttings descriptions, and with a short core recovered from Yolla-2. Cuttings descriptions match well with lithofacies interpretations derived using wireline log response and FMS image fabrics, and indicate a succession comprising sandstone, siltstone and claystone. The FMS lithofacies interpretations compare closely with core observations for sampled lithologies, and identify sandstones, mudstones, and heterolithic intervals (comprising dm scale intercalations of sandstone, siltstone and mudstone) However, very few argillaceous lithologies were sampled by the core, and detailed calibration of their interpretation from FMS images has not been feasible. Net sand contents determined from image log analysis through sections studied in detail are presented. Six lithofacies associations have been identified within the studied section. These are interpreted as having been deposited in a marginal marine (shelf-shoreface ?) or deltaic setting (prodelta, distributary mouthbar and delta plain), and within alluvial channels, probably also in a marginal setting. The lithofacies associations identified are summarised as follows:

- I. Mudstones that occur at the base of upward coarsening facies successions. (interpreted as either prodeltaic muds, or shelf-shoreface deposits).
- II. Heterolithic intercalations of sandstone siltstone and mudstone, typically occurring within the lower-mid parts of upward coarsening facies successions (interpreted as either distal distributary mouth bar, or shelf-shoreface deposits).
- III. Stratified sandstones with mottled image fabric and low angle (typically <5°) internal bedding surfaces, typically occurring towards the top of upward coarsening facies successions 9 mouth bar sandstones or shoreface deposits).
- IV. Successions (often erosively based) of stratified sandstones and pebbly sandstones with internal bedding fabrics inclined at angles of up to 25 or more (distributary or alluvial channel fills).
- V. Thin mudstone- heterolithic successions interbedded with lithofacies association IV (possible interdistributary bay fill, alluvial plain deposits).
- VI. Coals (deposits of swampy delta plain environments).

Lithofacies Association iii and iv are likely to form the main reservoir intervals. Palaeotransport analyses of sandstones from Lithofacies Association iii reveals them to be characterised by internal stratification fabrics with very wide ranging sedimentary dip azimuth, suggesting they were originally deposited as "flat lying" strata. Few palaeotransport interpretations can be made for these sandstones. In some cases however, a broadly WNW-ESE or NW-SE depositional strike can be inferred. Palaeotransport analyses of sandstones from channelised sandstones of Lithofacies Association iv reveals to comprise complex and multi-storey channels, infilled by both simple downstream and more complex lateral accreting bedforms. Interpreted channel drainage directions are variable, no consistent drainage direction can be inferred.

## TABLE OF CONTENTS

<b>SUMMARY .....</b>	<b>i</b>
<b>LIST OF TABLES .....</b>	<b>iii</b>
<b>LIST OF FIGURES .....</b>	<b>iv</b>
<b>LIST OF ENCLOSURES .....</b>	<b>v</b>
<b>LIST OF A4 ATLAS .....</b>	<b>v</b>
<b>1. INTRODUCTION.....</b>	<b>1</b>
1.1. Objectives.....	1
1.2. Depth and directional references.....	1
<b>2. PROCESSING AND QUALITY CONTROL .....</b>	<b>3</b>
2.1. Borehole conditions.....	3
2.2. Data processing .....	4
<i>Pre-processing</i>	4
<i>Speed Correction</i>	4
<i>Image Processing</i>	4
<i>Block depth shifts.</i>	5
2.3. Dip processing.....	5
<b>3. SEDIMENTOLOGICAL ANALYSES .....</b>	<b>6</b>
3.1. Tectonic tilt determination .....	6
3.2. Classification of sedimentary features .....	6
3.3. Lithofacies characterisation. ....	9
<i>Lithofacies identified from FMS logs.</i>	9
<i>Calibration of image log fabrics using core and cuttings descriptions.</i>	10
<i>FMS derived lithological fabric index.</i>	13
3.4. Lithofacies associations.....	13
<i>Lithofacies Association I.</i>	14
<i>Lithofacies Association II.</i>	15
<i>Lithofacies Association III</i>	15
<i>Lithofacies Association IV</i>	16
<i>Lithofacies Association V</i>	16
<i>Lithofacies Association VI</i>	17
3.5. Summary of environmental interpretations.....	18
<i>Study Interval 3030m-3060 m</i>	18
<i>Study Interval 2856 –2910 m</i>	18
<i>Study Interval 2792m-2820 m</i>	20
<i>Study Interval 1860-1951 m</i>	21
3.6. “Hot” sandstones .....	24
3.7. Net sand content .....	24
<b>4. BEDFORM ORIENTATION AND SEDIMENT DISPERSAL .....</b>	<b>25</b>
4.1. Argillaceous and arenaceous sediments of Lithofacies Associations I, II & III. ....	25
4.2. Arenaceous sediments of Lithofacies Association IV.....	25
4.3. Argillaceous and carbonaceous deposits of Lithofacies Associations V-VI.....	30
<b>5. CONCLUSIONS.....</b>	<b>31</b>

## LIST OF TABLES

- Table 1.1 Summary of well details, study objectives, and the data-set used for analysis of well Yolla-2.
- Table 2.1 Summary of hole conditions, Yolla-2.
- Table 3.1 Tectonic tilt summary, well Yolla-2.
- Table 3.2 Classification of surfaces identified from FMS images.
- Table 3.3 Lithofacies identified from FMS images within the studied succession.
- Table 3.4 Simple fabric index (applied to sandstone lithofacies) based upon mnemonics scheme used for FMS interpretation of lithofacies. Note, the fabric index may approximate to a bioturbation index within sandstone lithologies free of granular-pebbly detritus.
- Table 3.5 Summary of deposits in the study interval 3030 -3060 m.
- Table 3.6 Summary of deposits in the study interval 2856-2910 m.
- Table 3.7 Summary of deposits in the study interval 2872-2820 m.
- Table 3.8 Summary of deposits in the study interval 1860-1951 m.
- Table 3.9 Net sand content within studied successions.
- Table 3.10 Bedding orientations, channelised deposits in the study interval 3030-3060 m.
- Table 3.11 Bedding orientations, possible channelised deposits in the study interval 2856-2910 m.
- Table 3.12 Bedding orientations, channelised deposits in the study interval 2792-2820 m.
- Table 3.13 Bedding orientations, channelised deposits in the study interval 1860-1951 m.

## LIST OF FIGURES

- Figure 3.1 N-E trending open fault at 3026.5 m.
- Figure 3.2 Cumulative automatic, manual and muds and hets, dip azimuth plots for studied section (1860-1951 m).
- Figure 3.3 Cumulative automatic, manual and muds dip azimuth plots for studied section (2750-3080 m).
- Figure 3.4 Example of coal bearing strata (lithofacies v1) in interval 1926-1932 m.
- Figure 3.5 Dips were picked and categorised according to the illustrated scheme.
- Figure 3.6 FMS image through well laminated mudstone lithofacies (Ml). Note resistive fracture at 3029 m.
- Figure 3.7 FMS image through dm-scale heterolithic sst-mudstone lithofacies with well-developed lamination fabric (Hl) 2907.5-2909 m, and less well developed fabric (Hm) 2909-2909.5 m.
- Figure 3.8 FMS image illustrating mottled sandstones with vague lamination Sm (Sl) 2977.5-2978 m and well laminated sandstone Sl, 2878-2879 m.
- Figure 3.9 FMS image illustrating sandstone with fine scale mottled fabric, Sm.
- Figure 3.10 FMS image illustrating sandstone with coarse scale mottled fabric, Scm. Core calibration reveals these lithologies to comprise pebbly sandstones.
- Figure 3.11 FMS image through "hot" sandstone at 2870-2871 m. Note poorly defined lamination in radioactive sandstone. The sand overlies a thin dm scale cross stratified bed Sl(Sm) with only minor mottling (2871-2871.5 m), which turn rests upon pebbly lithologies Scm (2871 m downwards).
- Figure 3.12 Net sand percentage.
- Figure 3.13 Cumulative dip azimuth plot for intraset surfaces (ISS), structural dip removed. Note northerly azimuths above 3040 m, and southerly below 3040 m.
- Figure 3.14 Cumulative dip azimuth plot for intraset surfaces (ISS) in channelised deposits from interval 2860-2874 m. Structural dip removed.
- Figure 3.15 Cumulative dip azimuth plot for intraset surfaces (ISS) in channelised deposits from interval 2792-2814 m. Structural dip removed.
- Figure 3.16 Cumulative dip azimuth plot for intraset surfaces (ISS) from interval 1860-1951 m. Structural dip removed.

## LIST OF ENCLOSURES

		<b>Scale</b>
Enclosure 1	Quality control plot of FMS log, 1860-1951 m.	1:500
Enclosure 2	Quality control plot of FMS log, 2760-3080 m.	1:500
Enclosure 3	Overview structural summary log, 1860-1951 m.	1:500
Enclosure 4	Overview structural summary log, 2760-3080 m.	1:500
Enclosure 5	Data overview plot, 1860-1951 m.	1:200
Enclosure 6	Data overview plot, 2760-3080 m.	1:200
Enclosure 7	Sedimentological summary plot, 1860-1951 m.	1:100
Enclosure 8	Sedimentological summary plot, 2790-2820 m.	1:100
Enclosure 9	Sedimentological summary plot, 2856-2910 m.	1:100
Enclosure 10	Sedimentological summary plot, 3030-3060 m.	1:100
Enclosure 11	Core composite plot.	1:10

## LIST OF A4 ATLAS

Scale 1:20      FMI Image Atlas (1860 – 3084 m)

## 1. INTRODUCTION

This report summary includes both the processed Formation Micro-Scanner (FMS) images and the geological analysis of FMS data from Premier Oil Australia Pty Ltd, Yolla Field, Well Yolla-2. Results of detailed sedimentological interpretation based on FMS images are presented for the intervals 1860-1951 m, 2760-2948 m & 3000-3080 m. The study was initiated by David Evans of the Premier Oil Australia Pty Ltd.

### 1.1. Objectives

The well details and project objectives for well Yolla-2 are summarised in Table 1.1, along with the data provided for the study.

Well Details	
<b>Well:</b>	Yolla-2.
<b>Surface Latitude:</b>	39 51' 33.820" S
<b>Surface longitude:</b>	145 48' 38.530" E
<b>Intervals of interest:</b>	Palaeocene – Eocene succession interpreted as of marginal marine - alluvial origin.
Summary of Study Objectives	
Log Depth Intervals	Objectives
1860-1951 m 2750-2948 m 3000-3080 m	Loading of FMS acquisition data into a RECALL database for processing to provide speed corrected false colour images. Detailed quality control of images, to determine the quantity of information that is interpretable.
1860-1951 m 2750-2948 m 3000-3080 m	Summary structural overview using Schlumberger processed SHDT data. NOTE: These were not provided to Z&S. To allow the study to progress, automatic dip calculations were carried out by Z&S at no additional cost. The data were also supplemented by analysis of results of manual dip-picking.
1860-1951 m 2760-2948 m 3000-3038 m	Overview sedimentological interpretation of features evident within FMS images with the aim of focusing upon variations in palaeotransport directions. This required manual characterisation of dip features and their sedimentary interpretation over these intervals.
1860-1951m 2790-2820m 2856-2910m 3303-3060m	Detailed sedimentological interpretation and lithofacies characterisation.
Data Used for Study	
1860-1951 m 2760-2948 m 3000-3038 m	Raw openhole logs from Platform Express suite: GR, SP, NPHI, RHOZ, PEFZ, HLLS, HLLD, HGR, HCAL in DLIS format. Raw FMS data on DLIS format tape. Raw SHDT data on DLIS format tape.
3033-3050.5 m	Core (3031.6-3048.1m core depths).
1860-1951 m 2750-2948 m 3000-3080 m	Cuttings descriptions.

**Table 1.1 Summary of well details, study objectives, and the data-set used for analysis of well Yolla-2.**

### 1.2. Depth and directional references

Unless otherwise mentioned, all depths stated in this report are log depths, measured along hole below drill floor (ahbdf). Orientation data is referenced using the standard

convention of dip/dip azimuth. For example 25°/110° indicates a dip of 25° (measured from the horizontal) towards 110° (referenced clockwise from north). Borehole orientation data follows a convention of deviation/azimuth of deviation. For example, 77°/035° indicates a 77° deviation from the vertical towards 035° (NE).

## 2. PROCESSING AND QUALITY CONTROL

The Formation Micro-Scanner (FMS) tool was run by Schlumberger on May 17<sup>th</sup> 1998, in the 12<sup>1</sup>/<sub>4</sub> inch section of the well Yolla-2 over the intervals 1850-1951 m and 2030-3680 m.

The Schlumberger Formation Micro Scanner (FMS) tool is a micro-resistivity imaging device (Lloyd *et al.* 1986, Serra *et al.* 1989), with an array of 16 measuring electrodes on each of four orthogonal pads. The electrodes are 0.25 inch in diameter and are spaced in two rows 0.15 inch apart, giving resistivity traces with a very high lateral and vertical sampling (0.15 inch vertical, 0.15 inch lateral sampling). This data is processed to provide four *circa* 7 cm-wide strips of micro-resistivity image, spaced at 90° around the borehole. This gives approximately 41% coverage of the borehole wall in an 8.5 inch hole section. This data also provides eight Stratigraphical High Resolution Dipmeter (SHDT) tool curves for standard dipmeter processing.

Processing was carried out over the intervals 1850-1951 m Pass 1, 2754-2949 m Pass 1 & 2760-2927 m Pass 2 and 3000-3084 m Pass 1 & 3000-3083 m Pass 2, using RECALL 4v1 modules for FMS processing rationale.

The mud environment was type KCI PHPA with a resistivity range of 0.169-0.185 Ωm, a viscosity of 44 S and a density of 1.13 g/cc. The fluid losses encountered during the drilling of this well were minimal. The borehole mud reached a maximum temperature of 128°C.

An FMS log quality control plots are shown in Enclosures 1 and 2. These plots provide detailed information concerning hole orientation, tool orientation, hole condition and FMS operating parameters.

### 2.1. Borehole conditions

FMS image quality is mainly related to borehole condition, which is generally good throughout the section in Yolla-2 with clear geological detail visible and only minor image artefacts. Borehole deviation is 1.03/232° at 1860 m and 0.92/228° at 1950 and also 1.8°/051° at 2760 m and 2.4°/056° at the 3080, bottom of the studied section.

A summary of hole conditions is included in Table 2.1.

Within the uppermost study interval (1860-1951 m), the hole shows consistent but minor ovalisation (0.5 inch) in the direction of the C2-4 caliper. Whereas, within the lower studied interval (2760-3038 m), the hole shows consistent but minor ovalisation (0.5 inch) in the direction of the C2-4 caliper, which is consistently aligned *circa* 094°-274° (i.e approximately East-West). This orientation may reflect orientation of the minimum horizontal stress.

Nominal Hole Size	Interval Depth	Comments
<b>1860-1951 m</b>		
12.25	1860-1870	0.5" overgauge
	1870-1904	In gauge
	1904-1907	0.5" overgauge
	1907-1928	In gauge
	1928-1930	0.5" overgauge
12.25	1930-1951	In gauge
<b>2760 – 2948 m</b>		
12.25	2760-2790	0.5" overgauge
	2790-2835	In gauge
	2835-2900	0.5" overgauge
	2900-2905	In gauge
	2905-2950	0.5" overgauge
<b>3000-3038 m</b>		
12.25	3000-3075	0.5" overgauge

**Table 2.1 Summary of hole conditions through studied intervals in Yolla-2.**

## 2.2. Data processing

### *Pre-processing*

The pre-processing phase involved the correction of all acquired data from tape reference positions (on depth) to acquisition reference positions (synchronous) before input to the accelerometer-based speed correction phase and omitting correction of orientation data for a magnetic declination, as already been corrected. An uphole shift of 18 inches to accelerometer data was applied prior to speed correction.

### *Speed Correction*

The accelerometer speed correction utility corrects FMS micro-resistivity data for minor variations in recording velocity induced by tool or cable friction. Extremes in velocity variation may occur when the tool is either stationary or rapidly accelerating as a result of being stuck or the logging being stopped for pipe removal. The most important parameter for the speed correction procedure is the zero-sum window, which prevents cumulative build-up of erroneous shifts within a window. Thus all shifts applied by the speed correction should add up to zero within a certain window length. The length of this window is decided by experimenting and the general roughness of the logging run. In the case of Yolla-2, a window of 4 ft was chosen. The speed correction shift curve is calculated by double integration of the Z-accelerometer curve with the cable speed representing the window constant. The resulting shift curve is then applied to synchronously to all curves in the log.

### *Image Processing*

Before generating the false-colour images from the speed corrected data, the individual curves are transferred back to their physical depth referenced positions. The images are produced with two types of resistivity scaling:

- *Static normalised* images have the same relative resistivity scaling over larger intervals and therefore illustrate large-scale resistivity variations related to lithology and phase changes. Dependent on Emex current variability.
- *Dynamic normalised* images were scaled within a 0.5 m sliding window, thereby maximising the expression of more detailed rock fabrics (and noise).

In this study, the dynamic normalised images were used primarily for bedding, lithofacies and structure identification. Image polarity was correctly matched to openhole resistivity and density logs.

### ***Block depth shifts***

No block depth shifts were applied to any data set in Yolla-2.

### **2.3. Dip processing**

Two types of dip computation were carried out on this dataset.

Computed dip correlations were carried out on the SHDT curve sub-set from the loaded interval (Enclosures 1-2). These correlations use refined least-squares algorithms with regression coefficients cut-offs for each correlation pair. The interval computation parameters were aimed at correlating bedding features using pad-to-pad (PTP) algorithms with the following parameters:

- 60 cm correlation interval, 50 cm step distance and a 75° search angle (referenced to borehole axis) and the cut-off set at 0.2 for individual curve pairs.

These parameters are referenced as “6X5X75” (Enclosures 1-2). A second PTP correlation featured these parameters as well as stacking of three consecutive correlation surfaces. The stacking of dips in this way tends to smoothen dip patterns and trends and is a viable method of “quick-look” identification of structural dip. Detailed interpretation of dip patterns should not be carried out on results from this processing (“6X5X75ST3”).

Manual dips were computed directly from the images using the RECALL workstation (e.g. Enclosures 3-4). The major advantage of the manual dip technique is that each feature may then be classified into a geological category and that only the results in which the interpreter has confidence are used for further interpretation. A further advantage of manual dip picking is the ability to measure and orientate discordant surfaces such as fractures and faults, which are unlikely to be correlated by standard interval correlation techniques.

### 3. SEDIMENTOLOGICAL ANALYSES

#### 3.1. Tectonic tilt determination

Prior to detailed sedimentary analyses, it is first required to evaluate structural dip, so that the sedimentary surfaces identified in FMS images can be restored to their original orientation or "sedimentary dip". Structural dip (or tectonic tilt) is the attitude of formations resulting solely from tectonic movements. Structural dip is best determined from beds that were originally deposited as horizontally stratified deposits. These beds can include mudstones, or parallel stratified laminations within heterolithic successions comprising interbedded sandstone-mudstone laminae. The structural dip interpretation within well Yolla-2 was an iterative process involving:

- Initial evaluation of automatic computed dips to identify general data trends.
- Manual picking of shale bed dips to confirm tectonic tilt throughout the studied succession.

Tectonic tilt evaluated on the basis of dip data through shale intervals is summarised in Table 3.1. Before undertaking a sedimentological interpretation structural dip was removed from the "manual" data set. The structural dip was removed following identification of intervals of strata (structural zones) of consistent structural dip.

Structural Zone	Depth interval	Tectonic tilt	Comments
<b>Study Interval 1860-1951 m</b>			
Zone I	1860-1905	3.4°/189°	Fracture or possibly unconformity bound at 1905 m
Zone II	1905-1918	???	Non-quantified dip change within fracture zone
Zone III	1918-1951	4.2°/198°	Fracture bound at 1918 m
<b>Study Interval 2750-3080 m</b>			
Zone I	2750-2815 m	4.2°/224°	Change in shale dip at base sandstone 2815m
Zone II	2815-2830 m	4.7°/128°	Fault bound at 2830 m
Zone III	2830-3000 m	5.6°/262°	
Zone IV	3000-3006 m	8°/080°	Fault or unconformity in zone 2990-3000 m
Zone V	3006-3027 m	3°/175°	Fault /fracture bound at circa 3027 m. A large, N-S trending, open fault (dm aperture) is evident at 3026m. (Figure 3.1)
Zone VI	3027-3080 m	4.4°/299°	

**Table 3.1 Tectonic tilt summary, well Yolla-2.**

Cumulative dip azimuth walk-out plots for shale bedding surfaces within the studied intervals (2750-3080 m & 1860-1951 m) from Yolla-2 are indicated in Figures 3.2 and 3.3 respectively. The plots clearly illustrate the structural sub-divisions proposed for the studied intervals.

#### 3.2. Classification of sedimentary features

Classification of sedimentary surfaces recognised from borehole image logs is a 3 stage iterative process involving:

- First pass dip picking. This phase of feature identification is carried out in conjunction with examination of wireline logs, and results in a simple 2-fold subdivision of dip features into mudstone and "others".
- Structural dip is removed from the data set using a workstation based stereographic technique to provide sedimentary dips.
- Sedimentary dips are re-classified in the workstation environment. Wireline logs are used to drive lithofacies interpretation. Sedimentary dips within sandstone lithologies are characterised using a heirachial scheme depending upon their dip and orientation.

The heirachial scheme applied to Yolla-2 is illustrated in Figure 3.5 and Table 3.2 below, and sedimentary dips for the studied intervals 1860-1951 m, 2750-2950 m, and 3000-3080 m are indicated in Enclosures 7-10.

Dip type	Interpreted dip category	Colour	Description
LB	Lithological boundary	Red	Low true dip angle surfaces which define a marked resistivity between overlying and underlying beds. Wireline logs indicate a lithological contrast..
LBe	Erosional lithological boundary	Orange	Erosive surfaces which define a marked resistivity between overlying and underlying beds. Truncation of bedding fabrics beneath the surface may be evident. Wireline logs indicate a lithological contrast..
LBc	Cemented lithological boundary	Pink	Sharply defined highly resistive or conductive bed. Bounding surfaces may define planar or "nodular" features. Normally associated with change in wireline log response.
ISS	Intra set surface	Green	Inclined surfaces typically dipping at a true dip angle greater than 5°. Surfaces may be inclined at angles up to 25°-30° (i.e. close to angle of repose), and occur within distinct groups of similar orientation. Surfaces typically show cm-dm scale spacing in borehole image logs. They are discordant to set (or bed) and coset boundaries.
SB	Set (bed) boundary	Cyan	Surfaces within sandstone lithologies which are typically (though not exclusively) inclined at sedimentary dip of < 15°. Set boundaries define a group or "set" of intraset surfaces of similar orientation. The set boundary is distinguished from the intraset surfaces by its different orientation. Set boundaries typically occur at dm - m scale spacing in borehole image logs.
CSB	Coset boundary	Black	A surface separating a group of sets of similar orientation. Note: Coset boundaries may also define a single bed or set displaying a significantly different internal fabric to those sets surrounding it. Set boundaries are typically identified at m scale spacing in borehole image logs. Note: Coset boundaries may also define a single bed or set at dm scale which displays a significantly different internal fabric to those sets surrounding it.
ISSf	Flat/horizontal	Yellow	Near horizontal intraset surfaces with true dip angle (<5°), characterised by resistivity contrast several cm thick. Sedimentary dip azimuth may be variable due to flat lying nature of these beds, and errors associated with fitting dips to such surfaces. Surfaces typically show cm scale spacing in borehole image logs.
PDf	Poorly defined feature	Violet	These surfaces may be any of the above but are very poorly defined in terms of continuity around the borehole.
XSB	Small scale cross beds	Red	cm-dm scale cross stratification fabric, too small to be characterised in detail.
MUDS	Shale bedding	Brown	Confident bedding features with consistent magnitudes.
HETS	Heterolithic bedding	Olive	Confident bedding features with approximately consistent magnitudes.

**Table 3.2 Classification of surfaces identified from FMS images.**

### 3.3. Lithofacies characterisation

Lithofacies identification was first carried out using FMS images in conjunction with openhole log suites. The FMS interpretations were then calibrated against core data (from the interval 3033–3050.5 m). In this way, the initial FMS interpretations were not influenced by preconceptions gained from having seen the core, and an understanding of likely interpretation confidence was obtained.

#### *Lithofacies identified from FMS logs*

Sedimentological interpretation of FMS images and dipmeter data were carried out with the aid of gamma ray, density, neutron porosity, PEF and sonic logs. Lithofacies were interpreted upon the basis of variations in wireline log response in conjunction with fabrics observed in FMS images (Table 3.3). During interpretation, cuttings descriptions were also used to help provide a guide to lithology, but were found to have only moderate depth resolution (i.e. matching of cuttings description to log /response) due to dispersion of cuttings during circulation of drilling muds. Four broad lithofacies were interpreted as being present, i.e. sandstones, mudstones, finely inter-bedded heterolithic successions and coals. Heterolithic successions comprise centimetre-decimetre scale interbedded sandstone, siltstone and mudstone beds. Coals also formed a minor lithofacies within the study interval 1860-1951 m, and are clearly recognisable by their low density, high porosity and high resistivity log response (Figure 3.4).

Lithofacies types were classified according to a simple scheme using mnemonics based upon interpreted lithology and contained fabric, the latter being determined from borehole image log and associated dip data. Examples of identified lithofacies are summarised below in Table 3.3. Note, log “cut-offs” values used to interpret lithology within the studied interval 1860-1951 m, appear to be different to those applicable to the intervals 2750-2950 m, and 3000–3080 m. In addition, it was difficult to systematically apply a single set of log “cut-off”s” to strata within this uppermost study interval.

Inferred Lithology / Grain Size	Typical Log Response. Interval 1860-1951 m	Typical Log Response. Interval 2750-3080 m	Image Log Fabrics	Lithofacies Mnemonic
Sandstone	GR <80-85 API RHOB 2.15-2.2 g/cc NPHI 0.21-0.33	GR <70 API RHOB 2.2-2.4 g/cc NPHI 0.12-0.20	laminated	<b>Sl</b>
			cemented	<b>Sc</b>
			fine scale mottled or "speckled" texture with poorly defined or disrupted lamination fabric	<b>Sm</b>
			Coarse scale mottled texture with poorly defined or disrupted lamination fabric. Mottling comprises resistivity elements several cm in diameter.	<b>Scm</b>
Heterolithics	GR 80-105 API NPHI 0.21-0.26 RHOB 2.25-2.35g/cc	GR 70-105 API NPHI 0.20-0.25 RHOB 2.65-2.4 g/cc	laminated	<b>Hl</b>
			mottled with disrupted lamination fabric	<b>Hm</b>
Mudstone	GR >95-120 API NPHI 0.27-0.33 RHOB 2.07-2.15 g/cc	GR 105-135 API NPHI 0.25-0.35 RHOB 2.65-2.75 g/cc	laminated	<b>Ml</b>
			mottled with disrupted lamination fabric	<b>Mm</b>

**Table 3.3 Lithofacies identified from FMS images within the studied succession.**

The hierarchical combinations of different lithofacies mnemonics were used to provide detailed descriptions of lithofacies types. In these descriptions, the enclosure of lithofacies mnemonics in parenthesis was used to denote the minor presence of a lithofacies type, or poor development or preservation of a sedimentary structure, e.g.

- Mm (Ml) mottled mudstones with relict lamination or minor laminated intervals.
- Sm (Sl) mottled sandstone with poorly defined relict lamination.
- Sl (Sm) laminated sandstone with minor fabric loss due to mottling / disruption of lamination etc.

Figures 3.6-3.11 illustrate examples of different lithofacies types for the lithologies identified, together with their fabric index.

### ***Calibration of image log fabrics using core and cuttings descriptions***

Calibration of image log fabrics was carried out using:

- Cuttings descriptions through the logged intervals. Cuttings descriptions are summarised on Enclosures 5 and 6.
- Core from the interval 3033-3050 m was available to calibrate fabrics observed in borehole image logs. A comparison of core and image logs is illustrated in Enclosure 11.

### **Image log calibration using cuttings.**

Generally, cuttings descriptions match well with lithofacies interpretations derived using wireline log response and FMS image fabrics. Cuttings descriptions reveal a succession comprising sandstone, siltstone and claystone.

Characterisation of heterolithic successions comprising individual beds beneath the resolution of wireline logs is difficult. However, image logs revealing extreme resistivity variation within strata containing cm-dm scale bedding fabrics provide some insight as to the presence of these heterogeneous lithologies. Cuttings descriptions through successions interpreted from wireline log and FMS as comprising heterolithic deposits, invariably yield documentation of cuttings of claystone, siltstone and sandstone in varying proportions.

Within the interval 1934-1946 m (Enclosure 8), there appears to be a marked discrepancy between the Z&S interpreted lithofacies and cuttings description. The Z&S interpretation based upon wireline log response and image log fabric suggests the presence of a heterolithic succession within this interval. However, the cuttings description indicates the succession to comprise virtually 100% sandstone. The Z&S interpretation through this interval may thus under-estimate sandstone content. However, rates of penetration through the interval 1900-2000 m were highly variable (circa 8-50 m per hour), and it is feasible that this has contributed to a different interpreted sand distribution from cuttings, especially if depth referencing has been difficult. Sand content immediately beneath this interval (i.e. in interval 1950-1953 m) does decrease to 70%.

### **Image log calibration using core**

A good overall match exists between image log interpretations and core observations through the interval 3033 m-3050 m (Enclosure 11). However, the following points are relevant with respect to the confidence of image log interpretation.

#### The core may not be representative of the succession as a whole

The 17 m of core sampled have recovered mainly sandstone lithologies, and it is unclear as to how representative it may be of the studied succession as a whole.

#### Interpretation of mudstone lithologies should be treated with caution

The cored interval mainly sampled sandstones and mudstones. One argillaceous interval at *circa* 3040.2-3041.0 m log depth (*circa* 3037.8-3038.6 m core depth) comprises a dark coloured, highly argillaceous silty sandstone with a variety of small scale (cm-dcm scale) cross lamination fabrics. The log response of this interval suggests it that is best interpreted as heterolithic or mudstone lithologies. Only core comparison has enabled it to be confirmed as a sandstone lithology on Enclosure 4.

The interval *circa* 3041-3042 m log depth (3038.6-3039.6 m core depth) contains highly argillaceous lithologies comprising cm scale intercalations of dark argillaceous mudstone and fine dark argillaceous sandstone. Mudstone lithologies dominate, but the heterolithic nature of these sediments is not obvious from image log response, and the interval is interpreted as a mudstone.

The presence of heterolithic strata is largely an interpretation

Identification of a high frequency of large resistivity contrasts centimetre-decimetre scale within lithologies having log response intermediate between sandstone and mudstone, is interpreted as reflecting the presence of cm-dm scale interbedded sandstone – mudstone lithologies. However, no heterolithic lithologies of this type were sampled by the short core recovered from Yolla-2, and the presence of these lithologies has yet to be confirmed.

Correct interpretation of mottled image fabrics is difficult

Mottled fabrics in borehole image logs may arise from a number of different mechanisms. These could include:

- Differential cementation or the presence of nodular cements.
- Artifacts such as scattered drilling debris on the borehole wall.
- Textural variations due to biogenic disruption of sediments (bioturbation).
- Textural variations associated with dewatering fabrics in sediments.
- The presence of coarse detritus such as pebbles or clay flakes.

Core observations within the interval 3033-3050.5 m have revealed two different types of sedimentary fabric that have given rise to mottled image log fabrics. These are:

- The presence of granular and pebbly lithologies (gravels, and coarse granular-pebbly sandstones) with clasts up to 2 cm diameter.
- The presence of fine sandstone lithologies (e.g. circa 3033-3035 m core depth) with overall mottled character and poorly defined stratification. The lithologies within this interval contain abundant clay flakes <1 mm in thickness and several mm in length, some of which show sub-vertical alignment within parts of the core showing poorly defined sedimentary fabric. The cause of the pervasive mottling and poorly defined fabric within this cored interval is not obvious and could have been induced by either sediment dewatering or pervasive bioturbation.

Close examination of FMS images reveals that mottled textures are present at 2 distinct scales:

1. Speckled image texture, in which scattered mottles and speckles occur at *circa* 1 cm scale, and are associated with diffuse bedding fabric. Comparison with the short cored interval from Yolla-2 indicates that this “fine” scale mottling occurs within fine-medium grained sandstones displaying poorly defined lamination, vague and vague mottled texture. These sandstones are not characterised by the presence of coarse detritus (pebble clasts etc.).
2. Strongly mottled image texture, in which mottles are defined by resistivity features of several cm diameter, so that often, only 2 or three “mottles” may be seen across an individual FMS pad. Core calibration reveals that this “coarse” mottling corresponds to intervals containing granular and pebbly sandstones.

Argillaceous lithologies sampled by the cores do contain evidence of bioturbation, and mottled / disrupted lamination fabrics observed within image logs through mudstone lithologies may reflect bioturbation within sediments. However, in the absence of sufficient core calibration, this interpretation should be treated with caution. Similar

fabrics could be generated by a variety of phenomena including nodular cementation patchy sand distribution etc.

### ***FMS derived lithological fabric index.***

The hierarchical lithofacies nomenclature scheme applied to description of lithofacies from borehole image logs was also be used to provide a simple 4 fold fabric index as illustrated for sandstones in Table 3.4 below. This type of fabric index may be useful for comparison of reservoir properties with image log derived lithological properties. Note, if mottled fabrics identified within sandstones are due to bioturbation, this fabric index may also approximate to a 4 fold bioturbation index, which may be useful in construction of sedimentary models using data derived from image logs.

<b>Lithofacies</b>	<b>Approximate degree of fabric development within sediments.</b>	<b>Fabric Index</b>
Sl	Minimal <10%	1
Sl (Sm)	approximately 25 %	2
Sm (Sl)	approximately 75 %	3
Sm	near total 100 %	4

**Table 3.4 Simple fabric index (applied to sandstone lithofacies) based upon mnemonics scheme used for FMS interpretation of lithofacies. Note, the fabric index may approximate to a bioturbation index within sandstone lithologies free of granular-pebbly detritus.**

The implication of the fabric index is that low indices will result in strongly anisotropic reservoir properties (e.g.  $K_v > K_h$ ). If due to phenomenon such as bioturbation creating mottled image fabric and loss of stratification, higher fabric indices may reflect more homogeneous reservoir properties (e.g. decrease in  $K_v:K_h$  ratio due to loss of stratification).

### **3.4. Lithofacies associations**

The sedimentary deposits in the intervals 1860-1951 m, and 2750-3080 m within Yolla-2 comprise a heterolithic succession of sandstones and mudstones. Log responses indicate that the successions can be sub-divided into a number of discrete sub-units based upon log trends and stacking patterns of interpreted lithofacies.

In particular, upward decreasing gamma ray log trends, and NPHI and RHOB log response which trends towards sandstones indicate stacked successions of upward coarsening / upward cleaning deposits. These may be considered analogous to parasequences. Sedimentary dips within these upward cleaning successions are typically low ( $< 12^\circ$ ). However, upward cleaning (and coarsening) trends are in some cases punctuated by development of sandstones with blocky log character, and elevated sedimentary dips in excess of  $12^\circ$ .

The upward coarsening parasequences described are consistent with a model of deposition in a marginal marine environment, with upward coarsening profiles forming as a result of shoreface or delta front progradation. Blocky sandstones characterised by sedimentary surfaces with elevated dips may represent the deposits of fluvial or distributary channels. The lithofacies identified are described in detail in the following

sections. In the absence of core calibration, the following discussions are should be considered speculative.

Observed vertical transitions in lithofacies types identified in borehole images have enabled lithofacies to be grouped into genetically related successions of strata or *lithofacies associations*, which have some environmental significance (Collinson 1969, Walker 1992). 6 lithofacies associations were identified within the studied data set, and their distribution within the studied intervals is illustrated in Enclosures 7-10. The lithofacies associations identified may be summarised as follows:

### ***Lithofacies Association I***

Lithofacies Association I is argillaceous, mainly comprising mudstone lithologies (Ml and Mm), with minor interbedded heterolithic lithologies. The mudstones occur at the base of successions displaying overall upward cleaning (and coarsening) gamma ray log trend (e.g. 2895-2930 m Enclosure 6), or within thick mudstone intervals displaying no overall log trend (e.g. 2960-3010 m, Enclosure 6). Where mudstones occur at the base of upward coarsening facies successions, they commonly display a mottled fabric, which decreases in intensity upward through the succession. This may reflect decreasing intensity of cementation mottling or bioturbation upward through the succession.

Generally, Lithofacies Association I forms relatively thick deposits from one metre to several tens of metres thick, and is characterised by blocky to serrate, overall high gamma-ray log response ( $> 70$  API), reflecting the presence of a predominantly argillaceous succession of lithofacies types. Gamma ray log response within mudstones (typically  $> 70$  API) typically decreases slightly upward, forming part of an overall upward decreasing trend. Lithofacies Association I typically passes upward into heterolithic lithofacies of Lithofacies Association II.

The mudstones of Lithofacies Association I display low sedimentary dip (typically  $< 5^\circ$ ), with wide ranging dip azimuths (covering  $360^\circ$  spread) indicative of their original deposition as parallel stratified sediments upon a flat lying substrate.

Sedimentation within Lithofacies Association I was probably dominated by suspension fallout of argillaceous material, resulting in the accumulation of laminated mudstone lithofacies (Ml, etc.). If mottled and disrupted bedding fabrics identified are be due to bioturbation, in most examples this appears to have been most intense towards the base of upward coarsening successions suggesting extensive colonisation of the sediment substrate within deeper water environments. This may have occurred :

- at or close to fair-weather wave base in the shoreface of a marginal marine succession.
- in a distal mouth-bar / prodeltaic type environment.

As mudstones grade upward into sandier deposits, the proportion of mottling appears to decrease. Again, if mottled fabrics reflect the presence of bioturbation, this could indicate increased energy within the depositional system, and conditions less favorable for extensive colonisation of the substrate.

### ***Lithofacies Association II***

Lithofacies Association II comprises heterolithic lithologies. Heterolithic sediments consist of centimetre-decimetre scale interbedded sandstones and mudstones, and often display a highly mottled image fabric. Within the studied intervals, heterolithic deposits may form successions in excess of 15m thick.

Heterolithic deposits predominantly occur towards the base of facies successions which display overall upward cleaning (and coarsening) gamma ray log trend.

Sedimentary dips within heterolithic deposits are typically characterised by low angle fabrics (inclined typically < 10° sedimentary dip). Removal of structural dip reveals these bedding fabrics to be characterised wide ranging (up to 360° spread) dip azimuths, indicative of their original deposition as approximately horizontally stratified sediments.

Heterolithic nature of these deposits suggests deposition via both tractional and suspension processes. In a shallow marine setting, this style of deposition may have occurred at or around fair weather wave base in shelf-shoreface type settings, or perhaps in the lower parts of distributary mouth bars in more marginal deltaic environments.

### ***Lithofacies Association III***

Lithofacies Association III mainly comprises sandstone lithologies, with a variety of different internal fabrics (fine scale mottled, well laminated, mottled with relict lamination etc.). Well preserved lamination fabrics are not generally common within images through sandstone lithologies. Lithofacies Association III is characterised by low angle sedimentary dips (typically circa 10°), and may form successions up to 13 m thick within the studied sections. The sandstones typically rest gradationally upon heterolithic deposits of Lithofacies Association II, in the upper parts of upward coarsening successions. The sandstones of Lithofacies Association III are distinguished from those of Lithofacies Association (IV) discussed below by lower sedimentary dips. Cosets of strata occur at dm-m scale. The low angle sedimentary dips (typically <10° rarely up to 15°) characteristic of this lithofacies association often the presence dm-m scale coset which may display a relatively tight cluster of unimodal dip azimuths, typically lying within the southern hemisphere of stereoplots. Flat lying intraset surfaces are also common within this lithofacies association. Few interpretations can be made as to the relative spatial distribution of laminated versus mottled image fabrics within sandstones from this lithofacies association.

The low angle stratification within these sediments is indicative of deposition by tractional processes. The occurrence of these sediments within the upper parts interpreted upward coarsening lithofacies successions, and the often variable orientations of cosets comprising low angle internal stratification that is common within some successions may be consistent with deposition in a shallow marine environment. In these settings, both unidirectional and oscillatory currents (together forming combined flows) during storms may produce a wide variety of 2- and 3-dimensional bedforms. Sedimentary fabrics characterised by sets of low angle stratification of variable orientation may indicate deposition as low amplitude, perhaps strongly 3-dimensional mounded bedforms. In a shallow marine setting, this style of deposition may have occurred above fair weather wave base in shoreface type settings. Successions where low angle surfaces have display more unimodal distribution of

azimuths, this may reflect the presence of a more significant palaeoslope or sediment transport and deposition under the influence of more unidirectional current systems. Alternately, the low angle parallel lamination fabrics could be consistent with deposition as sands within the upper parts of distributary mouth bars.

### ***Lithofacies Association IV***

FMS derived lithofacies are sand dominated, mainly comprising Scm, Sm, Sl, Sm(Sl) and Sl(Sm), with minor heterolithic and mudstone lithofacies. Association IV occurs in successions up to 20 m thick within the studied intervals from Yolla-2. Five intervals within the studied succession have been assigned to Lithofacies Association IV, and few conclusions can be drawn concerning the spatial distribution of different lithologies within these deposits.

Interpretation of manually picked dips from FMS images indicates the presence of intraset surfaces inclined at angles up to 25° or more, these steeply inclined surfaces distinguishing this lithofacies association from Lithofacies Association III above. Coset and set boundaries occur at dm - m scale. Dip data sets for Lithofacies Association IV indicate an essentially unimodal overall distribution of azimuths for intraset surfaces, with low azimuthal dispersion. These distributions are WSW for deposits of Lithofacies Association IV in the interval 2793 m-2804 m, and 24 SSE for the interval 2402 m-2409 m. The succession in the interval 2042m-2048m contains oversteepened sedimentary surfaces oriented at dips in excess of 30°.

The cross stratified sediments of lithofacies association IV may represent the deposits of channels (fluvial or distributary) within a marginal marine setting. Evidence of primary stratification within these deposits testifies to the development and migration of bedforms, with the locally abundant cross-bedding indicating dunes and sand waves. Mottled FMS lithofacies Scm reflects the presence of coarse grained pebbly sandstones. Finer scale mottling and disrupted lamination / relict internal stratification fabrics within lithofacies Sm may indicate:

1. The presence of bioturbation. In this case, conditions within the environment of deposition were suitable for extensive frequent faunal colonisation of substrates, presumably during periods of low energy discharge, or temporary channel abandonment.
2. De-stratification a result of sediment de-watering. De-watering may have arisen as a result of pore-pressure adjustments during rapid deposition and burial of sediments, or as a result of a rapid rise / fall in fluvial stage.

The cosets of strata defining channel fill successions are typically circa 1 m-2 m thick, which may provide an indication of bank-full channel depth. Palaeotransport implications for this lithofacies association are discussed in detail in the following sections.

### ***Lithofacies Association V***

Lithofacies Association V comprises mudstones and heterolithic lithologies with varying degrees of lamination. They are indistinguishable from the lithologies of Lithofacies I and II. However, they occur as typically thin (1-3 m) successions

interbedded with lithologies interpreted as the deposits alluvial channels, suggesting that they may too be of alluvial origin. Mudstone lithologies may occur interbedded with channelised sandstones as a result of deposition of suspension fines upon floodplains, infill of abandoned channels, interbedding of channelised lithologies with interdistributary bays in marginal settings or floodplain lakes on the alluvial plain.

Core observation has revealed that argillaceous lithologies in the interval 3040-3042 m log depth (3038.6 m-3039.6 m core depth) contain a variety of sedimentary fabrics. These include opposing current ripples within sandstone, and ichnofabrics that include *Diplocraterion*, *Chondrites* and *Teichichnus*. These suggest that mudstones in this interval were deposited in a marginal marine environment, subject to tidal influences, and that the alluvial channels observed were also probably located in a marginal marine setting.

In FMS images, these lithologies are indistinguishable from those argillaceous lithologies which occur in the lower parts of large scale upward cleaning cycles (i.e. *Lithofacies Association I*). Mudstone lithologies are assigned to Lithofacies Association V purely on the basis of their close association with stacked channelised sandstones of Lithofacies Association IV. Assignment of depositional setting to mudstone interbeds within channelised successions can not be achieved with confidence in the absence of further core calibration.

### ***Lithofacies Association VI***

Coals form a minor lithology within the studied section, and are restricted to the interval (1925-1933m). They are characterised by high resistivity, low density and high porosity. In images they display little internal structure, other than rare flat lying internal “bedding” surfaces.

Coals occur towards the top of small scale upward coarsening mudstone-heterolithic sandstone successions 2-4 m thick.

### ***Summary***

The integrated analyses of wireline log signature and FMS fabric allows identification of a variety of different lithofacies types. Calibration with cuttings descriptions and the limited amount of core available has indicated that lithofacies interpreted from FMS logs show good correspondence with those observed within a short (17 m) core from the interval 3033-3050.5 m. However:

- The core sampling is strongly biased towards sandstone lithologies from channelised depositional settings.
- Few argillaceous intervals were sampled by the core.
- None of the “heterolithic” intervals interpreted from FMS logs to comprise cm-dm scale interbedded sandstone-mudstone lithologies were sampled by the core. Their presence in non-cored intervals is still to be proven.
- Lithofacies identified within core are not diagnostic of a particular environment of deposition.

In the absence of further core calibration, the environmental interpretations outlined in the following section should be treated with caution and regarded as highly speculative.

### 3.5. Summary of environmental interpretations

A brief summary of the sedimentary successions analysed in detail and their possible environmental interpretation is provided in the following sections. Detailed discussions of palaeotransport observations are included in Section 4 of this report.

#### *Study Interval 3030m-3060 m*

Wireline logs and FMS interpretations through this interval suggest that it comprises two large upward cleaning (coarsening) successions, the largest of which is 18m thick. The succession is heterolithic, with coarsening upward successions displaying transitions from mudstones into heterolithics and finally sands and coarse pebbly sands. Details are summarised in Table 3.5 below.

Study Interval 3030m-3060 m			
Depth (m)	Lithofacies Associations	Brief Description	Interpretation
3060-3051	I -> II -> III	Massive and laminated mudstones pass upward into a succession of heterolithic strata and sandstones, with low sedimentary dip.	Progradation of marine shelf-shoreface deposits, or a delta front (prodelta – distributary mouth bar) deposits.
3051-3042	IV	Cross-bedded sandstones and coarse pebbly sandstones. Sedimentary dips up to 30°, record predominance of Southerly dip azimuths.	Alluvial or distributary channel with S drainage.
3042-3041	V	Laminated and mottled mudstones.	Core observations suggest mudstones in this interval were deposited in a marginal marine environment, subject to tidal influences.
3041-3030	IV	Laminated and mottled sandstones. Sedimentary dips up to 25°.	Alluvial or distributary channel with NW drainage.

**Table 3.5 Summary of deposits in the study interval 3030-3060m.**

#### *Study Interval 2856 –2910 m*

Wireline logs and FMS interpretations through this interval suggest that it comprises a highly heterolithic succession of strata. A number of large scale upward cleaning (coarsening) successions are evident, punctuated by clean, sandstones and pebbly sandstones. The succession also contains “hot” radioactive sandstones, which may represent a correlateable horizon (2865-2874 m). Details are summarised in Table 3.6.

Study interval 2856 –2910 m.			
Depth (m)	Lithofacies Assoc.	Brief Description	Interpretation
2910-2899.4	II -> III Repeated	Stacked upward coarsening successions comprising mottled and laminated heterolithics, and mottled and laminated sandstones. Successions are 2-4 m thick, and display progradational motif (i.e. sand content increases upward through stacked successions). Low sedimentary dips with 360° spread indicate a flat lying succession	Progradation of shallow marine deposits. Small scale of stacked successions suggests possible deltaic mouth bar progradation. However a similar stacking pattern could be generated by shallow marine shoreface progradation.
2899.4-2876.5	II->I->II->III	Overall large scale upward cleaning (coarsening) succession comprising mottled and laminated mudstones, heterolithics and sandstones. The succession is mudstone dominated, but commences with initial phase of deposition of heterolithics. Low angle sedimentary dips (<5°) with wide ranging azimuth indicate deposition as flat lying substrate.	Large scale upward coarsening profile is consistent with progradation of shallow marine shelf -shoreface deposits. Thick succession of muds indicates prolonged deposition within deeper water environments with minimal coarse clastic input. Heterolithic deposits at base of interval may reflect deposition during initial phase of transgression.  Alternatively succession could represent deltaic setting (prodelta – distributary mouth bar).
2876.5-2874	I->II->III	Upward coarsening succession comprising mottled mudstones, mottled and laminated heterolithics.	Small scale stacked successions suggests possible deltaic mouth bar progradation. However a similar stacking pattern could be generated by prograding shallow marine shoreface, deposition within interdistributary bays or on an alluvial plain.
2874-2859.5	Interbedded III & IV	Stacked succession of mottled sandstones, laminated sandstones and coarse pebbly sandstones. Typically blocky log response. Base of succession (2865-2874 m) comprises pebbly sandstones overlain by “hot” radioactive sands. Sedimentary dips commonly in excess of 10°, record a wide range in dip azimuths, but are readily defined into dm-m scale sets.	Pebbly sandstones with elevated sedimentary dips are best interpreted as part of a complex channel fill succession (alluvial or distributary). Complex and variable dip patterns suggest deposition by laterally accreting bedforms, and overall channel drainage direction is unclear.  “Hot sands” may represent placer deposits associated with a basal channel lag. An alternate alternate interpretation could be shallow marine / marginal setting, perhaps overlying a coarse grained pebbly detritus deposited as a transgressive lag.

2859.5-2856	I	Laminated and mottled mudstones.	Base of thick (>40 m) argillaceous succession, of possible marine origin.
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**Table 3.6 Summary of deposits in the study interval 2856 –2910 m.**

***Study Interval 2792m-2820 m***

Wireline logs and FMS interpretations through this interval suggest that it comprises a heterolithic succession of strata, but is dominated by deposition of sandstones. The sandstones are cross bedded, and contain internal stratification surfaces with sedimentary dips of up to 30° or more. Details are summarised in Table 3.7 below.

<b>Study interval 2792-2820 m.</b>			
<b>Depth (m)</b>	<b>Lithofacies Assoc.</b>	<b>Brief Description</b>	<b>Interpretation</b>
2820-2814	I-II	Minor upward coarsening succession comprised mudstones and sandstones. Sandstones display low-moderate sedimentary dips (typically <12°), and sedimentary azimuths oriented to SE.	Upward coarsening profile suggests possible deltaic mouth bar progradation. However a similar stacking pattern could be generated by shallow marine shoreface progradation.
2814-2793.5	IV-V Interbedded  Rare II	Interval contains two separate sandstone dominated successions separated by a thin (2 m) interval of laminated mudstone (circa 2804.5-2806.5 m). Sandstones contain a variety of laminated and mottled fabrics. Minor interbeds of heterolithic strata (circa 2808-2808.5 m) are also present.  Sandstones are cross stratified, typically with sedimentary dips up to 25°. Some oversteepened sedimentary surfaces are also present (circa 2799 m) but these may be due to the effects of fracture related deformation at this depth.	Sandstones are interpreted as part of a channel fill complex. Sandstones consistently show a predominance of north-northwesterly to southwesterly oriented intraset surfaces, and a SW or WNW drainage direction is suggested.
2973.5-2790	I	Laminated and mottled mudstones.	Short interval studied forms base of thick (>30 m) argillaceous succession, of possible marine origin.

**Table 3.7 Summary of deposits in the study interval 2792-2820 m.**

***Study Interval 1860-1951 m***

Wireline logs and FMS interpretations through this interval suggest that it comprises a highly heterolithic succession of strata, with contained lithologies including mudstones, heterolithics, sandstones and coals. A number of upward cleaning (coarsening) and upward fining trends are evident on from log suites.

Examination of cuttings descriptions states that traces of glauconite were consistently recorded through the upper part of the studied interval, which is comprised of large upward cleaning successions comprising Lithofacies Associations I, II and III, several tens of m thick. The cuttings descriptions do not record traces of glauconite beneath circa 1909-1913 m, where the succession is comprised of more complex intercalations of the I, II, III, IV, and VI. (See Enclosure 7).

The apparent variation in glauconite distribution approximately corresponds with the gross structural sub-division of this studied interval, which comprises a broadly three-fold sub-division. The upper and lowermost structural zones are separated by a fractured interval extending from circa 1905-1913 m. Glauconite occurrence is not recorded beneath this fracture zone. Since the fracture zone extends over an interval of 8 m, it is not apparent whether it is a fault bound wedge, or whether one boundary is actually an unconformity. A transition from a sand prone succession beneath the fractured zone to a very thick, highly argillaceous deposits, containing large scale (>10 m) upward coarsening successions, above the fractured zone may indicate a landward shift in facies belts and transition to more “marine” environments.

Details of interpretations are summarised in Table 3.8 below.

Study interval 1860-1951 m.			
Depth (m)	Lithofacies Assoc.	Brief Description	Interpretation
1951-1947	III	Succession of laminated and mottled sandstones. Sandstones typically display low-moderate sedimentary dips (<12°), but some elevated dips are also present.	Possibly part of channel fill succession. Bipolar-bimodal dip azimuths, indicate sedimentary surfaces oriented to NE and SW
1947-1938	II	Thick succession of laminated and mottled heterolithic strata (dm-scale interbedded sandstones siltstones and shales). Note: cuttings descriptions suggest sandstones dominate this interval, contrasting with the Z&S interpretation.	Sedimentary dips indicate deposition as a succession of flat lying strata. No distinctive features are present which could aid environmental interpretation. Association with overlying strata may indicate a shallow marine, prodeltaic setting.
1947-1926	I, II, III and VI. Interbedded.	Succession of laminated and mottled heterolithics, mudstones, and sandstones with minor coals. Interval contains four stacked upward cleaning successions 2.5-4 m thick. Sand content increases upward. The three uppermost upward cleaning successions terminate with coal deposition. Sandstones and heterolithics are characterised by low angle sedimentary dips (typically <5°) with wide azimuth dispersion.	Upward cleaning successions terminating in deposition of coal indicate deposition within delta front – delta plain environments. Heterolithic and sandstone dominated parts of upward coarsening successions may represent progradation of distributary mouth bars. Mudstone dominated intervals may represent the deposits of interdistributary bays, or prodeltaic environments. Coals represent the deposits of swampy delta plain environments.
1926-1920	IV	Laminated and mottled sandstones forming part of an upward increasing gamma ray log profile (possibly upward fining succession). Sands have marked erosive base, and display internal stratification surfaces dipping at angles of up to 20°. The sands contain a predominance of northerly dip azimuths.	Possible distributary channel with overall northerly drainage.
1920-1916	II (minor III)	Succession of interbedded (1-2 m scale) heterolithic strata and thin (<0.5 m) sandstones with low angle (5°-7°) internal stratification fabrics with predominantly northeasterly azimuths.	Association with underlying channelised sandstones and coals suggests these heterolithic deposits may have been deposited as deltaic mouthbars, or as crevasse deposits within a shallow interdistributary bay or onto an alluvial delta plain. NE oriented sedimentary dips may reflect palaeoslope.

**Table 3.8 Summary of deposits in the study interval 1860-1951 m (cont.)**

*Continued Overleaf*

<b>Study interval 1860-1951 m.</b>			
<b>Depth (m)</b>	<b>Lithofacies Assoc.</b>	<b>Brief Description</b>	<b>Interpretation</b>
1913.7-1916	IV	Thin, sharp based succession of laminated and mottled sandstones with internal stratification surfaces displaying sedimentary dips of 5°-28°, and oriented towards the NE.	Possible distributary channel with overall easterly drainage.
1913.6-1909	II & III Interbedded	Stacked, 1-4 m scale upward coarsening successions comprising heterolithic deposits and thin sandstones (up to 2 m thick) with low angle (typically <5°) internal stratification fabrics.	Association with underlying channelised sandstones etc suggests these heterolithic deposits may have been deposited as deltaic distributary mouthbars.
1909-1894	II (minor III)	Thick succession interpreted to represent laminated and mottled heterolithic strata (dm-scale interbedded sandstones, siltstones and shales). Two sand intervals <1 m thick are also interpreted. Note: cuttings descriptions indicate occurrence of traces of glauconite within this interval.	Sedimentary dips within heterolithics indicate original deposition as succession of flat lying strata. Sparse sandstone dips indicate sediment dispersal to NE. The succession contains few distinctive characteristics, which could aid environmental interpretation. However, the occurrence of glauconite may indicate a shallow marine, (prodeltaic or shelf-shoreface) setting. Sandy intervals may represent thin storm deposits.
1894-1876	I->II->III	Single large scale upward coarsening succession dominated by sandstone deposition. Sandstones are commonly laminated and display low angle (<5°) internal stratification sets indicating original deposition as a succession of flat lying strata. Stratification displays a distinct transition from northeastely orientations in the lower part of the sandstone interval, to westerly in the upper part of the sandstone interval. There is also a decrease in the degree of preserved internal stratification in the uppermost sandstones. Cuttings descriptions indicate traces of glauconite.	The succession contains few distinctive characteristics to aid interpretation. Large-scale upward coarsening motif and occurrence of glauconite may support a shallow marine interpretation. Sediments may have been deposited in shelf-shoreface environments. NE oriented sedimentary dips in lower part of sand interval (lower-middle shoreface ?) may reflect an overall NE dipping palaeoslope. Westerly azimuths in the uppermost sandstones (upper shoreface ?) may reflect sediment transport in an alongshore direction.
1909-1894	II (minor III)	Thick succession of laminated and mottled heterolithic strata (dm-scale interbedded sandstones siltstones and shales) interbedded with 0.5-2 m thick sandstones. Sedimentary dips are low angle with wide ranging azimuth, indicating original deposition as succession of flat lying strata. Strata form stacked, broadly upward coarsening successions in which heterolithic deposits dominate. Cuttings descriptions indicate traces of glauconite within this the lower part of this interval.	The succession contains few distinctive characteristics which could aid environmental interpretation. However, the occurrence of glauconite may support a shallow marine setting.  Possible interpretations include deposition in prodeltaic - distal mouthbar environments.

**Table 3.8 Summary of deposits in the study interval 1860-1951 m (cont.).**

### 3.6. “Hot” sandstones

The interval 2865–2874 m contains highly radioactive lithologies having gamma ray log response of up to 250 API units. Density, neutron porosity and resistivity logs indicate this interval to comprise conductive sandstone lithologies. PEF log response of these sandstones is comparable to that of shales within the studied succession. The sandstones contain a variety of flat lying intraset surfaces, and small scale cross beds (cm-dm scale), and overly a succession comprising some 2 m of pebbly sandstones.

Apart from the association with underlying pebbly lithologies, these radioactive sandstones contain no features indicative of their environment of deposition. It is understood that they may form a regional marker bed correlateable with other wells. In core, coarse pebbly detritus was observed to occur within alluvial channels, and one interpretation of these “hot sands” is that they may represent placer deposits associated with a channel lag. If regionally correlateable, this “hot” sand may reflect unroofing of a particular lithology in response to regional tectonic event, or clastic input from a regionally extensive event. It is suggested that these sands are most readily interpreted as part of an alluvial channel complex. However, an alternative interpretation is that they could represent a placer deposit within a shallow marine / marginal setting, perhaps overlying a coarse grained pebbly detritus deposited as a transgressive lag.

### 3.7. Net sand content

The lithofacies types identified using FMI images were used to quantify net sand content within the studied intervals. The results are summarised in Figure 3.12 (a-d) and Table 3.9 below.

FMS Determined Lithofacies	% Content within study interval 3027.6-3060.3 m	% Content within study interval 2855.9-2908.9 m	% Content within study interval 2789.9-2819.6 m	% Content within study interval 1860-1951 m
Sc	1.3 %	0 %	0 %	1.9%
Sm	21.8 %	8.5 %	11.4 %	15%
Sl	9.2 %	5.1 %	1.9 %	4.6 %
Sl(Sm)	8.2 %	11.9 %	11.8 %	11.9 %
Sm(Sl)	10.8 %	10.6 %	35.2 %	7.99 %
Scm	7.6 %	2.3 %	0 %	0 %
Scm(Sl)	5.0 %	6.8 %	0 %	0%
Ml	15.0 %	6.2 %	10.8 %	0.8 %
Mm	12.9%	22.9 %	24.0 %	4.9%
Hl	7.8 %	15.0 %	1.5 %	19.1%
Hm	0 %	9.0 %	3.0 %	31.33 %
Coal	0	0	0	2.26

**Table 3.9 Lithofacies types identified using FMS images in study interval.**

## **4. BEDFORM ORIENTATION AND SEDIMENT DISPERSAL**

Following sub-division of the succession into the six lithofacies associations described above, detailed analysis of the orientation of different bedforms within these successions was undertaken in order to evaluate sediment dispersal, and orientation of the depositional system. Sedimentary dips for the different bedding categories identified are summarised in Enclosures 7-10.

### **4.1. Argillaceous and arenaceous sediments of Lithofacies Associations I, II & III.**

Sedimentary dips within mudstone and heterolithic lithologies (interpreted as comprising cm-dm scale interbedded sandstone and mudstone laminae) from lithofacies associations I and II typically display 360° azimuthal spread, indicative of the original deposition of these lithologies as “flat lying” effectively parallel stratified sediments. These sediments are mainly interpreted to have been deposited in shallow marine settings, in shelf-shoreface or prodelta-distributary mouth bar environments. However, in some intervals, e.g. where they occur as part of a well developed overall upward cleaning succession comprising Lithofacies Associations I to III, heterolithic lithologies may often display a preferred orientation. For example, heterolithic strata within upward cleaning log profiles in the interval 2880-2910 m (Enclosure 9) appear to contain a predominance of northeasterly and southwesterly oriented surfaces, which may be indicative of palaeoslope.

Sedimentary dips within sandstones of lithofacies association III are also typically highly variable, and indicative of original deposition as “flat lying” sediments. This may have occurred within shallow marine shoreface settings or as deltaic distributary mouth bars. However, intraset surfaces (ISS) and flat lying intraset surfaces (ISSF) do often show preferred orientations, which may be similar to that within heterolithic lithologies of lithofacies association II with which they are associated with. The significance of these orientations is unclear. However, they are most readily interpreted as reflecting the presence of an overall palaeoslope upon which deposition took place. In most cases, this can broadly be interpreted to have had WNW-ESE or NW-SE depositional strike, although data sets are small and hence biased.

### **4.2. Arenaceous sediments of Lithofacies Association IV**

The low gamma ray log response typical of Lithofacies Association IV, indicates that these successions contain a significant proportion of clean, potentially high reservoir quality sandstones. This has been confirmed by core observations, which have revealed the presence of coarse granular sandstones having permeabilities of several Darcies. In this respect, the orientation of this lithofacies association can have important implications with respect to development of production strategies. Channels which have their long axis oriented perpendicular to an advancing water flood front may act as thief zones, resulting in by-passing of hydrocarbons within adjacent lithofacies associations. Channels oriented with their long axis parallel to the advancing water flood front may be subject to more efficient sweep. The dipmeter data obviously provide important insight as to bedform orientation and hence flow within channels. However, interpretation of channel drainage directions will be hampered by relatively small dip data sets from successions where bedded fabrics are not well preserved.

Several intervals of channelised deposits assigned to lithofacies association IV have been identified within the four intervals studied in detail.

The main intervals of channelised deposits occur at circa:

- 3030-3041m
- 3042-3051m
- 2859-2875m (possible channel)
- 1920-1926 m
- 1915-1916m (possible, low confidence channels).

The orientation of bedding surfaces within these intervals are summarised in Tables 3.10-3.13, below.

<b>Study Interval 3030m-3060m (log depth).</b>				
<b>Depth (m) of coset or group of cosets</b>	<b>Orientation of ISS's</b>	<b>Orientation SB's</b>	<b>Orientation CSB's</b>	<b>Comments</b>
3030-3034 <i>Sediment dispersal to NE ? NW oriented channel ?</i>	NE		W	Laterally accreting bedforms. Low angle bedforms within sandstone. Orientation of CSB are typically not within 60° of ISS.
3034-3037				No bedding fabric measured
3037-3040.0 <i>Channel with flow to NNW</i>	NNW NE NNW	NW	NW	3 cosets identified in fine-med sandstone. Uppermost metre lacks surfaces. Orientation of SB and CSB are within 60° of ISS. Simple, downstream accreting bedforms.
<b>Base channel complex, probable overall NW drainage direction.</b>				
3042.0-3046.6 <i>Channel with flow to SSE</i>	ESE SSE SSE	SSE SSE	E	Coarse pebbly sandstone. 3 main cosets are identified. Orientation of SB and CSB are typically within 60° of ISS. Simple, downstream accreting bedforms.
3046.6-3048 <i>Channel with flow to SSE</i>	SSE	SSE?	? possibly S	Medium – fine sandstone. Simple, downstream accreting bedforms. carbonaceous debris at circa 3046.6 m
3048-3050.5 <i>SW sediment dispersal, possible within channel with significant southerly component to drainage ?</i>	WSW SW Variable	SW SW	S E	3 cosets identified in low angle stratification of fine-medium sandstone. Flat lying ISSF surfaces form lowermost set. SB are subparallel to ISS indicating reactivation surfaces within relatively simple bedforms. CSB surfaces recognised, are somewhat more divergent to ISS possibly indicating more complex bedform geometry than occurs within more steeply inclined fabrics of overlying coset group.
<b>Base Channel with overall S-SE drainage direction.</b>				

**Table 3.10 Bedding orientations, channelised deposits in the study interval 3030-3060 m.**

Study Interval 2856 –2910m (log depth).				
Depth (m) of coset or group of cosets	Orientation of ISS's	Orientation SB's	Orientation CSB's	Comments
2859.5-2865m <i>Downstream accreting bedforms indicate possible flow to SE.</i>	SE S SSE .	ESE SE S	SE	Sandstone containing dm scale low angle stratification sets (5°-20°). Orientation of CSB are typically within 60° of ISS indicating simple, low angle downstream accreting bedforms
2865-2868 <i>Downstream accreting bedforms indicate possible flow to NNW.</i>	NNW NW		NNW SE	Sandstones and coarse pebbly sandstones with low angle stratification sets (5°-10°). Surfaces inclined at 20° in base of interval. Variable ISS and CSB orientations suggest laterally accreting gravel sheets.
2868-2869.75 Possible laterally accreting bedforms within broadly westerly flowing system.	NNW NW SW W	SW	SW SE	Sandstones with inclined stratification surfaces up to 16°. Sets up to 25-50 cm thick. However, CSB surfaces are divergent to ISS suggesting complex bedform geometry (laterally accreting bedforms ?)
2869.75-2874m Possible laterally accreting bedforms. Strong NE component to flow ?	NNE SSE E SE		ENE SE	Hot, high gamma ray log response sandstones with a predominance of low angle and flat lying intraset surfaces (5-10°). Small cm scale cross sets are also present Interval 2872-2874 m comprises pebbly sands in which little stratification is evident (channel lag deposit?).
<b>Base of succession of stacked, mainly laterally accreted channelised sandstones.</b>				

Table 3.11 Bedding orientations, possible channelised deposits in the study interval 2856-2910m.

Study Interval 2792m-2820m (log depth).				
Depth (m) of coset or group of cosets	Orientation of ISS's	Orientation SB's	Orientation CSB's	Comments
2792.5-2799.75 <i>Channel with westerly flow.</i>	Variable. W WSW and NW.  W oriented fabrics are over-steep.	Variable, NE to SW. (Most parallel ISS)	WSW	Low angle- to steeply inclined bedforms (10°-40°) within sandstone. Sets decrease in size upward. As many as 5 cosets may be present. Orientation of CSB are typically within 60° of ISS indicating downstream accreting bedforms. Greater divergence of SB/CSB azimuth from ISS surfaces in uppermost 1m may indicate more complex, laterally accreting bedforms superimposed upon larger simple bedforms.
2799.75-2804.1 <i>Lateral accreting bedforms within channel with possible NE or SW flow ?.</i>	N WNW SSW WNW NE		NNE SSW WNW WSW	Up to 6 cosets may be present, and bedding fabrics. Orientation of CSB are generally not within 60° of ISS within overlying and underlying sets. Possible laterally accreting bedforms.
<b>Base Channel</b>				
2805-2813.5 <i>Channel with possible SW or WNW.</i>	NW SW WSW	NW	N NW SSW SW	At least 6 cosets within sandy channel fill. Bedding fabrics inclined at up to 30°. Orientation of <b>most</b> SB and CSB typically appear within 60° of ISS. Probably relatively simple, downstream accreting bedforms.
<b>Base Channel</b>				

Table 3.12 Bedding orientations, channelised deposits in the study interval 2792-2820 m.

Study Interval 1860-1951 m (log depth).				
Depth (m) of coset or group of cosets	Orientation of ISS's	Orientation SB's	Orientation CSB's	Comments
1920.5-1924 <i>Channel with N-NE drainage .</i>	N	NE & E	NE & E	Low – moderate angle bedforms (5°-18°) within sandstone. Cosets present, uppermost comprising <0.5m flat bedded, parallel laminated strata. Orientation of CSB are within 60° of ISS indicating downstream accreting bedforms.
1924-1925.75 <i>Lateral accreting bedforms within channel base ? Orientation unclear.</i>	S & ESE	SSE & WNW		ISS within basal sets inclined at angles of up to 20°. ISS pass upward into set comprising ISSF, and sedimentary dips rotate from southerly to easterly orientations. erosion surface at channel base dips northward. Possible laterally accreting bedforms. Note fracturing may have resulted in rotation of sedimentary dips, in lowermost part of channel fill.
<b>Base Channel</b>				
1913.5-1916 <i>Low confidence with possible NE drainage.</i>	NE SE SW		NE WNW	Probably relatively simple, downstream accreting bedforms.
<b>Base Channel</b>				

**Table 3.13 Bedding orientations, channelised deposits in the study interval 1860 -1951 m.**

#### 4.3. Argillaceous and carbonaceous deposits of Lithofacies Associations V-VI

These data sets are too small and biased for orientation analyses.

## 5. CONCLUSIONS

1. The studied successions dip at low angles, mainly towards the south. A number of structural zones have been defined, these are summarised as follows:

### Study Interval 1860-1951 m

Zone I	1860-1905	3.4°/189°
Zone II	1905-1918	Non-quantified dip change within fracture zone
Zone III	1918-1951	4.2°/198

### Study Interval 2750-3080 m

Zone I	2750-2815 m	4.2°/224°
Zone II	2815-2830 m	4.7°/128°
Zone III	2830-3000 m	5.6°/262°
Zone IV	3000-3006 m	8°/080°
Zone V	3006-3027 m	3°/175°
Zone VI	3027-3080 m	4.4°/299°

2. Detailed structural evaluation was not part of the workscope. However, several fault and fracture zones were identified. In particular those at 1905-1918m, and 3027 m appear to be associated with changes in structural tilt, and may truncate the reservoir sections.
3. The sedimentary succession is highly heterolithic, comprising sandstones, mudstones and heterolithic intervals composed of dm scissile intercalations of sandstone, siltstone and mudstone.
4. Six lithofacies associations have been identified, these comprise:
  - I. Mudstones that occur at the base of upward coarsening facies successions. (interpreted as either prodeltaic muds, or shelf-shoreface deposits)
  - II. Heterolithic intercalations of sandstone siltstone and mudstone, typically occurring within the lower-mid parts of upward coarsening facies successions (interpreted as either distal distributary mouth bar, or shelf-shoreface deposits).
  - III. Stratified sandstones with mottled image fabric and low angle (typically <5°) internal bedding surfaces, typically occurring towards the top of upward coarsening facies successions 9 mouth bar sandstones or shoreface deposits).
  - IV. Successions (often erosively based) of stratified sandstones and pebbly sandstones with internal bedding fabrics inclined at angles of up to 25 or more (distributary or alluvial channel fills).
  - V. Thin mudstone- heterolithic successions interbedded with lithofacies association IV (possible interdistributary bay fill, alluvial plain deposits).
  - VI. Coals (deposits of swampy delta plain environments).
5. “Clean” sandstones of Lithofacies Association III and IV are likely to form the main reservoir intervals.

6. Palaeotransport analyses of sandstones from Lithofacies Association III reveals them to be characterised by internal stratification fabrics with very wide ranging sedimentary dip azimuth, suggesting they were originally deposited as “flat lying” strata. Few palaeotransport interpretations can be made for these sandstones. However, in some examples, a dominant sedimentary dip is present, and may reflect the presence of an overall palaeoslope upon which deposition took place. In most cases, this can broadly be interpreted to have had WNW-ESE or NW-SE depositional strike, although data sets are small and hence biased.
7. Palaeotransport analyses of sandstones from Lithofacies Association IV reveals them to be characterised by internal stratification fabrics with variable azimuth. The relationship between intra-set lamination and set/coset boundaries suggest that channel fills are complex and multi-storey, with channels being infilled by both simple downstream and more complex lateral accreting bedforms. Interpreted channel drainage directions are variable, no consistent drainage direction can be inferred.
8. Highly radioactive lithologies (2865 m – 2874 m) having gamma ray log response of up to 250 API units may form a regional marker bed correlateable with other wells. The hot radioactive lithologies comprise sandstones which contain a variety of flat lying intraset surfaces, and small scale cross beds (cm-dm scale), which overly a succession comprising some 2 m of pebbly sandstones. These “hot sands” may represent placer deposits associated with a channel lag.
9. In the absence of a detailed core calibration, environmental interpretations are highly subjective. However, observed lithofacies stacking patterns do appear to be consistent with an interpretation of deposition of strata within a marginal marine-deltaic setting.

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**FIGURES**

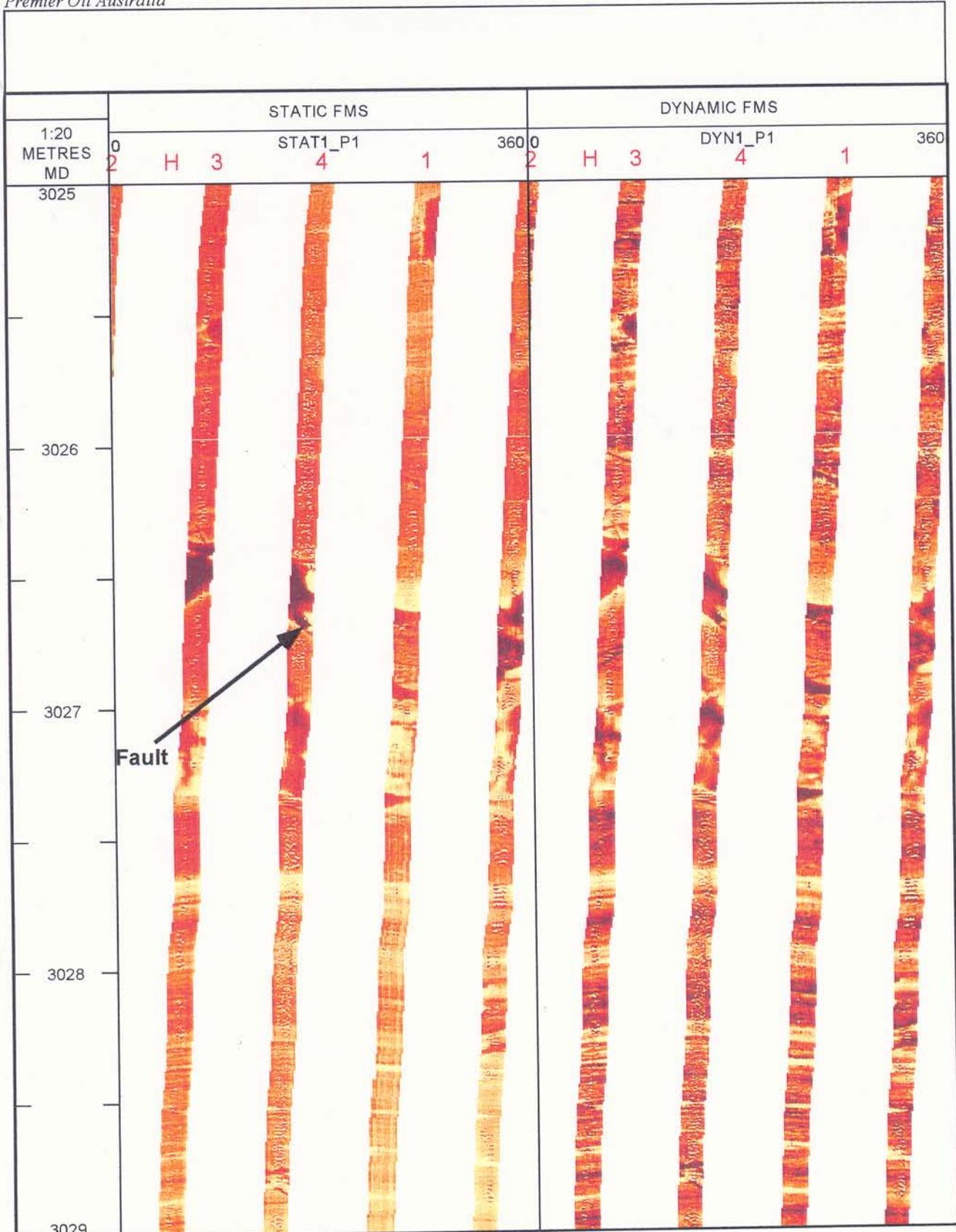
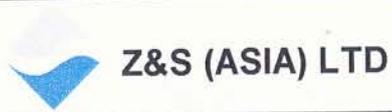
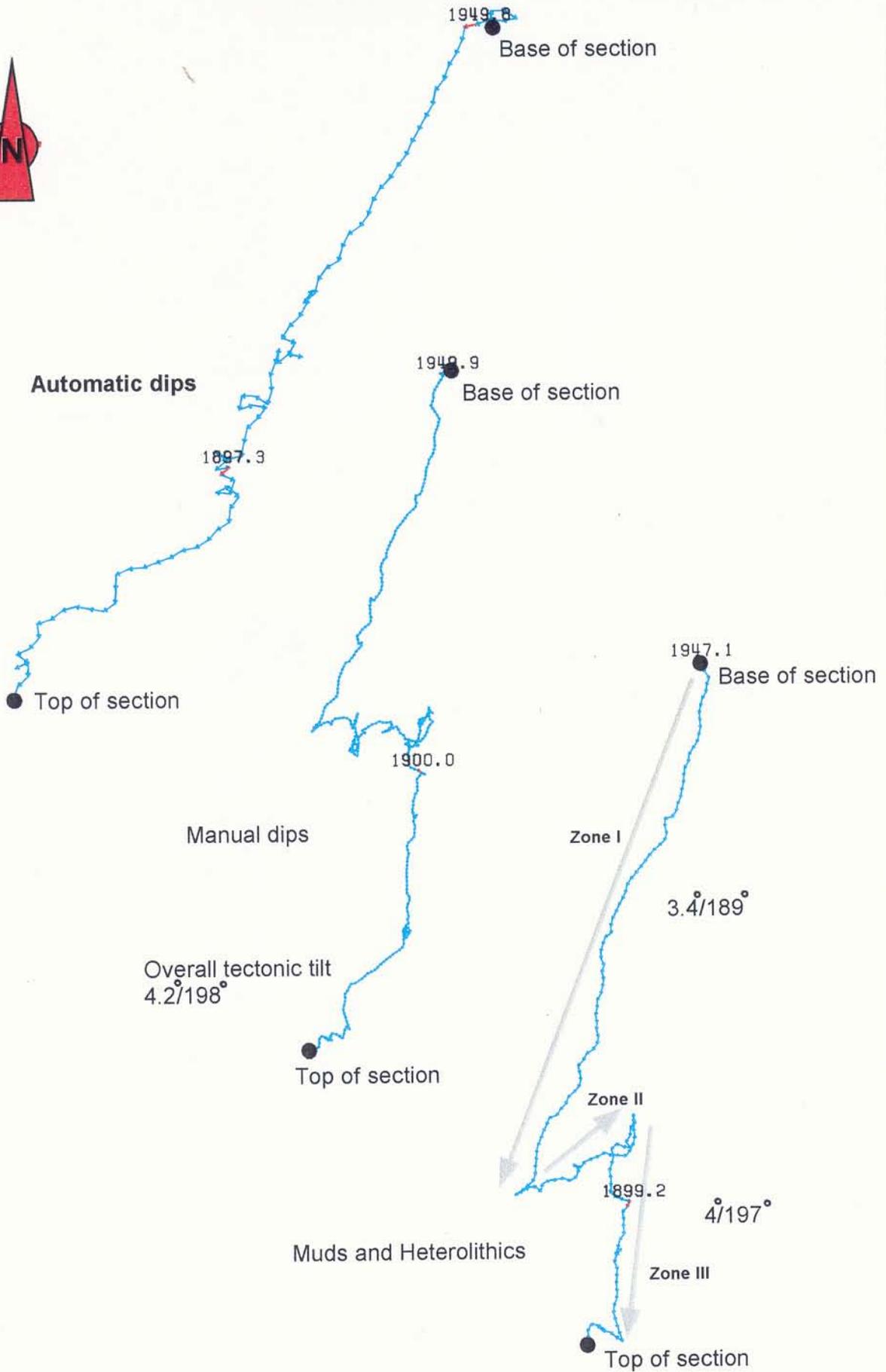


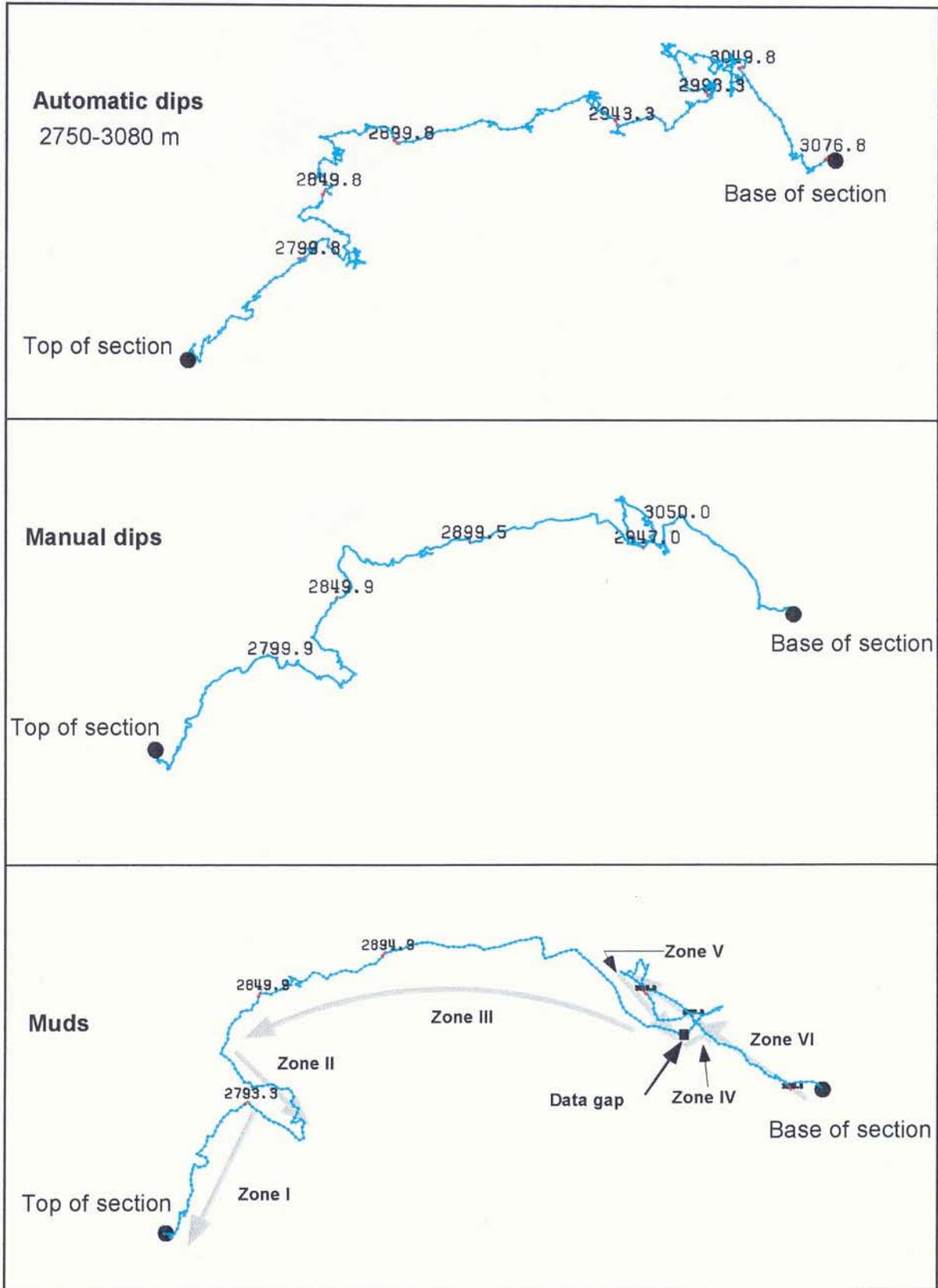
Figure 3.1 A large NE trending open fault (dm-aperture) at 3026.5 m.





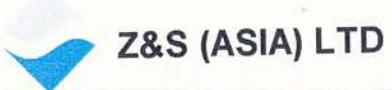
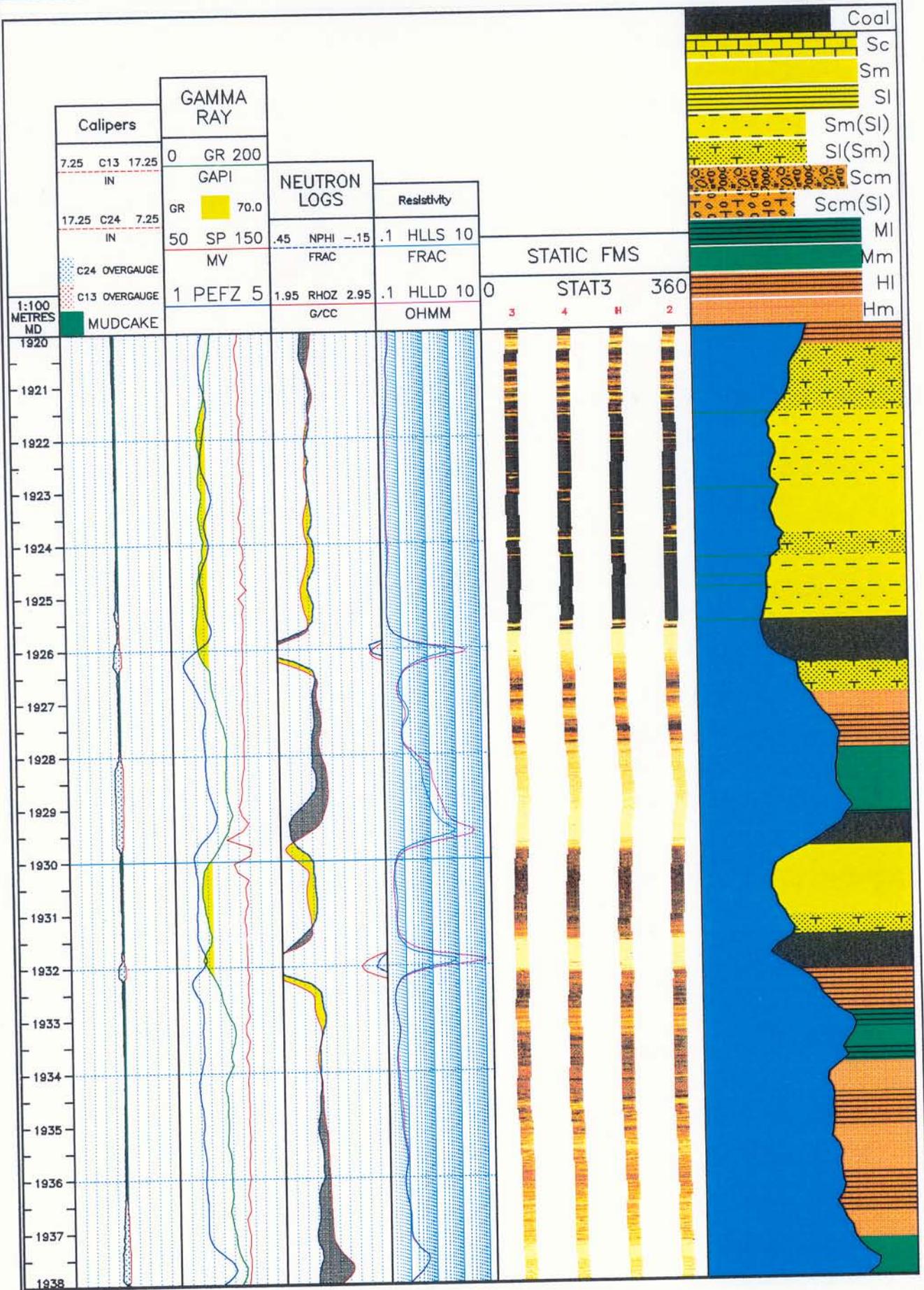
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**Figure 3.2** Cumulative automatic, manual and muds & hets , dip azimuth plots for studied section (1860 - 1951 m).



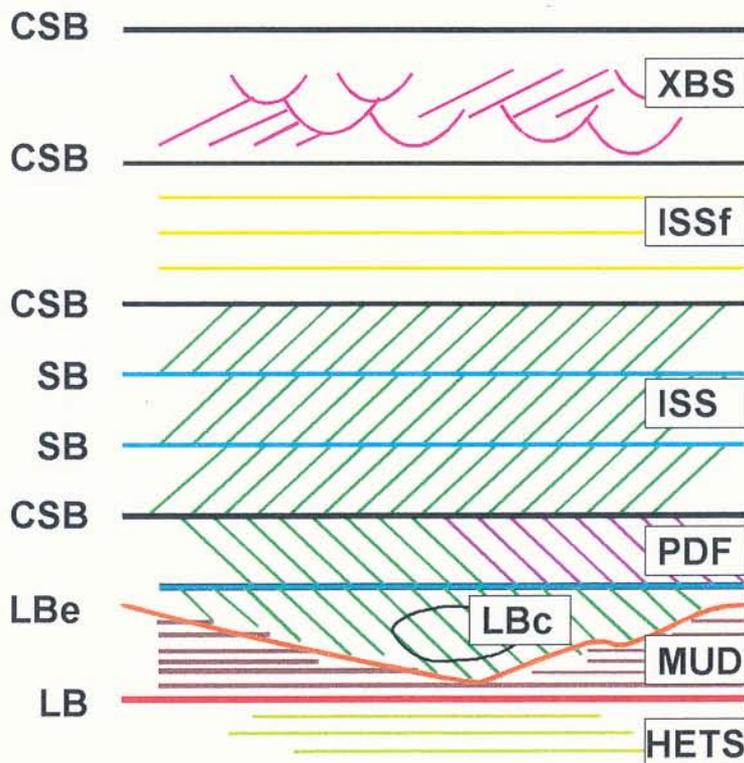
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**Figure 3.3** Cumulative automatic, manual and muds dip azimuth plots for studied section.



**Figure 3.4** Example of coal bearing strata (lithofacies VI) in interval 1926-1932 m.

CODE	DESCRIPTION	COLOUR	TADPOLE
LB	lithological boundary	red	
LBc	cemented lithological boundary	pink	
LBe	erosional lithological boundary or surface	orange	
SB	set boundary	cyan	
CSB	coset boundary	blue	
ISS	intra set surface	green	
ISSf	flat lying intra-set surfaces	yellow	
XSB	small-scale cross bedding	magenta	
PDF	poorly defined surface	purple	
HETS	surface interpreted as lamination within heterolithic lithologies alternating sand/mud	olive	
MUD	mudstone lamination	brown	



**Figure 3.5** Dips were picked and categorised according to the illustrated scheme.

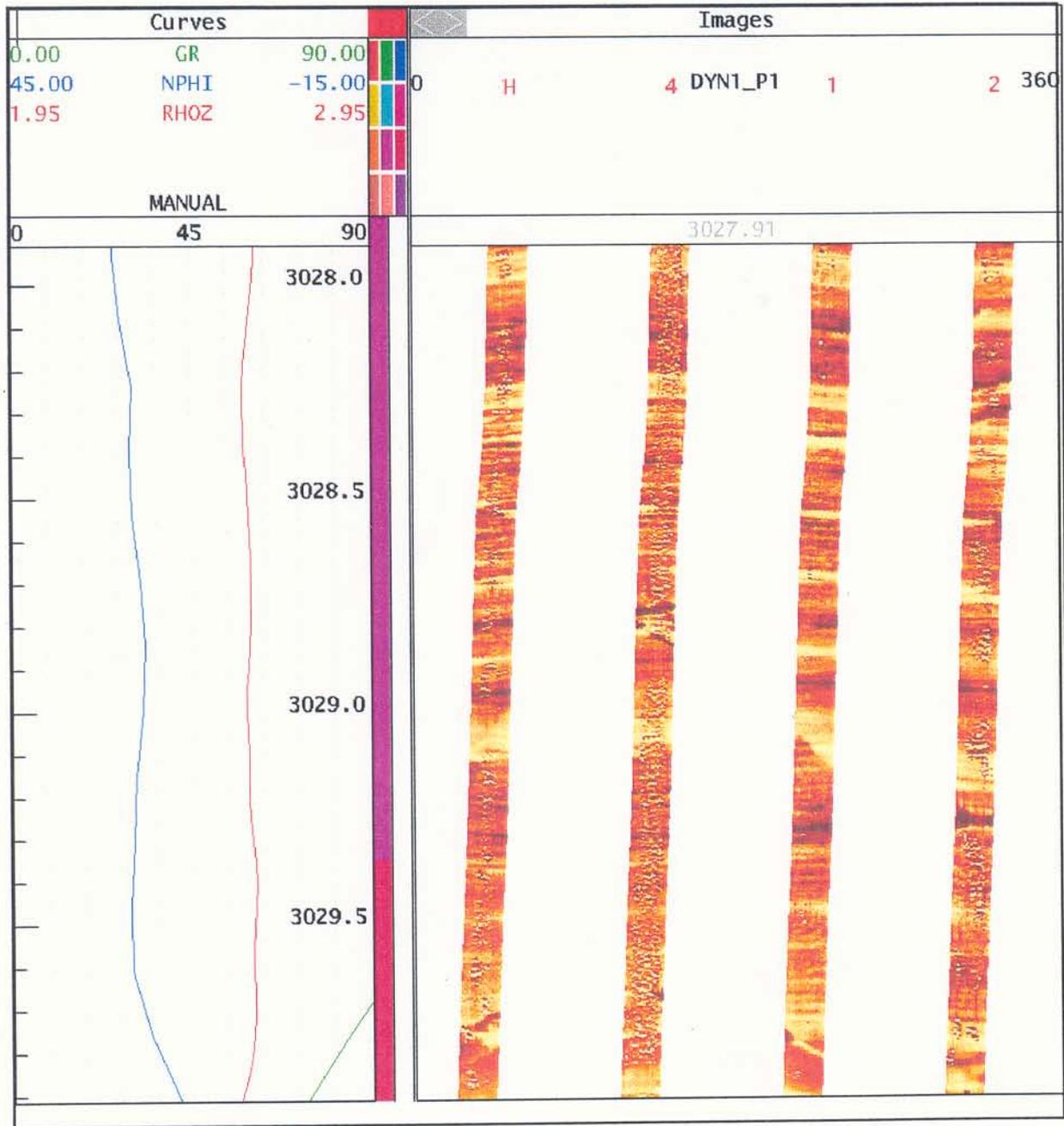
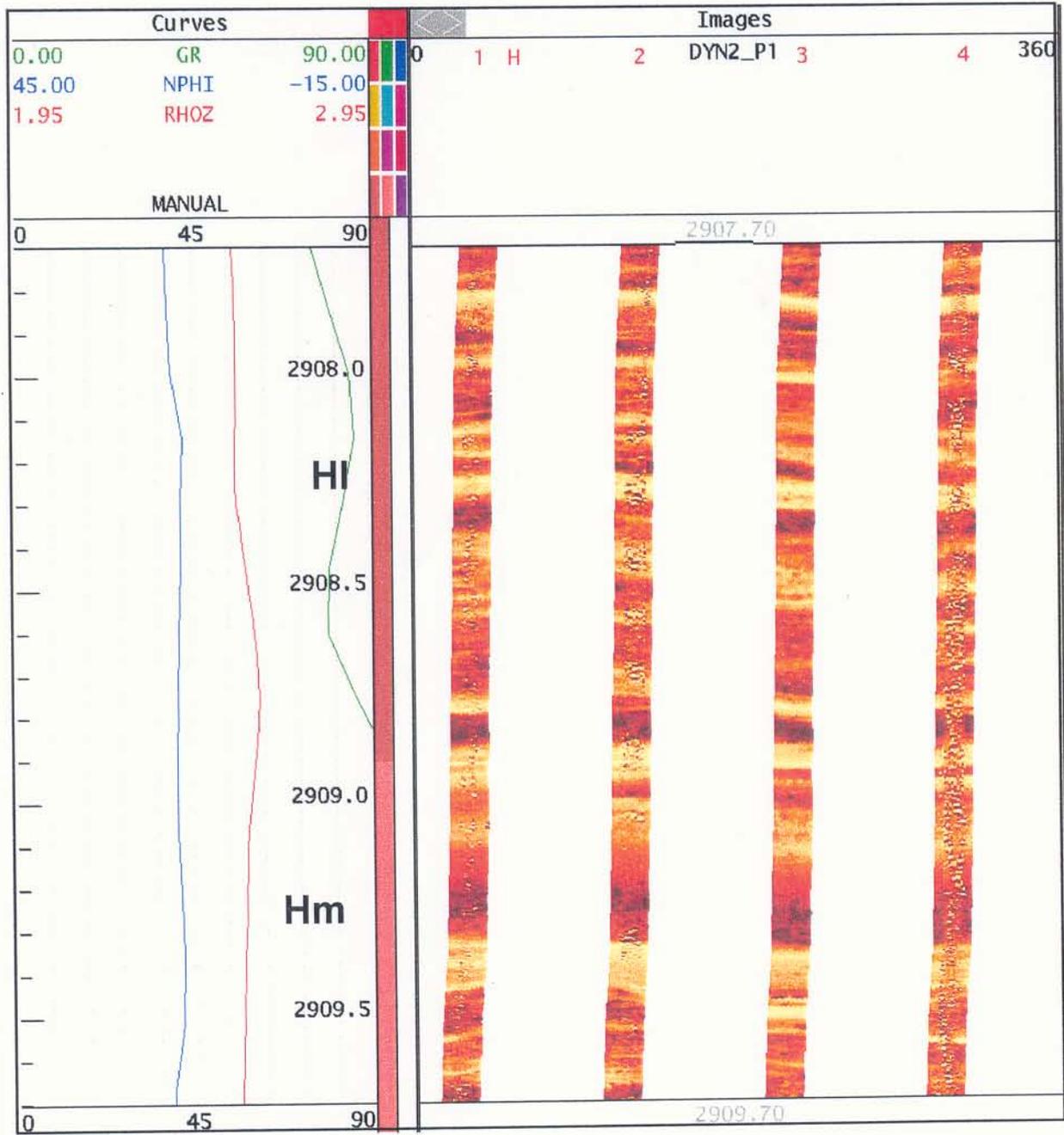
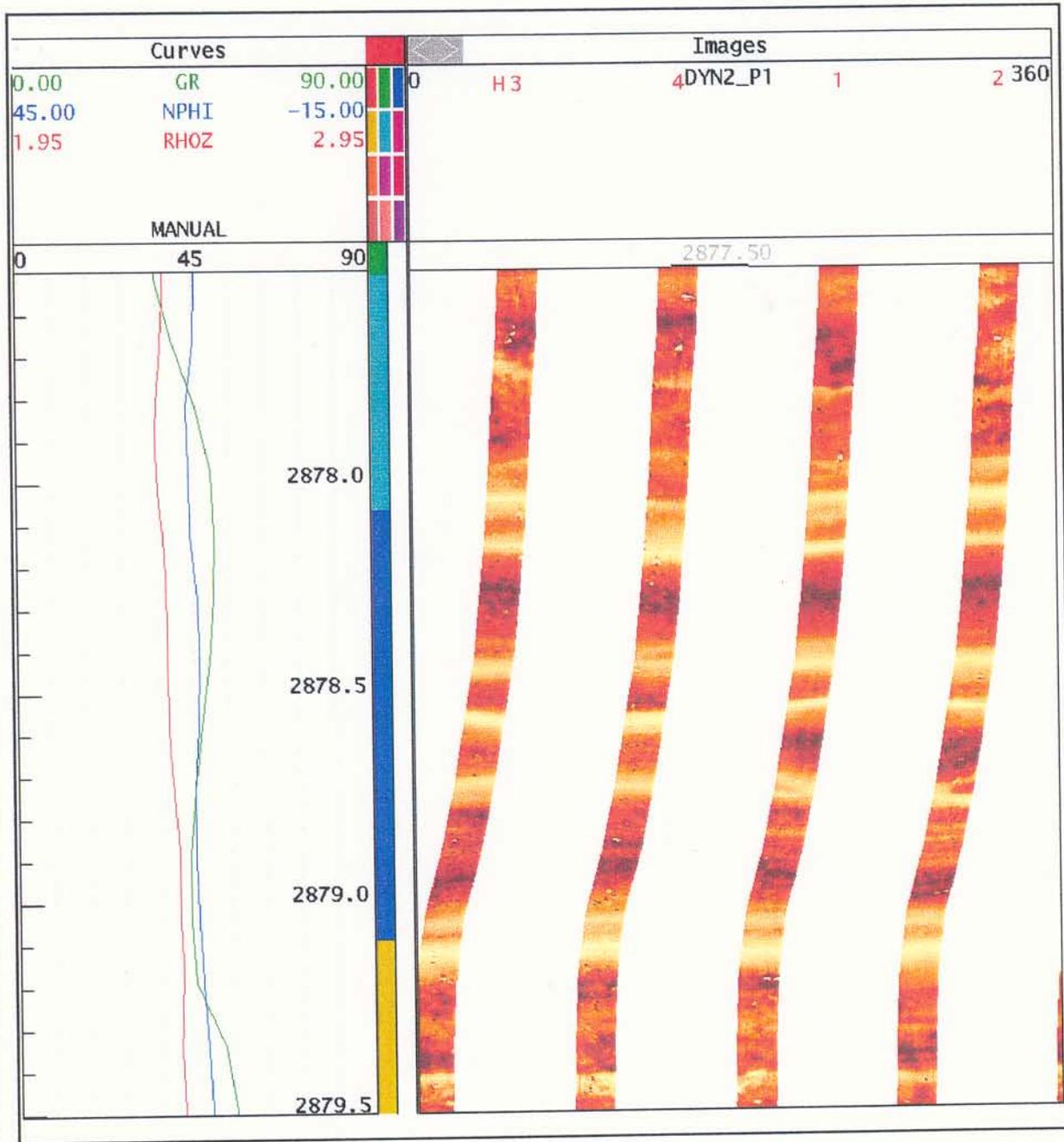


Figure 3.6 FMS image through well-laminated mudstone (lithofacies M1). Note resistive fracture at 3029 m.

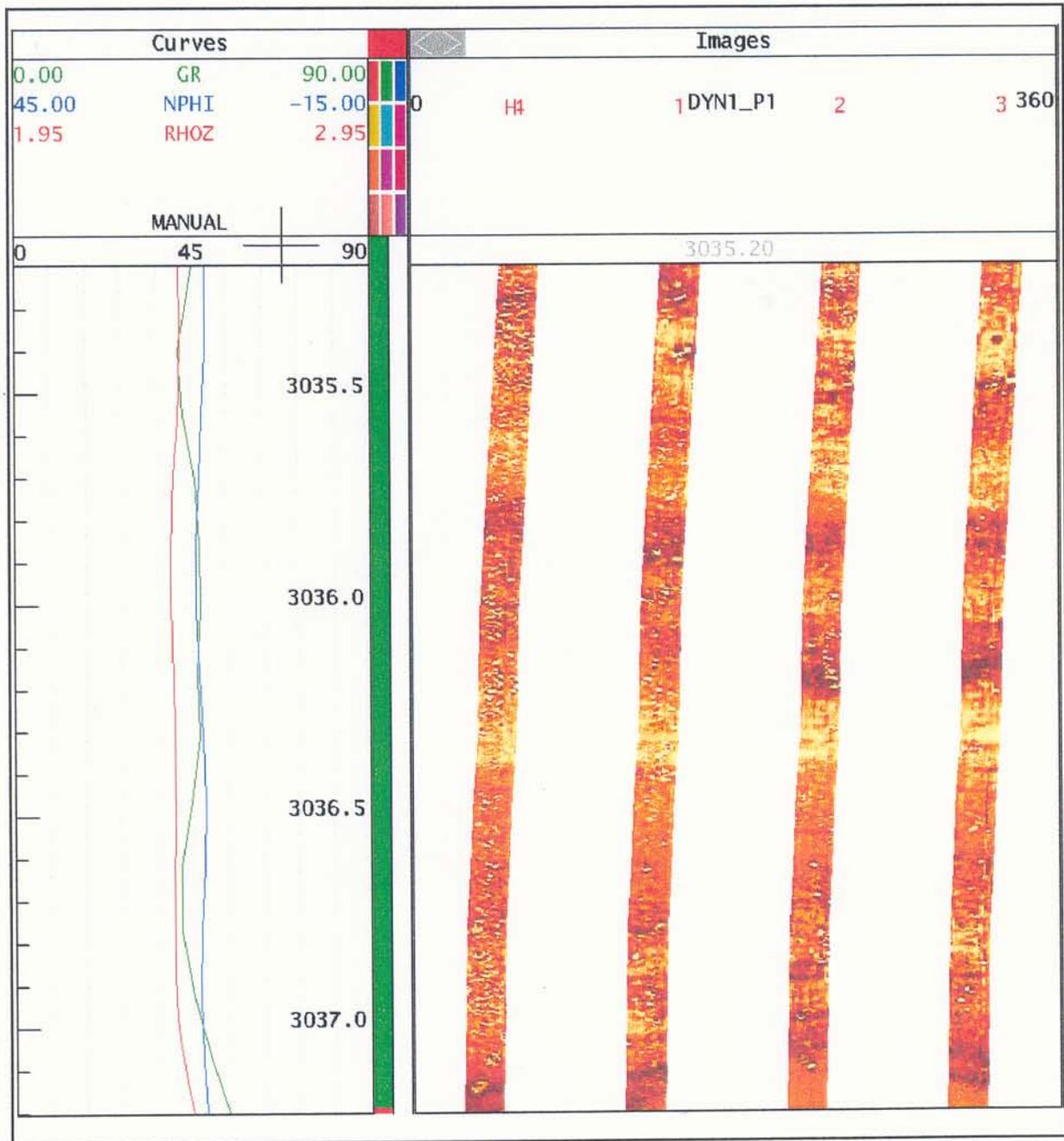


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**Figure 3.7** FMS image through dm-scale heterolithic sst-mudstone lithofacies with well developed lamination fabric (HI) 2907.5-2909 m, and less well developed fabric (Hm) 2909-2909.5 m.

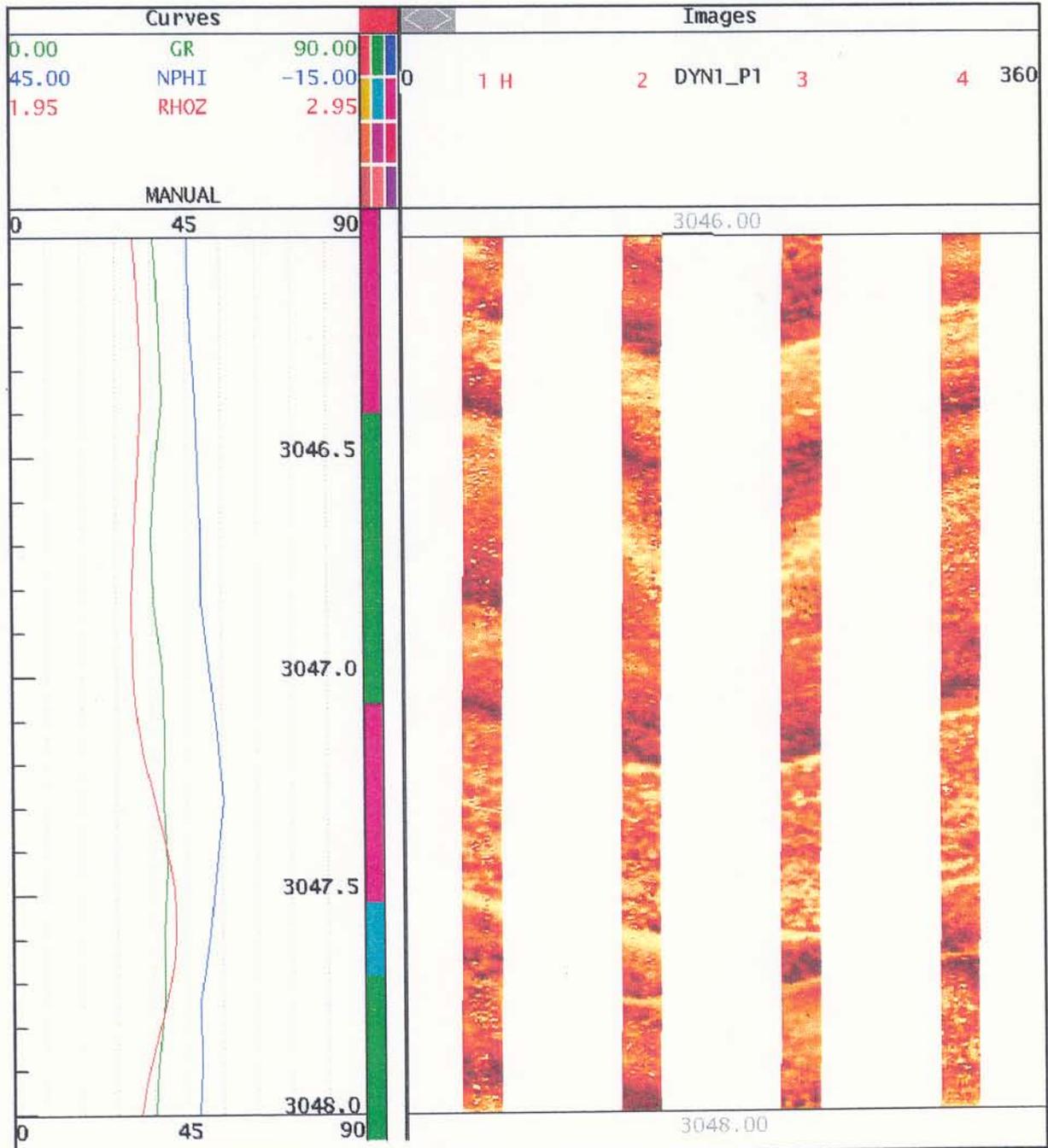


**Figure 3.8** FMS image illustrating mottled sandstones with vague lamination Sm(SI) 2977.5-2978 m and well laminated sandstone SI, 2878-2879 m.



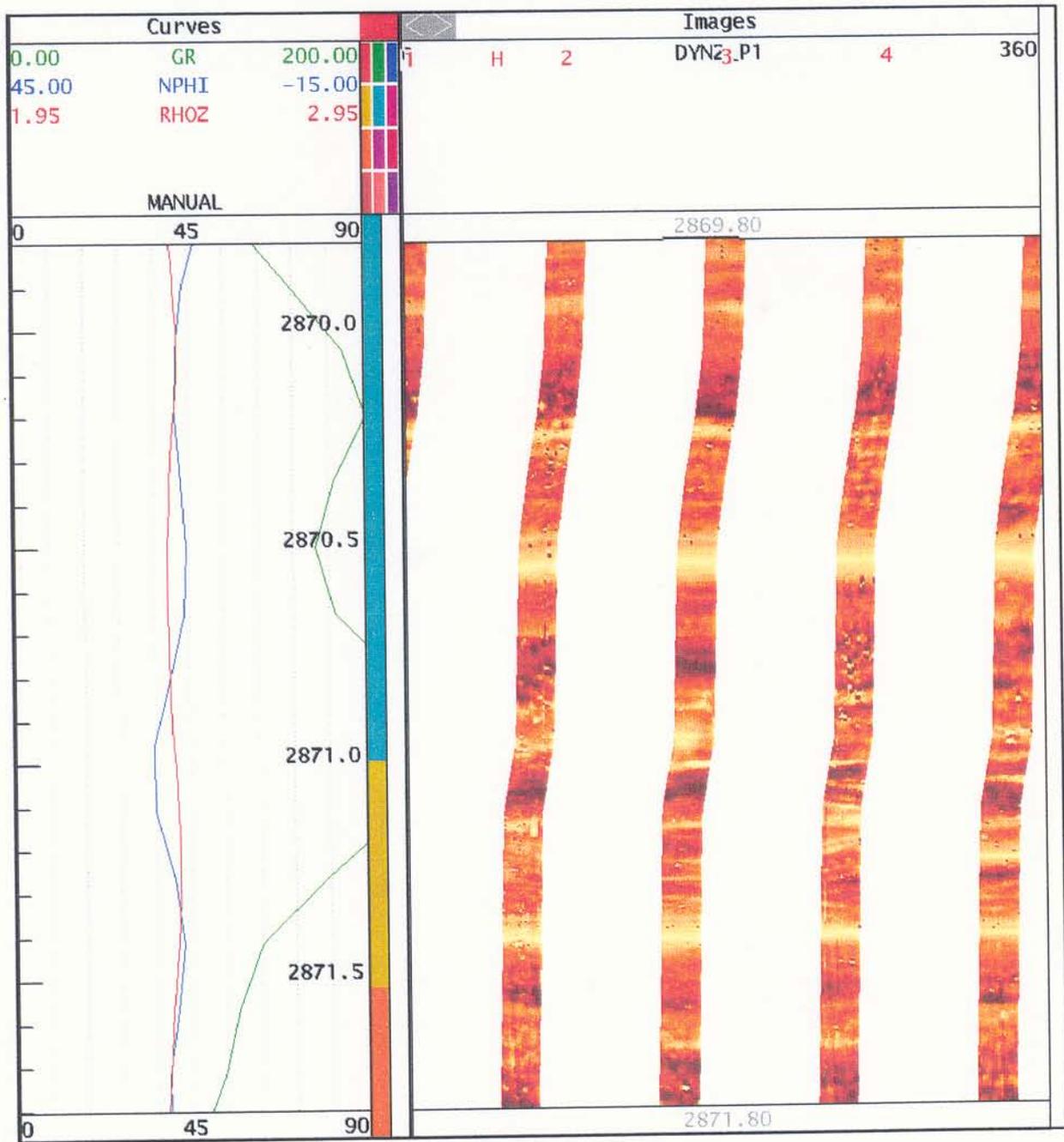
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Figure 3.9 FMS image illustrating sandstone with fine scale mottled fabric, Sm.



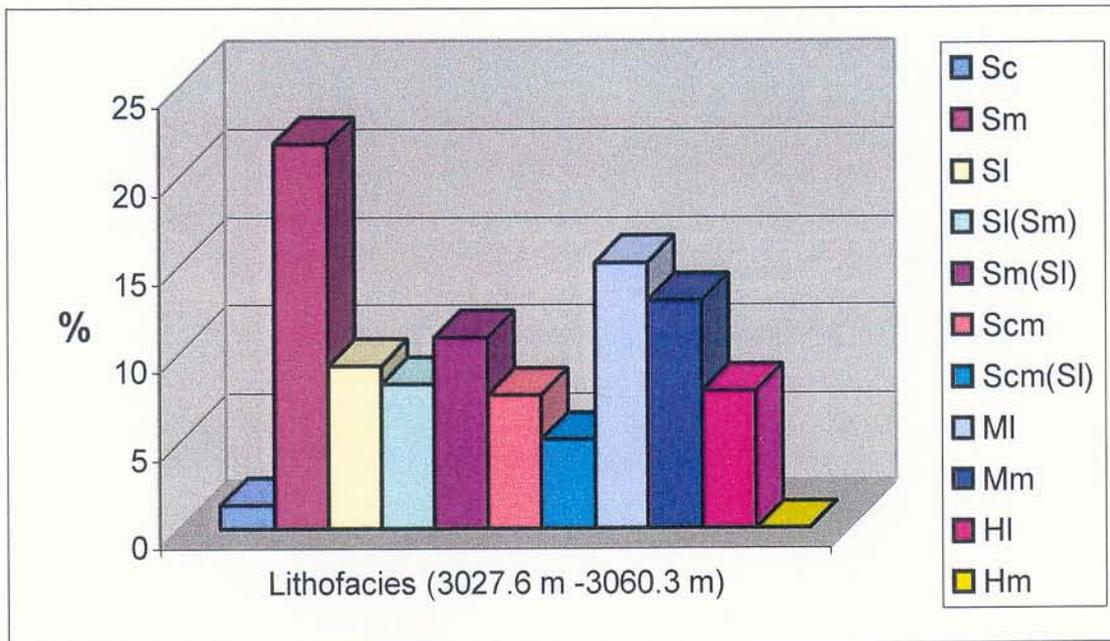
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**Figure 3.10** FMS image illustrating sandstone with coarse scale mottled fabric, Scm. Core calibration reveals these lithologies to comprise pebbly sandstones.

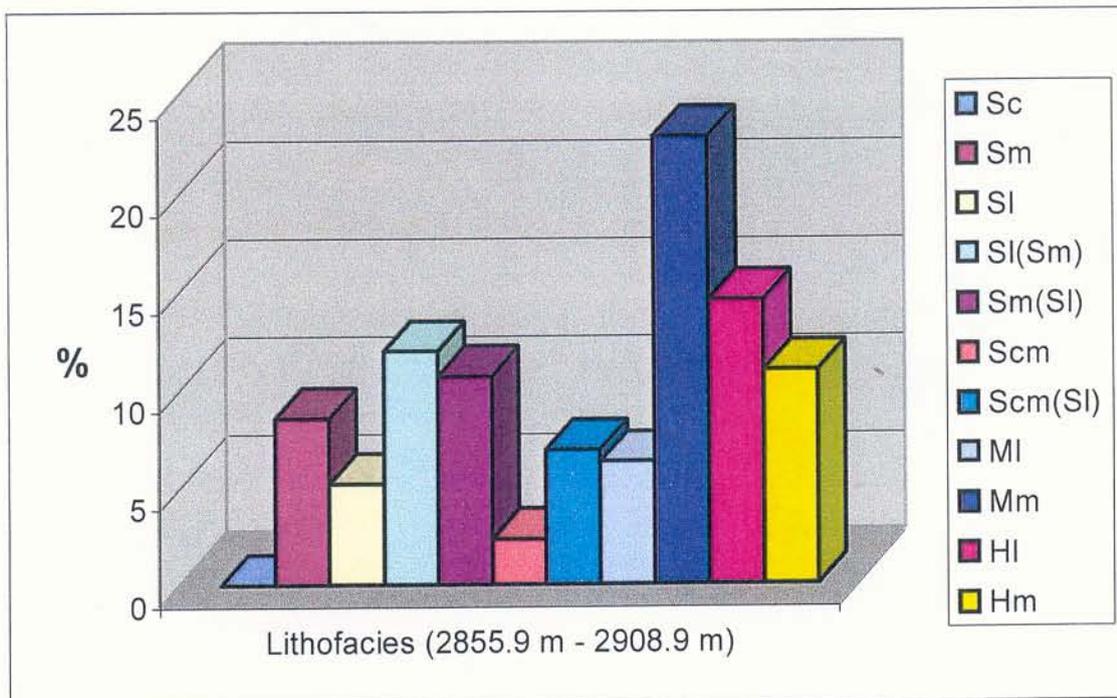


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**Figure 3.11** FMS image through "hot" sandstone at 2870-2871 m. Note poorly defined lamination in radioactive sst. The sand overlies a thin dm-scale cross stratified bed Sl(Sm) with only minor mottling (2871-2871.5m), which in turn rests upon pebbly lithologies Scm (2871m downwards).

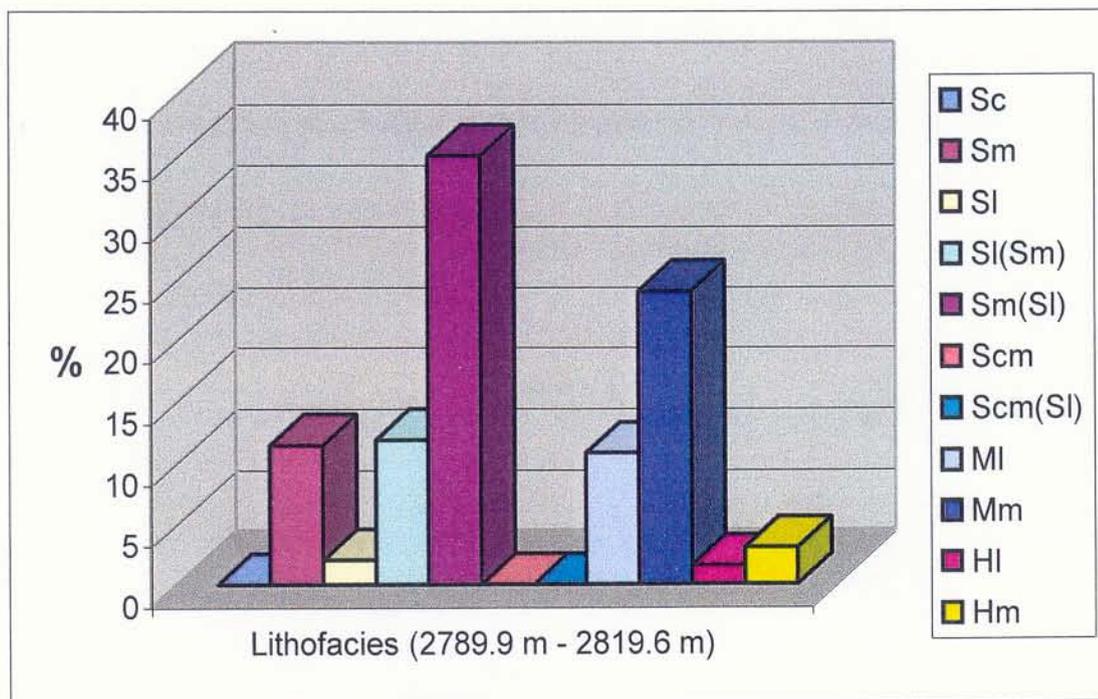


(A)

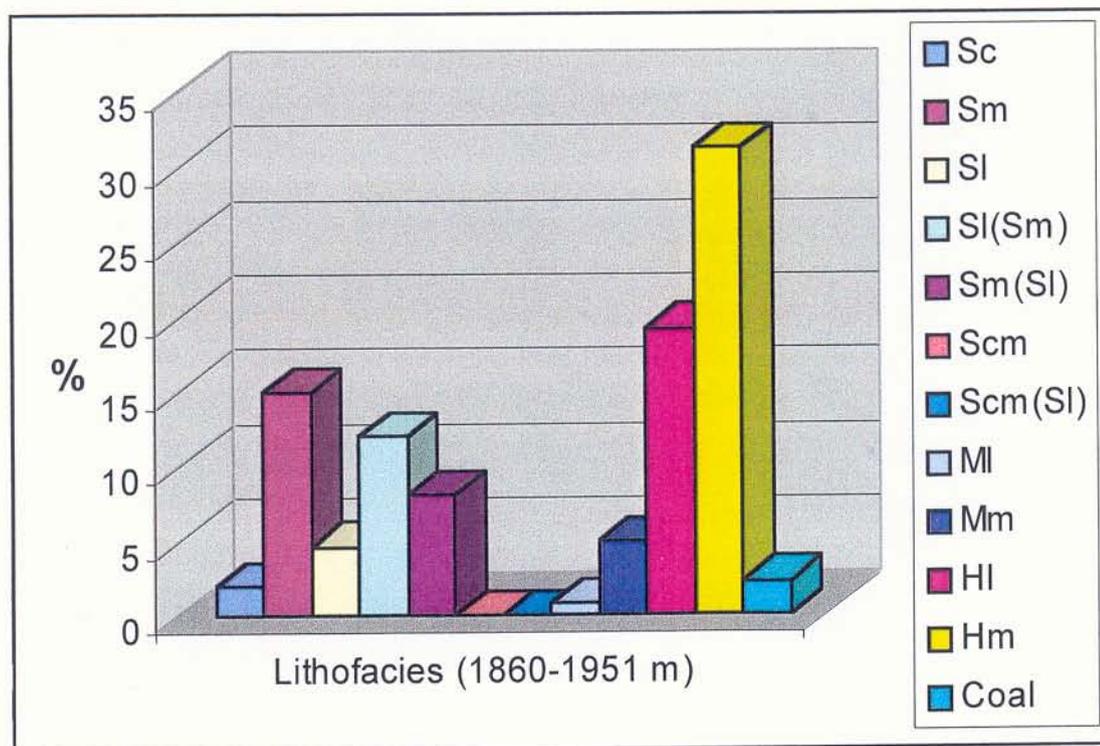


(B)

Figure 3.12 Lithofacies percentage in the studied intervals.

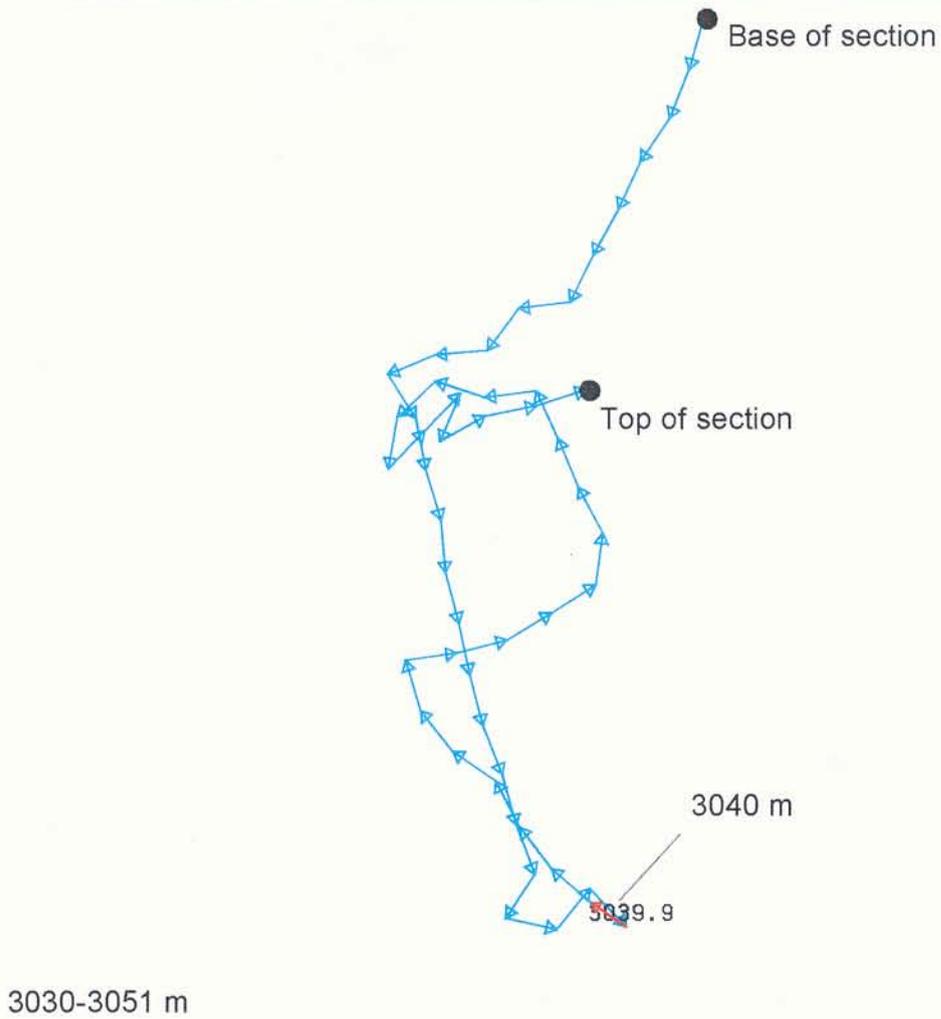
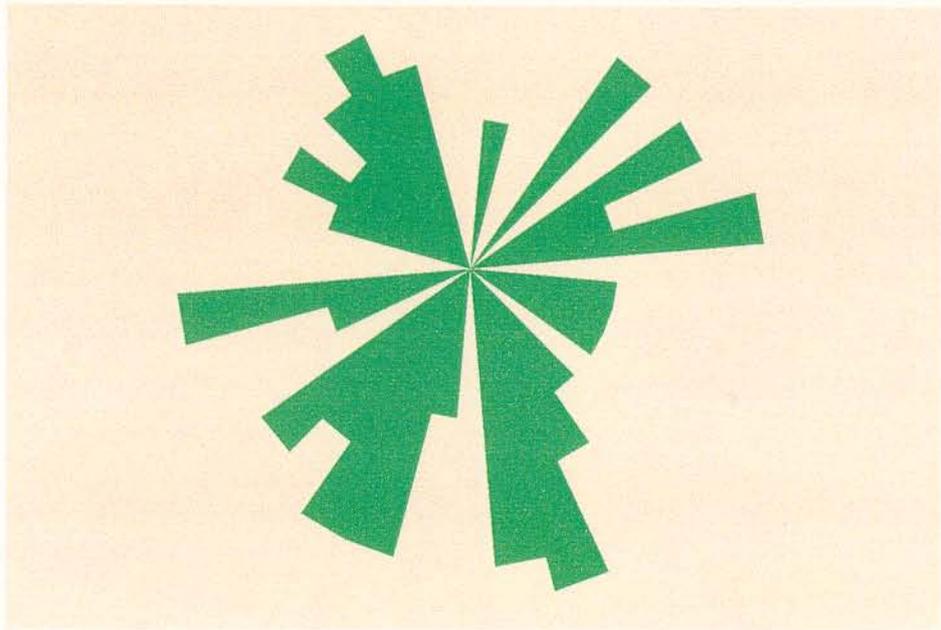


(C)

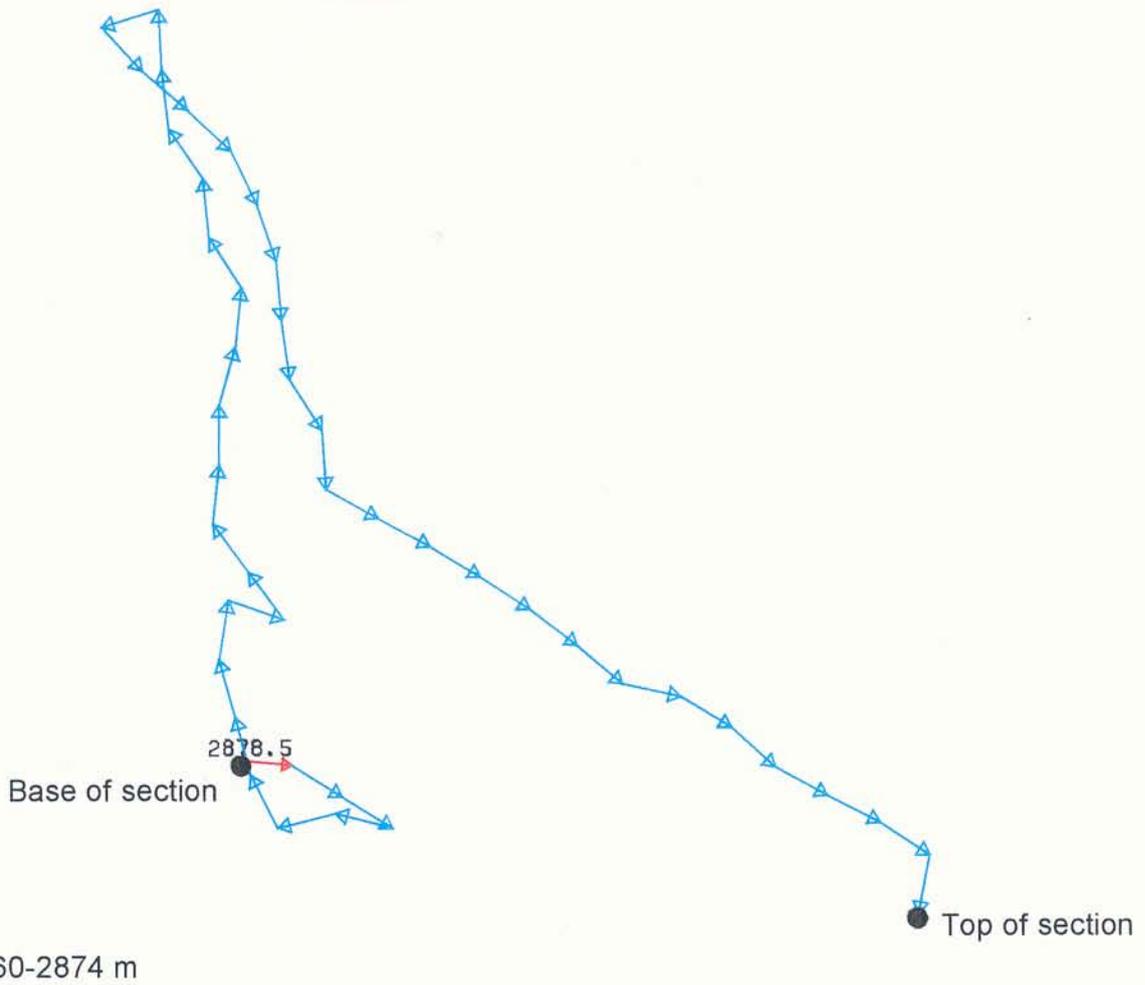
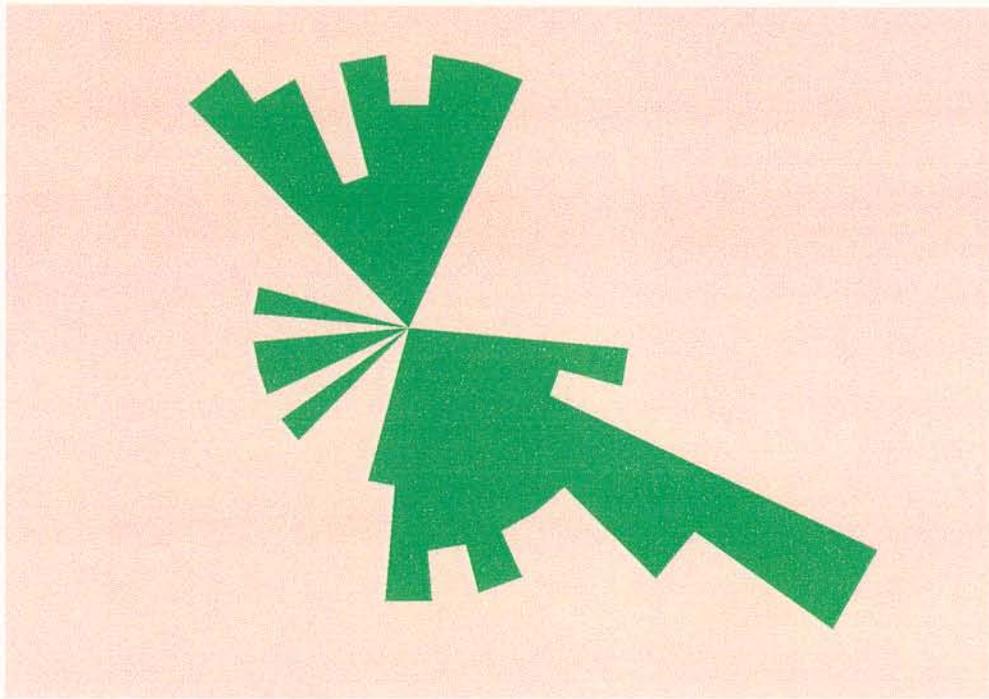


(D)

Figure 3.12 (cont) Lithofacies percentage in the studied intervals.

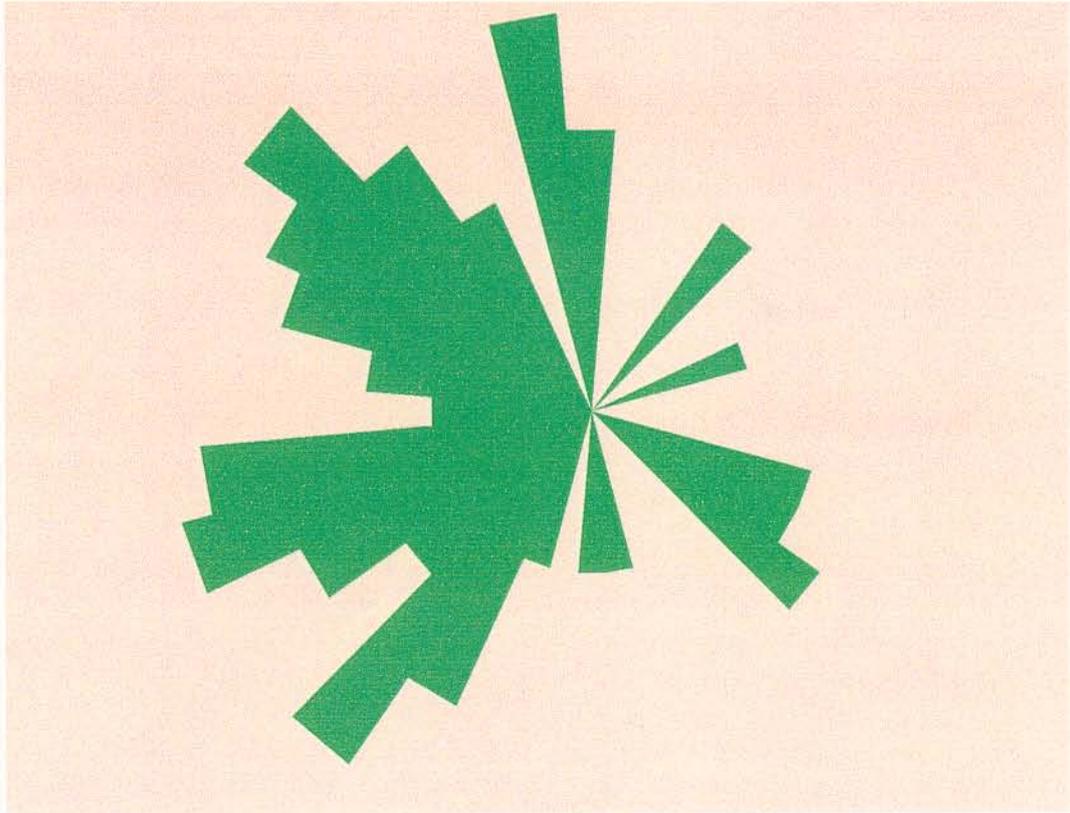


**Figure 3.13** Cumulative dip azimuth plot for intraset surfaces (ISS), structural dip removed. Note northerly azimuths above 3040 m, and southerly below 3040 m.



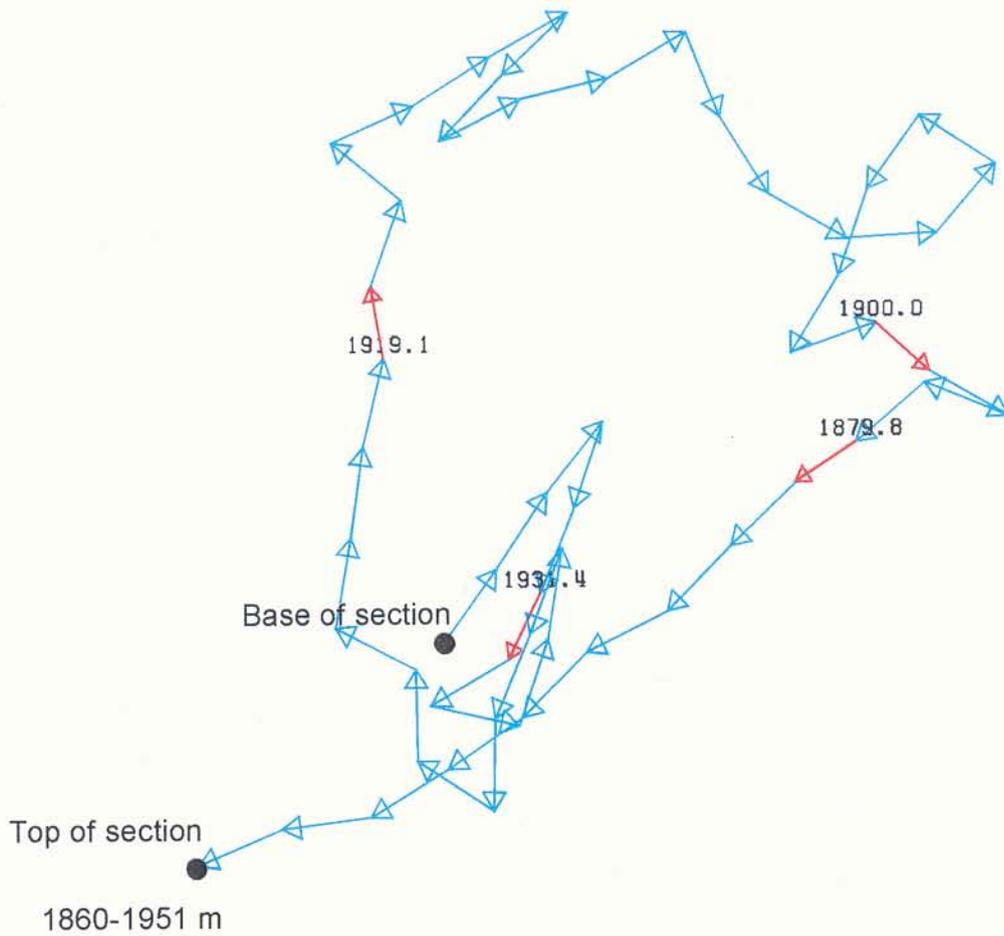
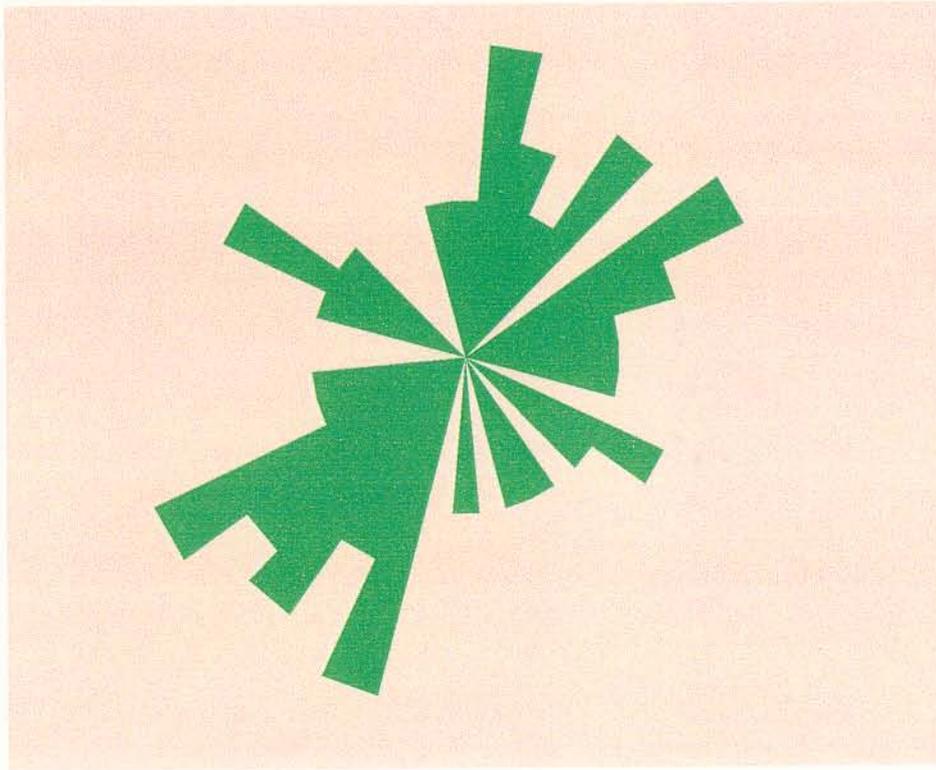
**Z&S (ASIA) LTD**

**Figure 3.14** Cumulative azimuth plot for intraset surfaces (ISS) in channelised deposits from interval 2860-2874 m. Structural dip removed.



**Z&S (ASIA) LTD**

**Figure 3.15** Cumulative dip azimuth plot for intraset surfaces (ISS) for channelised deposits within interval 2792-2814 m. Structural dip removed.



**Z&S (ASIA) LTD**

**Figure 3.16** Cumulative azimuth plot for intraset surfaces (ISS) in channelised deposits from interval 1860-1951m . Structural dip removed.

## APPENDICES

Top depth (metres)	Lithofacies
1859.3288	Hm
1859.5784	Sc
1859.9027	Sm
1860.6842	Hm
1861.6193	Sm
1861.9626	Hm
1863.2291	HI
1863.8048	Hm
1864.1385	Sm
1865.5845	Sc
1865.7706	Hm
1866.342	Sm
1866.6253	SI
1866.7945	Hm
1867.1836	Sm
1868.2027	Hm
1871.7945	Sm
1872.1764	Hm
1875.0275	HI
1875.6505	SI(Sm)
1876.0299	Sm
1876.5005	SI
1876.6745	Sm(SI)
1876.9435	Sm
1877.2868	Sm(SI)
1877.6685	Sm
1878.1332	Sm(SI)
1878.3061	Sm
1878.6374	Sm(SI)
1879.2965	Sm
1879.4406	Sm(SI)
1879.934	Sm
1880.2113	Sm(SI)
1880.3626	Sm
1880.5138	Sm(SI)
1880.6362	Sm
1880.9147	Sm(SI)
1880.9154	SI(Sm)
1882.0768	Sc
1882.7105	SI(Sm)
1882.8493	SI
1883.0222	SI(Sm)
1883.4356	SI
1883.797	Sc

1884.1931	SI(Sm)
1884.8594	Sm(SI)
1885.2058	SI
1887.1577	Sm(SI)
1888.1715	Sc
1888.402	SI(Sm)
1889.1975	Hm
1891.4321	Sm
1891.9124	Mm
1894.1284	Hm
1896.7922	HI
1896.7924	SI(Sm)
1897.2642	Hm
1898.013	HI
1898.7177	Hm
1899.6337	SI(Sm)
1900.0443	Hm
1900.3564	HI
1900.7009	Hm
1901.5593	HI
1901.6986	Hm
1904.5305	HI
1905.2651	Hm
1906.4596	HI
1908.0912	Hm
1908.8884	Sm(SI)
1909.1715	Sm
1909.7321	Sm(SI)
1910.7322	SI
1911.0083	SI(Sm)
1911.2628	Hm
1911.8248	SI
1912.1597	SI(Sm)
1912.6723	HI
1912.9652	SI(Sm)
1913.2665	Hm
1913.7179	Sm
1913.9363	SI(Sm)
1914.7833	Sm
1915.1831	SI(Sm)
1915.356	Sm
1915.8818	HI
1916.5993	Sm
1916.9027	SI(Sm)
1917.2905	HI
1918.1741	Hm
1918.6745	SI(Sm)
1919.3036	HI

1920.3949	SI(Sm)
1921.6541	Sm(SI)
1923.0635	Sm
1923.9458	SI(Sm)
1924.371	Sm(SI)
1924.7264	Sm
1924.9292	Sm(SI)
1925.5751	Coal
1926.3984	SI(Sm)
1926.9603	Hm
1927.3864	HI
1928.0323	Mm
1929.1595	MI
1929.2952	Coal
1929.8739	Sm
1931.1859	SI(Sm)
1931.5532	Coal
1932.2178	HI
1933.0005	MI
1933.3156	Mm
1933.6925	MI
1933.9747	Hm
1934.538	HI
1935.1739	Hm
1935.9795	HI
1936.7861	Hm
1937.2939	Mm
1938.0683	HI
1938.3444	Hm
1938.5665	HI
1940.5676	Hm
1940.9891	HI
1941.4861	Hm
1941.7658	HI
1943.1355	Hm
1943.6245	HI
1944.3867	Hm
1944.5692	HI
1944.9558	Hm
1945.1743	HI
1946.1527	Hm
1946.4167	HI
1947.0591	Sm
1947.6071	SI(Sm)
1948.379	SI
1949.1497	Sm
1949.4462	Sm
1950.2169	Sm

Top depth (metres)	Lithofacies
2789.9362	Mm
2792.5798	HI
2792.5798	Hm
2793.1435	MI
2793.5825	Sm
2793.5825	Hm
2793.8963	SI(Sm)
2794.4043	Sm
2794.7395	Sm(SI)
2795.7473	SI(Sm)
2796.9202	SI
2797.5185	Sm
2797.9123	SI(Sm)
2798.3139	Sm(SI)
2798.6889	SI(Sm)
2799.7287	Sm(SI)
2804.2766	MI
2805.9362	Mm
2806.4123	Sm(SI)
2806.9335	Sm
2807.6914	Hm
2808.0372	HI
2808.4946	SI(Sm)
2808.4947	Sm(SI)
2809.1304	SI(Sm)
2809.5771	Sm
2810.6091	Sm(SI)
2812.814	Mm
2813.4282	Sm(SI)
2814.2927	Sm
2814.9097	Sm(SI)
2815.3271	MI
2815.7287	Mm
2816.0665	MI
2816.1941	Mm
2817.3776	MI
2817.6569	Mm
2818.9468	MI
2819.0798	Mm
2819.3989	MI
2819.609	Mm
2855.9787	MI
2858.0691	Mm
2858.4574	MI

2858.6091	Mm
2859.3803	Sm
2859.978	Sm(SI)
2860.3405	Sm
2860.8032	Sm(SI)
2860.9228	SI(Sm)
2861.9176	Sm
2862.2048	Sm(SI)
2862.7606	Sm
2863.0452	SI(Sm)
2863.6223	SI(Sm)
2864.5984	Sm
2864.9793	Scm(SI)
2867.8198	Sm(SI)
2869.0957	SI
2869.6755	Sm(SI)
2870.9973	SI(Sm)
2871.5178	Scm(SI)
2872.3874	Scm
2873.6402	HI
2874.9734	HI
2875.4787	Mm
2876.5532	Sm
2877.5066	Sm(SI)
2878.0652	SI
2879.0904	SI(Sm)
2879.9401	HI
2881.5452	Hm
2882.2287	Hm
2883.0059	HI
2883.3936	Hm
2884.1755	Mm
2885.7554	MI
2886.8989	Mm
2895.4573	HI
2899.3564	SI(Sm)
2900.1223	Sm
2901.3697	Sm(SI)
2902.5691	SI(Sm)
2903.1914	Hm
2903.6436	HI
2904.3271	SI(Sm)
2904.6941	Sm(SI)
2905.0559	SI(Sm)
2905.5266	SI
2905.7872	HI
2906.0132	SI
2906.2686	Sm

2906.6516	SI(Sm)
2906.9415	SI
2907.5957	HI
2908.9016	Hm
3027.6836	MI
3029.3484	Mm
3029.9629	Sm
3030.6216	Sm(SI)
3031.4895	Sm
3032.4681	Sm(SI)
3032.686	Sm
3033.1914	Sm(SI)
3033.6436	Sm
3034.3288	Sm(SI)
3034.3298	SI(Sm)
3035.1543	Sm
3037.1892	Sc
3037.6414	Sm(SI)
3038.0239	SI(Sm)
3038.2554	SI
3038.6516	SI(Sm)
3039.593	SI
3040.9876	MI
3041.9441	Mm
3042.1569	Sm
3042.3112	Sm(SI)
3042.9946	Scm
3043.6809	Scm(SI)
3044.9942	Scm
3046.3984	Sm
3047.0633	Scm
3047.5181	Sm(SI)
3047.6865	Sm
3048.54	SI
3049.0638	Sm
3049.8505	Scm(SI)
3050.2415	SI(Sm)
3050.9973	HI
3051.9309	SI
3052.7234	HI
3053.5931	Mm
3053.9123	MI
3054.1862	Mm
3057.3721	MI
3059.5266	Sm(SI)
3060.3911	HI

**ENCLOSURES**

**ENCLOSURE 1**

Scale 1:500 Quality Control plot of FMS log  
(1860 – 1951 m)



**ENCLOSURE 2**

Scale 1:500 Quality Control plot of FMS log  
(2760 – 3080 m)

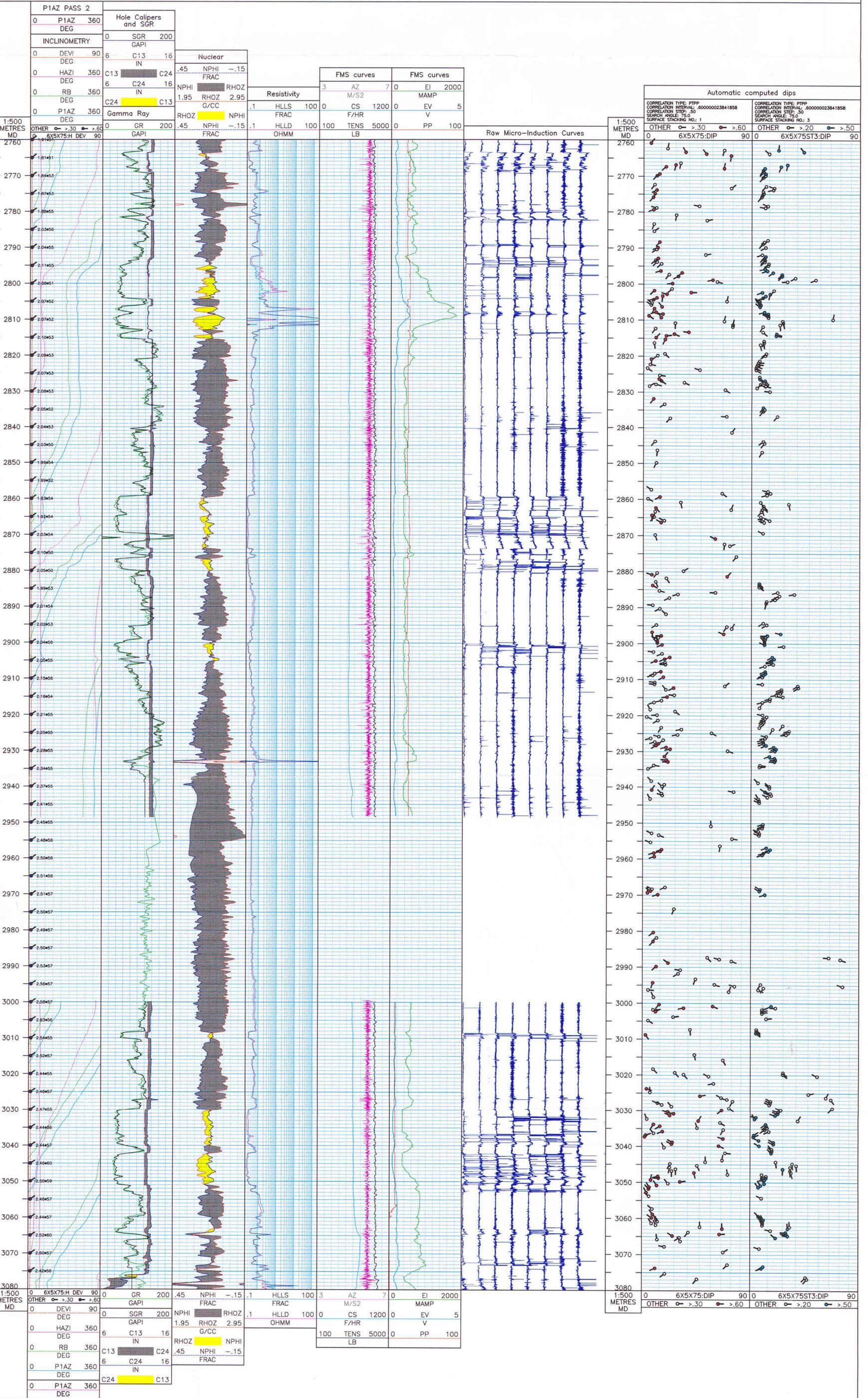


# PREMIER OIL AUSTRALIA YOLLA-2

Enclosure 2

## 1:500 QUALITY CONTROL PLOT

BIT SIZE: 12.25 IN  
 BH TEMP: 128 DEGC  
 BOREHOLE SALINITY: 39000 PPM  
 FLUID LOSS: 5.5 cm<sup>3</sup>  
 MAGNETIC DECLINATION: 12.5778000000 DEG  
 MAGNETIC INCLINATION: -70.6549000000 DEG  
 MUD DENSITY: 1.13 G/CC  
 MUD PH: 8.8  
 MUD TYPE: KCI / PHPA  
 MUD VISCOSITY: 44 S  
 SURF. LATITUDE: 39 51' 33.820" S  
 SURF. LONGITUDE: 145 48' 38.530" E  
 RUN DATE: 17-MAY-1998  
 DEPTH RANGE: 2760.00-3080.00 METRES



**ENCLOSURE 3**

Scale 1:500 Overview Structural Summary log  
(1860 – 1951 m)

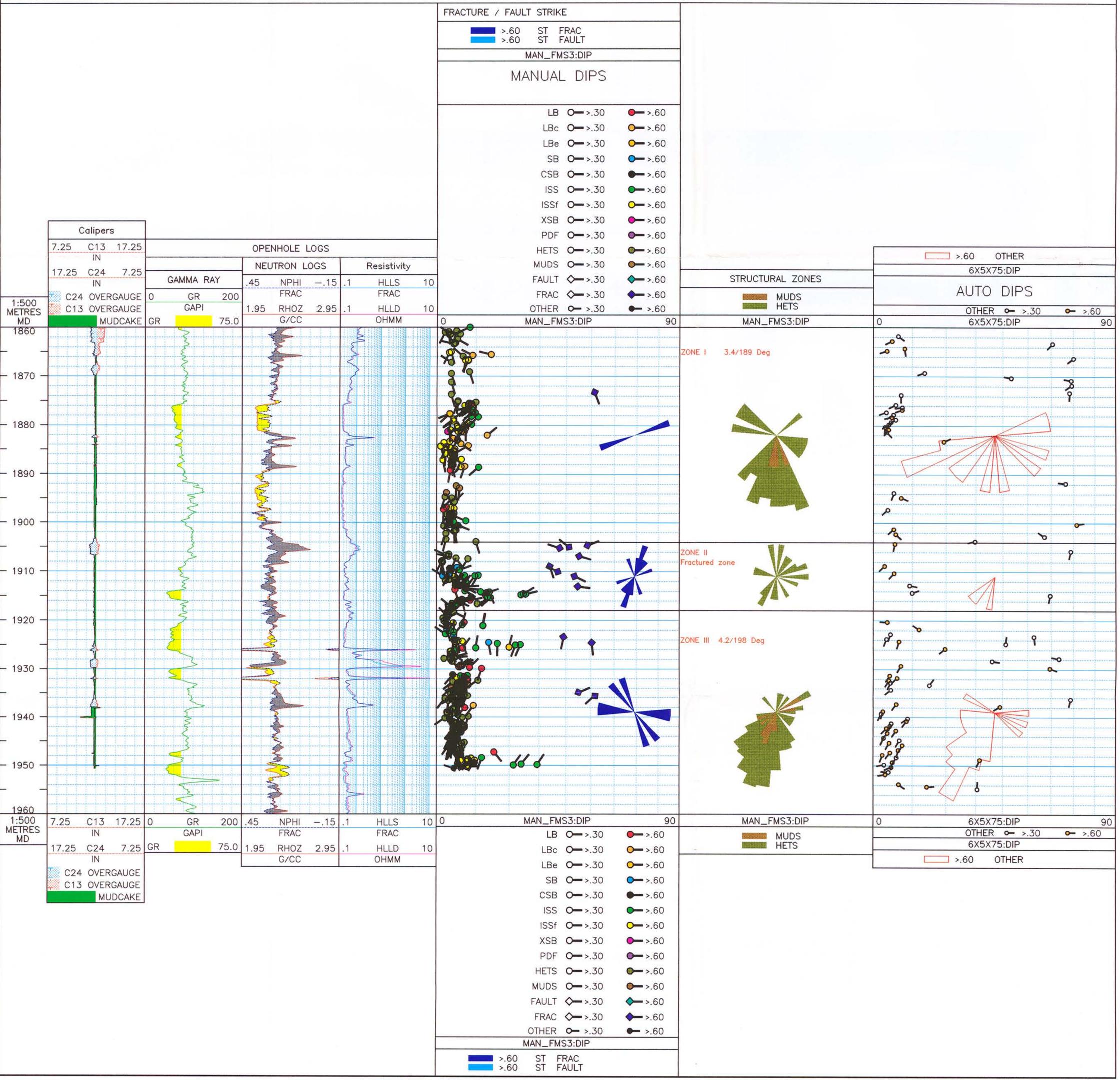


# Premier Oil Australia YOLLA-2

Enclosure 3

1860.00-1960.00 METRES

1:500 STRUCTURAL SUMMARY PLOT



**ENCLOSURE 4**

Scale 1:500 Overview Structural Summary log  
(2760 – 3080 m)

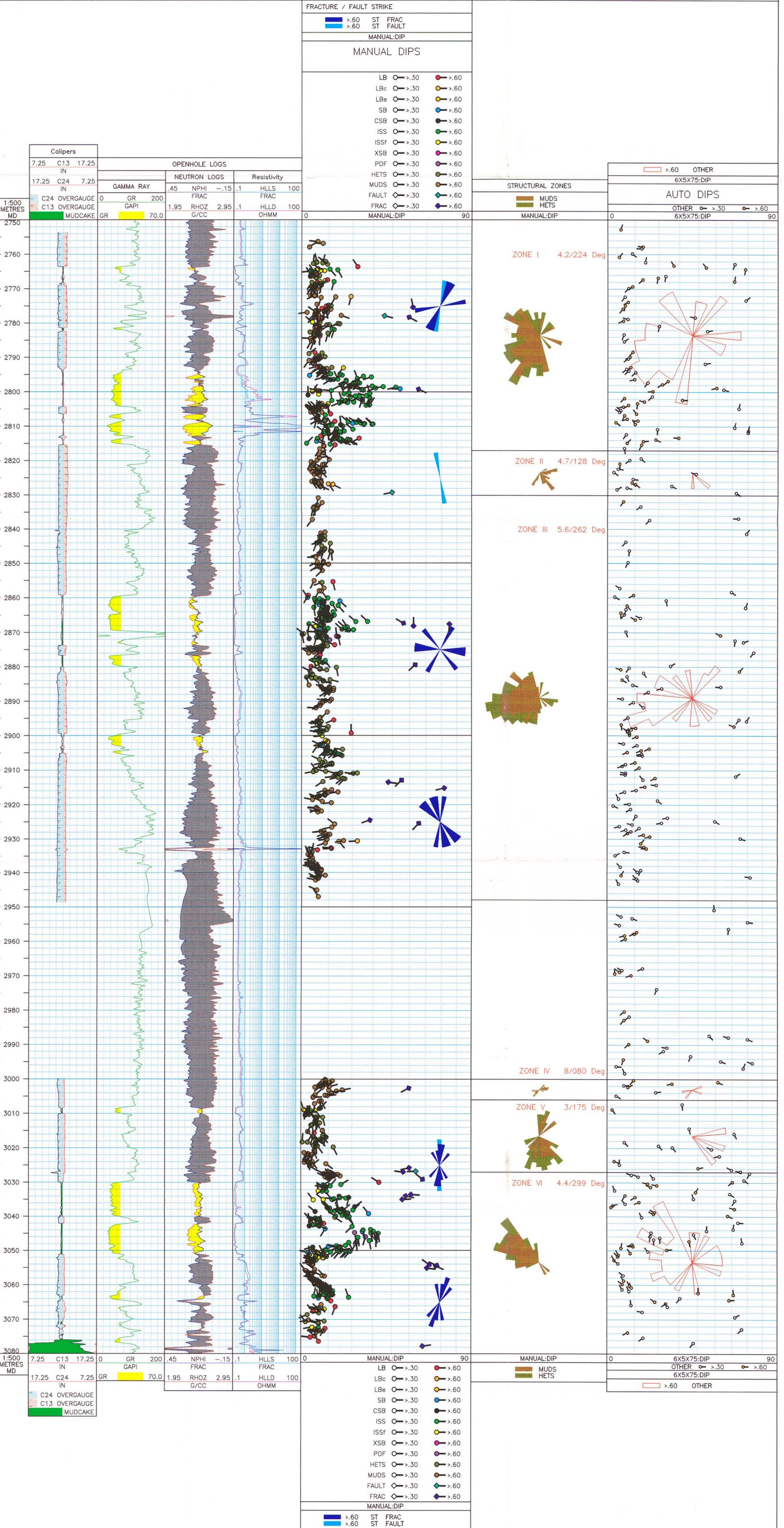


# Premier Oil Australia YOLLA-2

Enclosure 4

2750.00-3080.00 METRES

1:500 STRUCTURAL SUMMARY PLOT



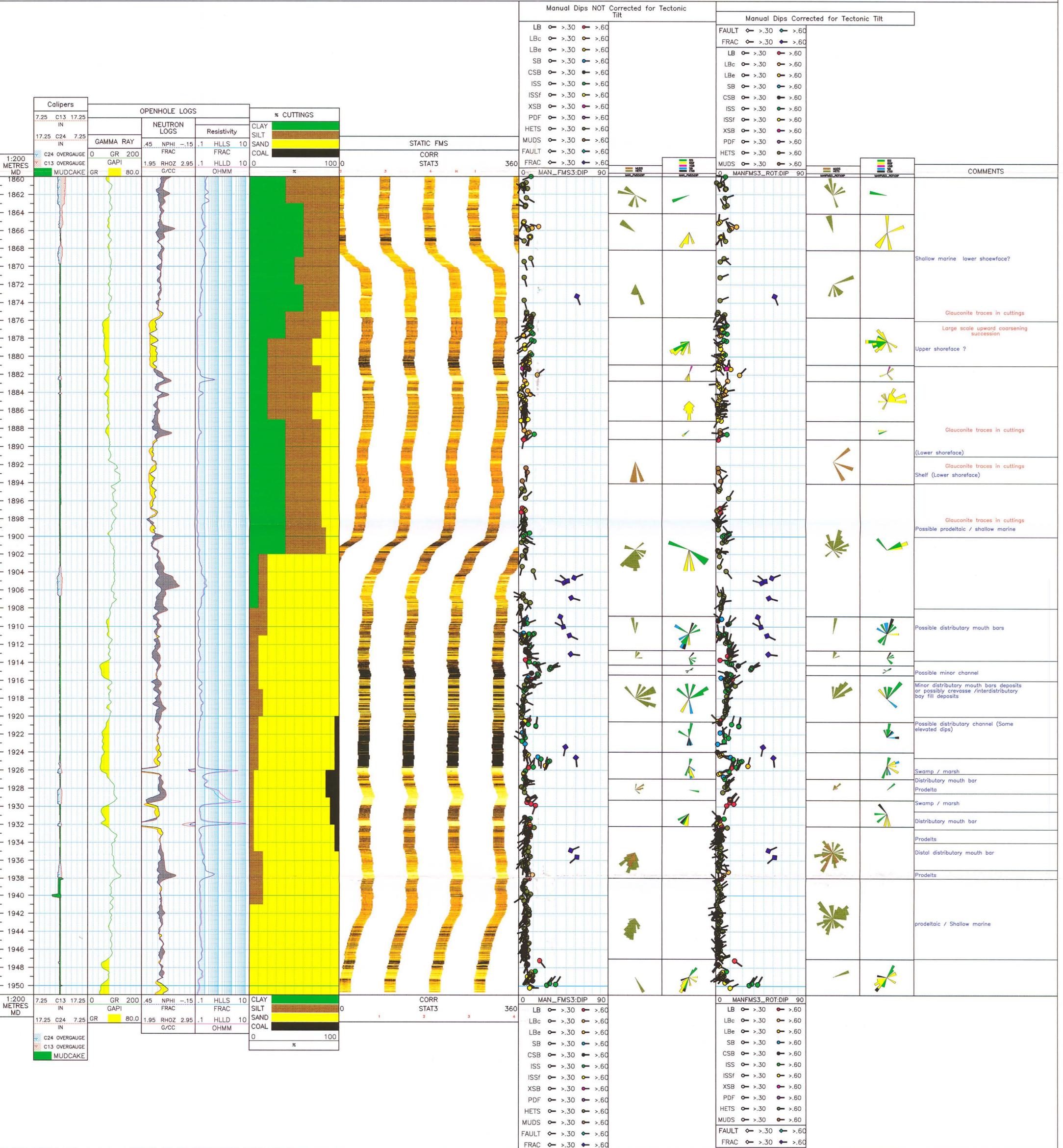
**ENCLOSURE 5**

Scale 1:200 Data Overview Plot  
(1860 – 1951 m)



1860.00-1951.00 METRES

## 1:200 Data Overview Plot



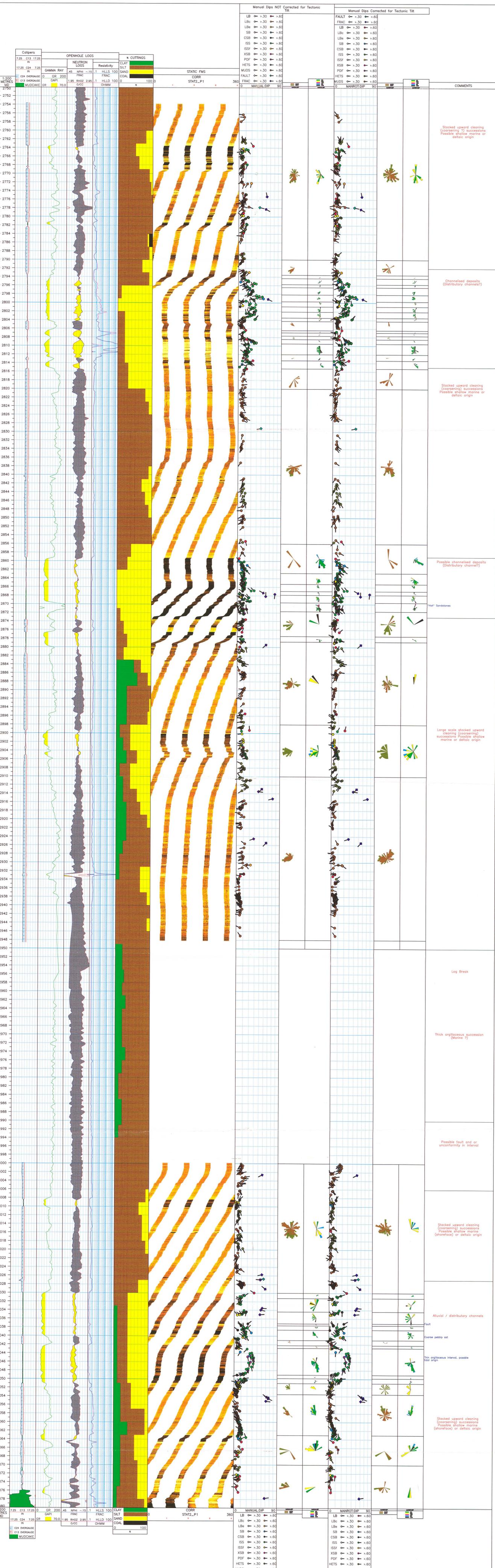
**ENCLOSURE 6**

Scale 1:200 Data Overview Plot  
(2760 – 3080 m)



2750.00-3080.00 METRES

1:200 Data Overview Plot



Legend for Callipers: C24 OVERGAUGE, C13 OVERGAUGE, MUDCAKE

Legend for OPENHOLE LOGS: GAMMA RAY, GAPI, NPHI, RHOD, GVIC

Legend for NEUTRON LOGS: NPHI, RHOD, GVIC

Legend for RESISTIVITY: HLLS, HLLD

Legend for CUTTINGS: CLAY, SILT, SAND, COAL

Legend for MANUAL DIPS: LB, LBc, LBe, SB, CSB, ISS, XSB, PDF, HETS, MUDES, FAULT, FRAC

Legend for MANUAL DIPS CORRECTED: FAULT, FRAC, LB, LBc, LBe, SB, CSB, ISS, XSB, PDF, HETS, MUDES, FAULT, FRAC

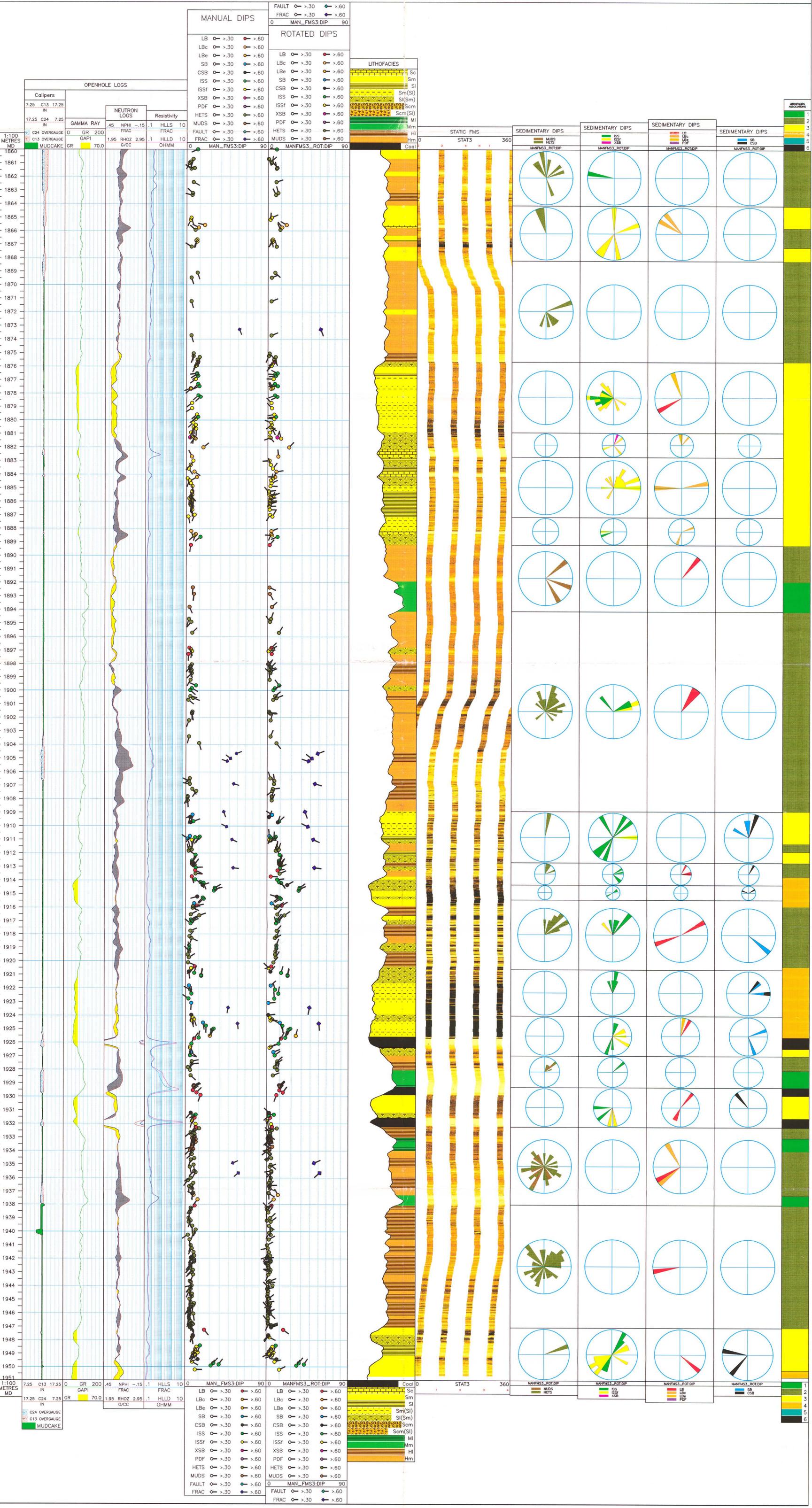
**ENCLOSURE 7**

Scale 1:100 Sedimentological Summary Plot  
(1860 – 1951 m)



1:100 Sedimentological Composite Plot

1860.00-1951.00 METRES



**ENCLOSURE 8**

Scale 1:100 Sedimentological Summary Plot  
(2790 – 2820 m)

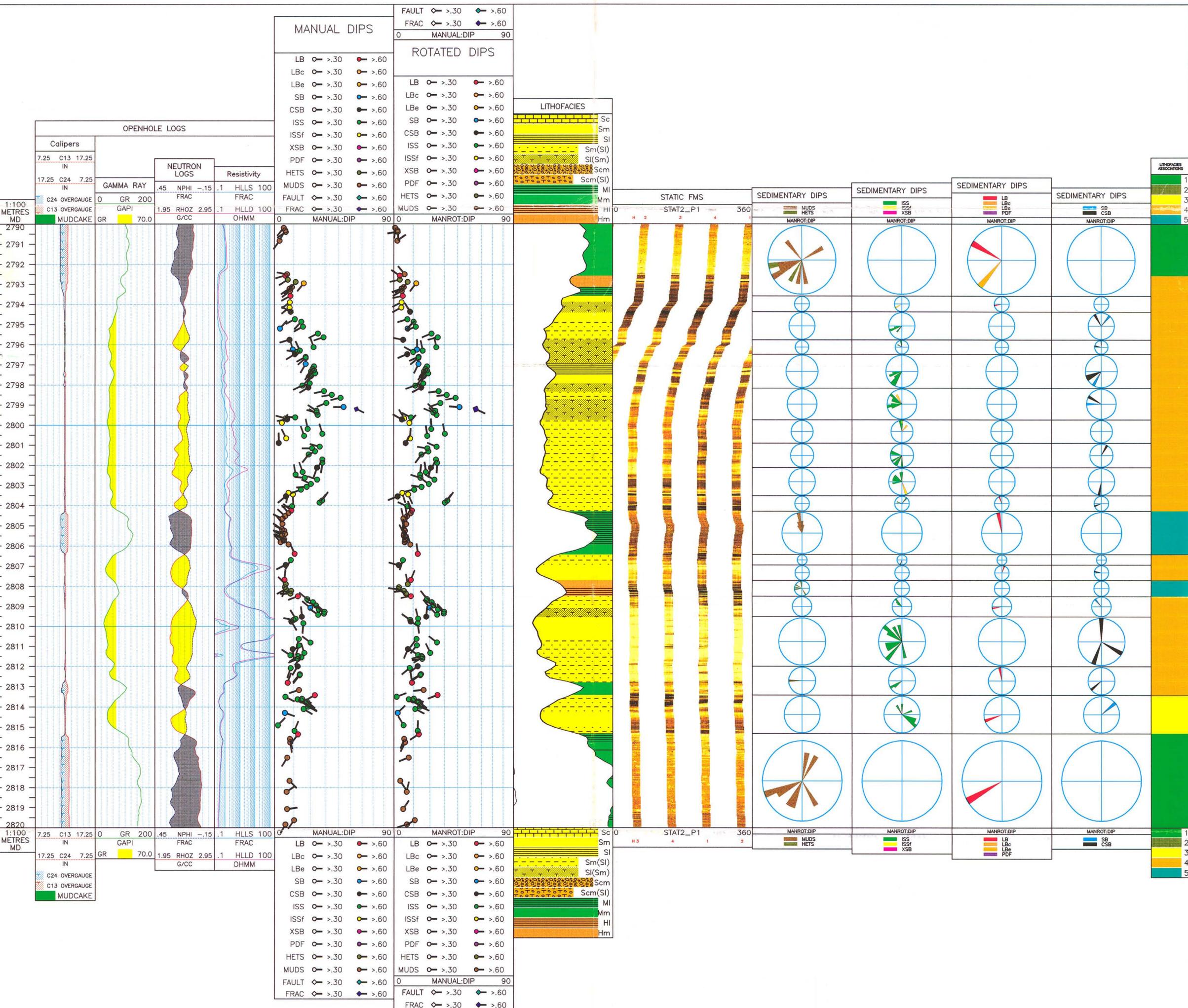


# Premier Oil Australia Yolla-2

Enclosure 8

2790.00-2820.00 METRES

1:100 Sedimentological Composite Plot



**ENCLOSURE 9**

Scale 1:100 Sedimentological Summary Plot  
(2856 – 2910 m)

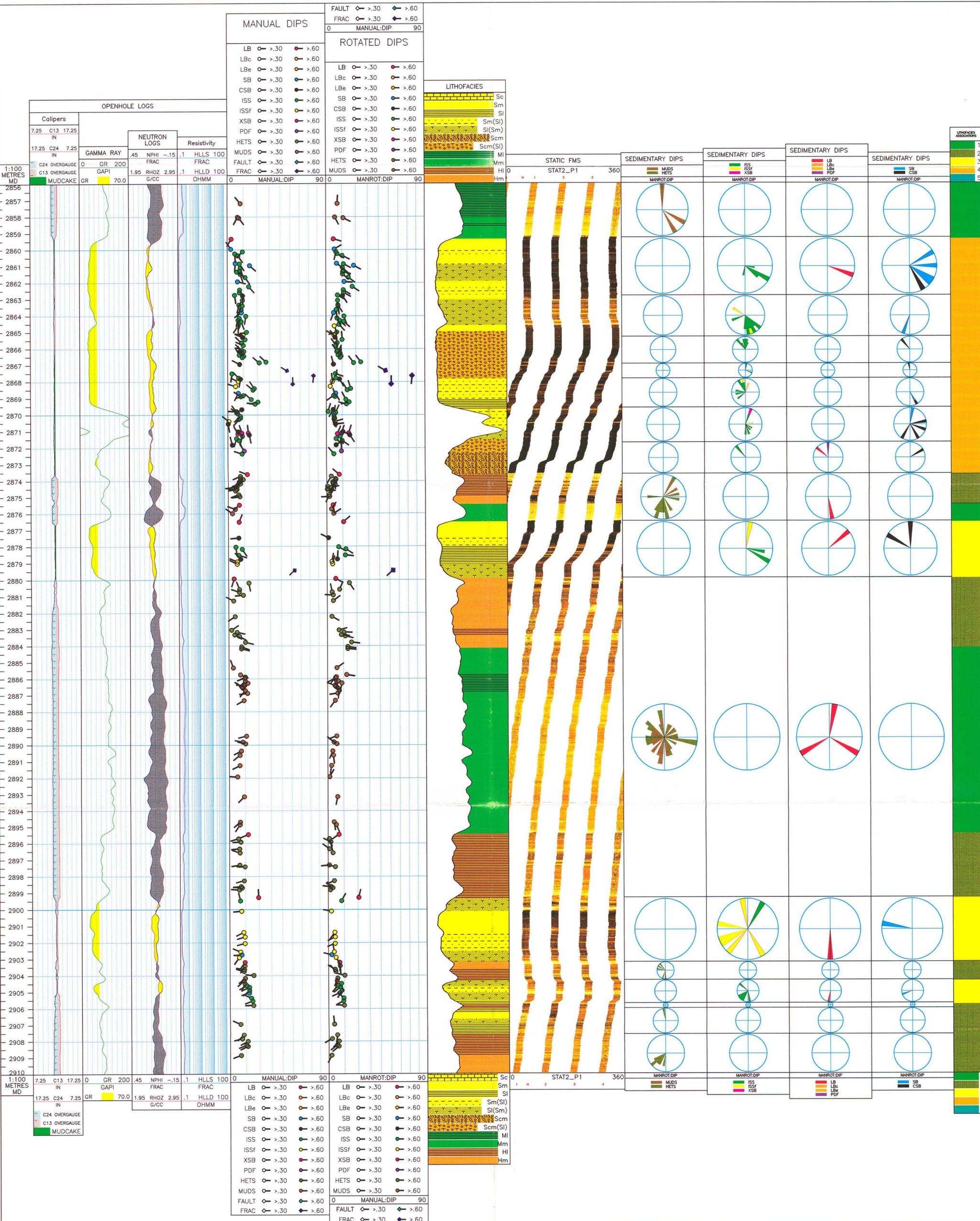


# Premier Oil Australia YOLLA-2

Enclosure 9

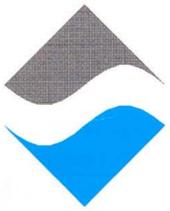
2856.00-2910.00 METRES

1:100 Sedimentological Composite Plot



**ENCLOSURE 10**

Scale 1:100 Sedimentological Summary Plot  
(3030 – 3060 m)

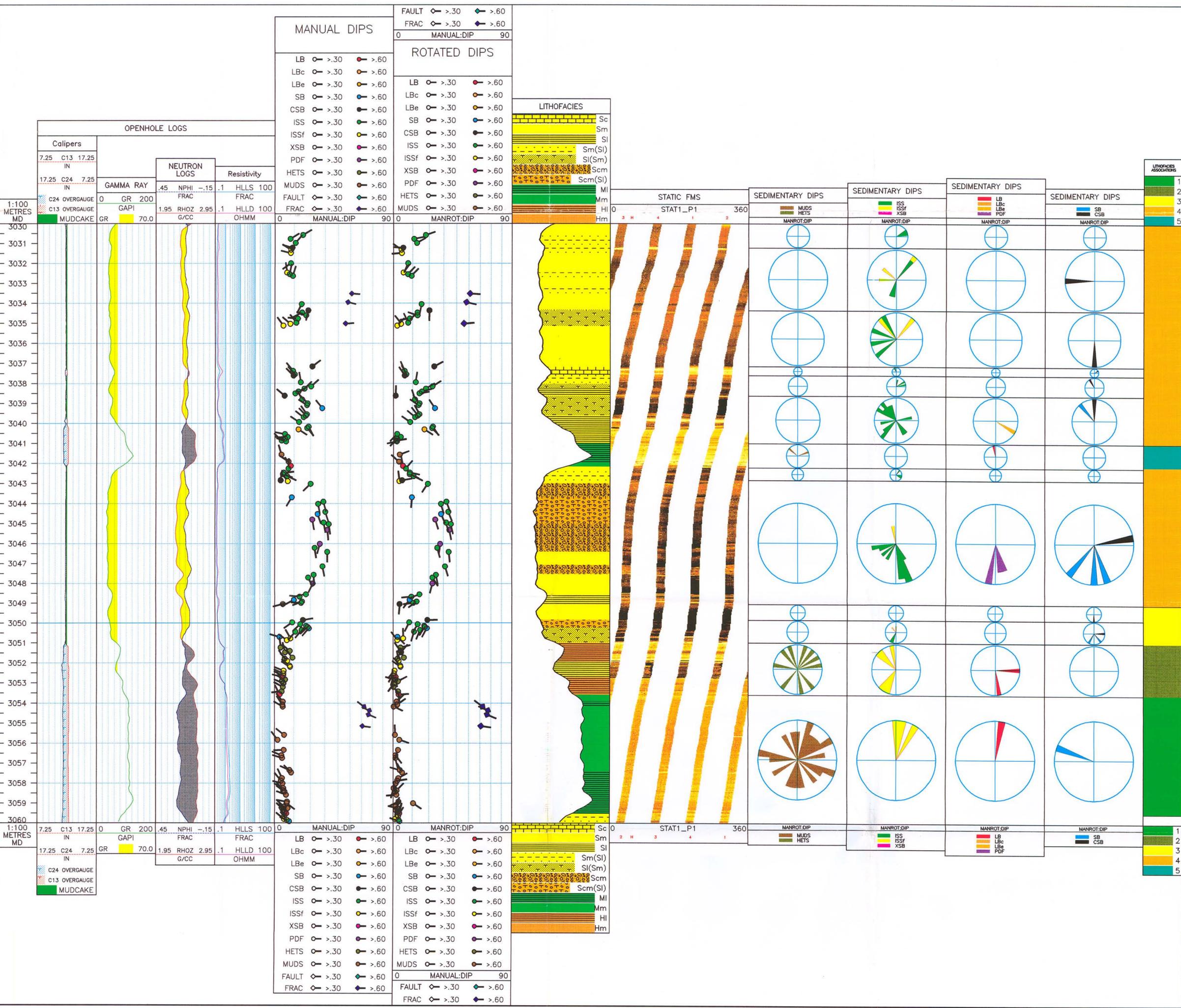


# Premier Oil Australia Yolla-2

Enclosure 10

3030.00-3060.00 METRES

1:100 Sedimentological Composite Plot



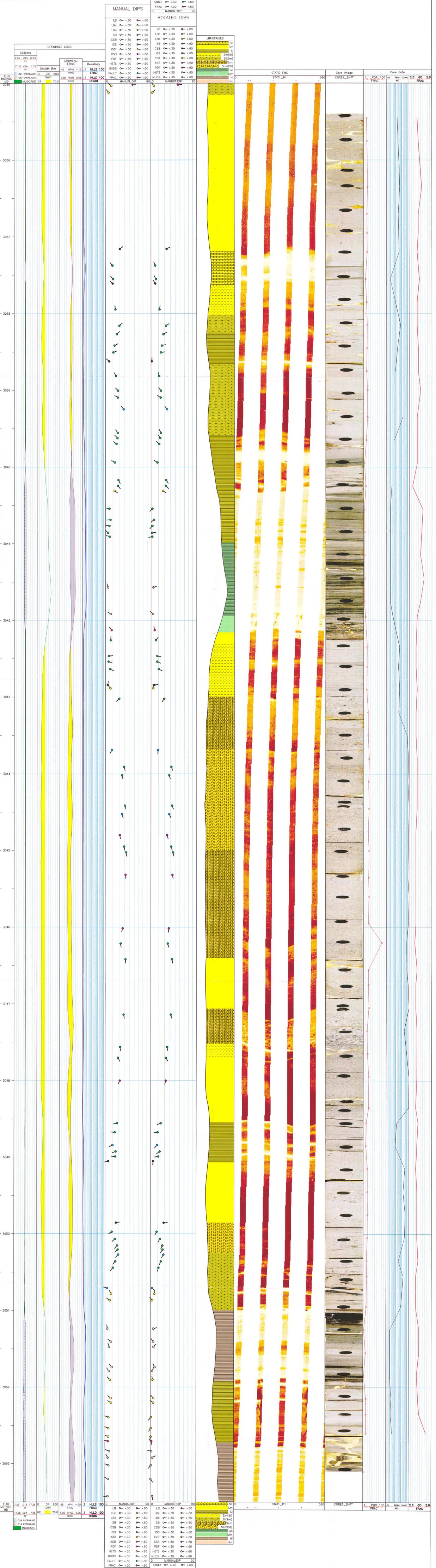
**ENCLOSURE 11**

Scale 1:10 Core Composite Plot



3035.00-3053.50 METRES

1:10 Core Composite Plot



7.25	C13	17.25	IN	GR	200	45	NPHI	-15	1	HLLS	100	0	MANUAL-DIP	90	0	MANROT-DIP	90	0	STAT1_P1	360	CORE1_SHT	1	POR	100	PERM	10000	GD	2.8
17.25	C24	7.25	IN	GR	200	45	NPHI	-15	1	HLLS	100	0	MANUAL-DIP	90	0	MANROT-DIP	90	0	STAT1_P1	360	CORE1_SHT	1	POR	100	PERM	10000	GD	2.8

**A4 IMAGE ATLAS**



