Premier Oil Australia

White Ibis Field

White Ibis-1

Sedimentological and Structural Interpretation of Formation Micro-Scanner (FMS) images

Report Status:	FINAL
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Date:	14 September 1998
Report reference:	ZSA-98-050

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SUMMARY

This report presents processed and interpreted FMS images from the intervals 1948 - 2214 m within the Bass Strait well White Ibis-1. The studied succession within White Ibis-1 is of Palaeocene-Eocene age, and is characterised by low magnitude tectonic tilt, typically in the range 2º-5º, as listed below.

Study Interval 1950-2214 m			
Zone I	1950-2001 m	2.7°/307°	Change in shale dip at 2001 m
Zone II	2001-2071.8 m	1.8°/310°	Fault boundary at 2071.8m
Zone III	2071.8-2157.5 m	4.3°/016°	Top of igneous section
Zone IV	2157.5-2214 m	-	Igneous, tectonic tilt is undefined

Lithofacies identified from FMS images have been calibrated with cuttings descriptions. Cuttings descriptions match well with lithofacies interpretations derived using wireline log response and FMS image fabrics. The FMS interpretations identify lithofacies including sandstones, mudstones, and heterolithic strata (comprising dm scale intercalations of sandstone, siltstone and mudstone). However, only circa 1m of core was recovered from White Ibis-1, and core calibration of image log fabrics was not feasible.

Six simple lithofacies associations have been identified within the studied section. However, the lithofacies stacking patterns interpreted from FMS data are not diagnostic in terms of a specific depositional environment. The succession has been interpreted as having been deposited in marginal marine (largely deltaic or possibly shelf – shoreface settings) or continental origin (alluvial and possible lacustrine settings). These environmental interpretations have been strongly influenced by palynological data provided for the study. In the absence of core calibration, the interpretations should be considered highly speculative. The lithofacies associations identified are summarised as follows:

Facies assoc.	Description	Interpretation
I	Mudstones that occur at the base of upward coarsening facies successions.	Prodeltaic muds, shelf-shoreface, or alluvial/lacustrine mudstones depending upon biostratigraphic inferences as to environment.
II	Heterolithic intercalations of sandstone siltstone and mudstone, typically occurring within middle parts of upward coarsening successions.	Interpreted as lower parts of distributary mouth bars in marginal deltaic environments. In continental settings, may reflect episodic storm / or seasonal deposits within lacustrine settings, or deposition from overbank events onto alluvial floodplains.
III	Sandstones with mottled and laminated image fabric and low angle (typically <10º) internal bedding surfaces, typically occur at the top of upward coarsening successions.	Occurrence may be consistent with deposition in shallow marine shoreface environments, and also as mouthbars within both lacustrine or marine deltas.
IV	Sandstones with mottled and laminated image log fabrics, with very minor associated heterolithic and mudstone lithofacies (V below). Internal stratification is inclined at angles up to 25° or more.	Sandstones with steeply inclined stratification sets may represent alluvial or deltaic distributary channels.
V	Lithofacies Association V (a single occurrence) comprises mudstones and heterolithic lithologies identical to Lithofacies I & II, but distinguished by close association with lithologies interpreted as the deposits of channels.	Association with channelised (Lithofacies Association IV), suggests they too may be of alluvial origin, deposited as a result of deposition of suspension fines upon floodplains, or infill of abandoned channels.
VI	Coals	Deposits of swampy delta plain environments.

Palynological data indicate the studied succession to have been deposited in continental, marginal marine with freshwater influence, and nearshore marine environments. A transition from continental to marine influenced sedimentation is inferred at circa 2104m. The sandstones of lithofacies Association III are likely to form the main reservoir intervals in both continental and marginal marine settings. Channelised sandstones of Lithofacies Association IV also form prospective targets.

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 NW-SE depositional strike can be inferred through much of the succession, regardless of inferred marine or continental origin. Palaeotransport analyses of sandstones from channelised sandstones of Lithofacies Association IV suggests their fill is dominated by downstream accreting bedforms. The main interval of channelised sandstones (2157.5-2149m) indicates easterly sediment transport.

Net sand contents determined from image log analysis through sections studied in detail are also presented.

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1. INTRODUCTION

This study reports on the processing of FMS (Formation Micro-Scanner) images and the subsequent geological analysis of these FMS images from White Ibis-1 for Premier Oil Australia. Results of a detailed sedimentological interpretation based on FMS images are presented for the interval 1950-2160 m. The study was initiated by David Evans of Premier Oil Australia.

1.1. Objectives

The well details and project objectives for the White Ibis-1 study are summarised in Table 1.1, along with the data provided for the study.

Well Details	
Well: **Surface Latitude:** **Surface longitude:** **Intervals of interest:**	White Ibis-1. 39 57' 49.607" S 145 15' 17.234" E Palaeocene – Eocene succession interpreted as of marginal marine and lacustrine origin.
Summary of Study Objectives	
Log Depth Intervals	**Objectives**
1950-2211 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.
1950-2211 m	Summary structural overview using Schlumberger processed SHDT data. NOTE: These were not provided to Z&S. To allow the study to progress, Z&S have carried out automatic dip calculations at no additional cost. The data were also supplemented by analysis of results of manual dip-picking through the main interval of interest.
Interval of interest 160m. (used interval 1997m-2160m).	Sedimentological interpretation of a 160m section of interest. Quantification of features evident within FMS images with the aim of focusing upon variations in lithology and palaeotransport directions. This required manual characterisation of dip features and their sedimentary interpretation over these intervals.
Interval of interest 160 m. (used interval 1997m-2160m).	Detailed sedimentological interpretation and lithofacies characterisation.
Data Used for Study	
1935-2215 m 1948-2214 m 1970-2211 m	Raw openhole logs from Platform Express suite: GR, SP, NPHI, RHOZ, PEF8, HLLS, HLLD, RXO8, RXOI in DLIS format. Raw FMS data on DLIS format tape (Pass 1) Raw FMS data on DLIS format tape (Pass 2)
2008.0-2008.75 m	Only 0.75 m core was recovered from White Ibis-1. This was not sufficient for any detailed calibration of images.
1948-2215 m	Cuttings descriptions.

Table 1.1 Summary of well details, study objectives, and the data-set used for analysis of well White Ibis-1.

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 June 26th 1998, in the 12 1/4 inch section of the well White Ibis-1 over the intervals 1948-2214 m (Pass 1) and 1970-2211 m (Pass 2).

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 2x8 measuring electrodes on each of four orthogonal pads (Figure 2.1). 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 29% coverage of the borehole wall in a 12¼-inch hole section. The data also provides a subset of eight Stratigraphical High-Resolution Dipmeter (SHDT) tool curves for standard dipmeter processing.

The mud environment was type KCI PHPA with a density of 1.09 g/cc, a viscosity of 41 S. The fluid losses encountered during the drilling of this well were minimal. The borehole mud reached a maximum temperature of 94°C.

Processing was carried out over the intervals entire intervals of both passes, using RECALL 4v1 modules for FMS and dipmeter processing. The Recall database was named “white_ibis1”

An FMS log quality control plot is shown in Enclosure 1. This plot provides 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 White Ibis-1 with geological details clearly visible on images and only minor image artefacts. Borehole deviation is 0.6°/105° at 1950 m, top of the study section and 0.3°/123° at 2210 m, bottom of the studied section.

Within the study interval (1948-2214 m), the hole shows consistent but minor ovalisation (0.5 inch) in the direction of the C2-4 calliper, which is consistently aligned *circa* 092º-272º (i.e approximately East-West). This orientation may reflect orientation of the minimum horizontal stress.

Nominal Hole Size	Interval Depth	Comments
1948-2214 m		
12.25"	1950-1958 m	In gauge
	1958-1979 m	0.25” overgauge
	1979-1983	In gauge
	1983-2001 m	0.25” overgauge
12.25"	2001-2207	0.5” overgauge

Table 2.1 Summary of hole conditions through studied intervals in White Ibis-1.

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. The contractor had already applied the correction of orientation data for magnetic declination. 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. Experimenting and the general roughness of the logging run decide the length of this window. In the case of White Ibis-1, a window of 5 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 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.

Depth shifts

FMS Pass 1 images were shifted 18 cm uphole to match FMS pass 2 images in White Ibis-1. Pass 1 and Pass 2 follow similar paths (similar rotational movement) throughout the well except for 10-15 m in the upper part and 15-20 m in the lower part of the borehole. In these intervals, the image coverage of the wall has thus been increased successfully.

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 (Enclosure 1). These correlations use refined least-squares algorithms with regression coefficient 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, 40 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 “A60X40X75B” (Pass 1) and "B60X40X75B” (Pass 2), see Enclosure 1. 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 smooth dip patterns and trends and is a viable method of “quick-look” identification of tectonic tilt. Detailed interpretation of dip patterns should not be carried out on results from this processing. These parameters are referenced as “A50x40x75ST" and "B50x40x75ST" for Pass 1 and Pass 2, respectively, in Enclosure 1.

Manual dips were computed directly from the images using the RECALL workstation (e.g. Enclosure 2). 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. GEOLOGICAL ANALYSES

3.1. Tectonic tilt determination (1950-2211 m)

Structural evaluation was carried out over the entire study interval, 1950-2211m.

Structural Sub-division

Evaluation of tectonic tilt was carried out over the entire interval for which FMS images were obtained. In addition to evaluation of gross structure, an evaluation of the tectonic tilt is also required for sedimentary analyses, i.e. so that the sedimentary surfaces identified in FMS images can be restored to their original orientation or "sedimentary dip". Tectonic tilt is the attitude of formations resulting solely from tectonic movements and is thus 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 tectonic tilt interpretation within White Ibis-1 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.

- Identification of structural breaks (i.e. changes of tectonic tilt) and their interpreted causes.

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

Structural Zone	Depth interval	Tectonic tilt	Comment
Study Interval 1950-2214 m			
Zone I	1950-2001 m	2.7°/307°	Change in shale dip at 2001 m.
Zone II	2001-2071.8 m	1.8°/310°	Fault bound at 2071.8m
Zone III	2071.8-2157.5 m	4.3°/016°	Top of igneous succession at 2157.5m
Zone IV	2157.5-2214 m	-	Igneous succession of indeterminate tectonic tilt.

Table 3.1 Tectonic tilt summary for White Ibis-1.

Cumulative dip azimuth vector plots (termed "walk-out" plots) for automatic computed dips, manually interpreted dips of shale bedding surfaces within the study interval (1948-2214 m) from White Ibis-1 are illustrated in Figure 3.1. The plots clearly illustrate the structural sub-divisions proposed for the succession.

Unconformity Recognition.

No distinctive angular unconformities have been identified within the studied succession. However, a minor change in structural dip from 2.7°/307° within Zone I

(1950-2001m) to 1.8°/310° within Zone II (2001-2071.8m) coincides with a number of other variations which may indicate the presence of an unconformity at circa 2001 m. These include:

- Palynological data. A cutting sample from *circa* 1967 m is of late Palaeocene age and probably indicative of deposition in a near-shore marine environment. Palynological samples from *circa* 1990-2000 m are of early Palaeocene age, and of probable marginal marine-fresh water environments. The possible shift from near-shore marine environments to environments with a marginal-fresh water influence indicated by palynological analyses may support interpretation of an unconformity at *circa* 2001m.

- Image log fabric. Observations of image log data within the interval 1950-2001m indicates the mudstone dominated succession to contain abundant, cm scale conductive mottling. Cuttings descriptions indicates these argillaceous intervals to contain common pyrite cements, suggesting the conductive mottling fabric observed in image logs is due to nodular pyrite cementation. This may be confirmed by a high density log response for these argillaceous deposits. The conductive mottled fabric is not developed within argillaceous lithologies beneath *circa* 2001 m, suggesting some type of stratigraphical break at this depth, perhaps correlateable at inter-well scale on the basis variations in image log fabrics.

The contact between the sedimentary deposits and underlying igneous succession (circa 2157.5 m) may also represent an unconformity, although no estimate of tectonic tilt was feasible within the igneous interval logged.

3.2. Fracture/Fault identification

Fractures: A fracture is a surface along which there has been loss of continuity of a structural element in rock or in a mineral. Fractures are commonly discordant to bedding, planar to sub-planar, usually continuous around the borehole, though sometimes terminated at bed boundaries. Displacement might or might not be present and fractures may occur on any scale (Walsh, 1991). Fractures parallel to bedding cannot be recognised in borehole images. The FMS images are displayed as an unwrapped cylinder split vertically, therefore, in a vertical to sub-vertical well fractures appear as sinusoidal traces, hence, the dip of a fracture is computed from the maximum amplitude of the fracture's sine wave. The relatively steep fractures of White Ibis-1 are of high amplitude as the wellbore is vertical.

The fractures show resistivity contrast from the host rock in the FMS images, depending on the fracture fill, the lithology and fluid saturation of the host rock. Fractures in White Ibis-1 were categorised as either relative conductive or resistive. Conductive fractures on FMS images may be open, filled with drilling fluid, or they may be clay smeared or filled with carbonaceous fill or sometimes mineralised with pyrite or galena etc. On the other hand, resistive fractures on the FMS images are typically closed to fluid flow and may be cataclastic, mineralised with calcite or quartz etc. Fractures identified in White Ibis-1 are listed in Appendix 1, while fracture and fault orientations are illustrated in Enclosure 2. Mean dip and azimuth of conductive and resistive fractures for each structural zone is summarised in Table 3.2 below.

The orientational spread of the fracture population is considerable, but despite the scatter shown in the stereograms of Figures 3.3-3.6, the trend seems to be striking

WSW-ENE. This trend is most obvious in the sedimentary strata and while present in the igneous rocks as well, it is only one of several ill defined trends.

	Resistive fractures		Conductive fractures	
Structural zones	**No of fractures**	**Mean dip/azimuth**	**No of fractures**	**Mean dip/azimuth**
Zone I	5	46°/340°	4	35°/162°
Zone II	8	41°/218°	9	55°/152°
Zone III	7	43°/010°	20	61°/346°
Zone IV	2		53	64°/271°….12 samples 58°/209°….13 samples 62°/152°…9 samples 60°/056°…. 8 samples

Table 3.2 Mean dip and azimuth of resistive and conductive fractures.

There is not enough data to define a dominant set in Zone I. In Zone II the conductive fractures have a dominant trend of NE-SW, whereas resistive fractures show a NW-SE trend. The fault at the base of Zone II also strikes NW-SE. Zone III consists of clusters of conductive fractures striking WNW-ESE and NNW-SSE. Conductive fractures of Zone IV occur in small clusters and have variable, but predominantly WSW-ENE strike.

Faulting: Two high confidence faults were identified at 2071.8 m and 2199.5 m dipping at 57°/213° and 71°/044° respectively. These are characterised on the resistivity images by a wide range in resistivity contrast and by truncation of bedding.

The first fault at 2071.8 m is illustrated in Figure 3.2. This fault may have significant impact on the well and its vicinity. The shale bedding above this fault (hanging-wall) show northwesterly dip directions, whereas north-northeasterly dips of shale bedding are well defined in the footwall below the fault zone, see Enclosure 2. This fault seems to be responsible for the hanging-wall rotation. The hanging-wall shows approximately 3° rotation in a southwest direction relative to the footwall. The fault plane dips 57°SW which is same as that of the hanging wall rotation relative to the footwall. This suggests that the fault movement was essentially dip-slip with little probability of strike-slip movement. Whether the fault is normal or reverse is uncertain.

The second fault was recognised at 2199.5m in the structural zone IV. The fault plane dip at 71.2°/044°. This fault was recognised on the basis of immense resistivity contrast on the opposing sides of the faulty plane and also associated with deformation.

3.3. Classification of sedimentary features

Classification of sedimentary surfaces recognised from borehole image logs is a three 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 sub-division of dip features into mudstone and "others".

- Tectonic tilt 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 hierachial scheme applied to White Ibis-1 is illustrated in Figure 3.7 and Table 3.3, and sedimentary dips for the studied interval 1950-2160 m is shown in Enclosure 3.

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 3.3 Classification of surfaces identified from FMS images.

3.4. Lithofacies characterisation

Sedimentological interpretation of FMS images was carried out over the studied interval (1997-2158 m) within White Ibis-1. Use of the FMS images in conjunction with gamma ray, density, neutron porosity, Sonic, PEF and resistivity logs enabled quantification of lithofacies types. Lithofacies types were classified according to a simple scheme described in Table 3.4. FMS interpretations could not be calibrated with core as there was only 0.75 m core recovered from White Ibis-1.

Lithofacies identified from FMS logs

Cuttings descriptions were 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 within the studied interval, i.e. sandstones, mudstones, finely inter-bedded heterolithic successions and minor coals. Igneous lithologies occur immediately beneath the studied interval. Heterolithic successions comprise centimetre-decimetre scale interbedded sandstone, siltstone and mudstone beds. Coals may form a very minor lithofacies at circa 2026.5m, interpreted from low density, high porosity and high resistivity log response.

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 in Table 3.4.

Inferred Lithology / Grain Size	**Typical Log Response. Interval 2001-2160 m**	**Image Log Fabrics**	**Lithofacies Mnemonic**
Sandstone	GR <100 API RHOB 2.25-2.45 g/cc NPHI 0.12-0.24	laminated	**Sl**
		cemented	**Sc**
		fine scale mottled or "speckled" texture with poorly defined or disrupted lamination fabric	**Sm**
		Coarse scale mottled texture with poorly defined or disrupted lamination fabric. Mottling comprises resistivity elements several cm in diameter.	**Scm**
Heterolithics	GR 100-110 API NPHI 0.24-0.28 RHOB 2.50-2.60 g/cc	laminated	**Hl**
		mottled with disrupted lamination fabric	**Hm**
Mudstone	GR 105-180 API NPHI 0.30-0.37 RHOB 2.50-2.65 g/cc	laminated	**Ml**
		mottled with disrupted lamination fabric	**Mm**
Coaly lithologies	NPHI 0.30-0.32 RHOB 2.30-2.35	mottled with disrupted lamination fabric	**Coal**
Igneous Lithologies	GR <40 API RHOB >2.85 g/cc	Mottled fabric	**ignious**

Table 3.4 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 3.9-3.13 illustrate examples of different lithofacies types for the lithologies identified, together with their fabric index.

Calibration of image log fabrics using cuttings descriptions

Calibration of image log fabrics was carried out using cuttings descriptions through the logged intervals. Cuttings descriptions are summarised on Enclosure 3.

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 lower logged interval, e.g. 2116-2158, (Enclosure 4), there appears to be a 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 succession comprising circa 50% argillaceous lithologies within this interval. However, the cuttings description indicate the succession to be dominated by sandstone lithologies. It is feasible that the Z&S interpretation through this interval could under-estimate sandstone content, especially if the sands overlying the igneous body at 2158m are particularly feldspathic or radioactive.

In addition, previous studies of similar Palaeocene-Eocene strata within Yolla-2, revealed difficulties in distinguishing fine grained, argillaceous silty sandstones with a from mudstones or heterolithics. These problems may also exist within White Ibis-1.

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.

Interpretation of mottled image fabrics

Mottled fabrics have been observed within both sandstone and mudstone lithologies. Mottled fabrics in borehole image logs may arise from a number of different mechanisms. These could include:

- Differential cementation or the presence of nodular mineral cements.
- Artefacts 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.

Within White Ibis-1, several different types of mottled fabric have been identified within the different lithologies present. Close examination of FMS images reveals that mottled textures within sandstone lithologies 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. In the absence of core calibration, any inferences as to the precise origin of this fine scale mottling would be highly speculative. However, bioturbation or differential cementation may be the most probable candidates.

2. Strongly mottled image texture, in which mottles are defined by resistivity features of several cm diameter. By analogy with similar fabrics encountered in Palaeocene

– Eocene sediments from Yolla-2 (Z&S-98-044), this coarse scale "coarse" mottling is interpreted as indicating the presence of granular and pebbly sandstones.

Argillaceous lithologies may also display mottled and disrupted fabric within borehole image logs. As with sandstone lithologies, the origins of these textures are speculative, but once again they may be generated by processes such as bioturbation. In the absence of core calibration, this interpretation should be treated with caution, because similar fabrics could be generated by a variety of phenomena including nodular cementation patchy sand distribution etc.

Sharply defined, cm scale, conductive mottling has also been observed within image logs through mudstones in the interval 1950-2001m (above the main interval used for sedimentary analyses). Cuttings descriptions through these lithologies indicate they contain pyrite cements, suggesting the conductive mottling fabric observed in image logs is due to nodular pyrite cementation.

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 3.5 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.

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

Table 3.5 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. Kv > Kh). 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 Kv:Kh ratio due to loss of stratification).

3.5. Lithofacies associations within the interval 1997-2160m.

The sedimentary deposits in the interval 1997-2158m mainly comprise a heterolithic succession of sandstones and mudstones. Wireline 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.

Upward decreasing gamma ray log trends, and NPHI and RHOB log response which trends towards sandstones indicate the sediments to be dominated by 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 (< 10°). However, some thin sandstone and pebbly sandstone intervals with sedimentary dips in excess of 20° are also present at 2035-2036.5m, 20561.25-2052.6m, and 2150.5-2154m.

Biostratigraphical (palynological) data suggest that the studied succession from White Ibis-1 was deposited in environments ranging from near-shore marine to continental. Upward coarsening parasequences of the type which dominate the studied succession may be developed in a variety of depositional settings. These may include marginal marine environments where upward coarsening profiles may form as a result of shoreface or delta from progradation. Similarly, the same profiles may be generated via progradation of lacustrine deltas, or lacustrine fan deltas in a continental setting. Blocky sandstones characterised by sedimentary surfaces with elevated dips may represent the deposits of fluvial or distributary channels.

The lithofacies stacking patterns interpreted from FMS data are not diagnostic in terms of a specific depositional environment. Interpretation of the studied succession in terms of a marine, marginal-marine or continental origin has thus been strongly influenced by the biostratigraphic data, which is summarised on Enclosure 3. The lithofacies identified are described in detail in the following sections. In the absence of core calibration, the following discussions should be considered highly 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* (Collinson 1969, Walker 1992). Ideally, these lithofacies associations would have environmental significance. However, lithofacies associations determined from wireline logs and borehole image logs throughout the studied succession may have been deposited in a variety of environmental settings. Six lithofacies associations were identified within the studied data set, and their distribution within the studied interval is illustrated in Enclosure 4. 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 or within thick mudstone intervals displaying no overall log trend. Where mudstones occur at the base of upward coarsening facies successions, they often 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 over ten metres thick, and is characterised by blocky to serrate, overall high gamma-ray log response (> 105 API), reflecting the presence of a predominantly argillaceous succession of lithofacies types. Gamma ray log response within mudstones (typically > 105 API) typically decreases slightly upward, forming part of an overall upward decreasing trend. Lithofacies Association I passes upward into heterolithic lithofacies of Lithofacies Association II or III.

The mudstones of Lithofacies Association I display low sedimentary dip (typically < 5), with wide ranging dip azimuths (covering 360^o 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.).

Biostratigraphic data indicates that mudstones may have been deposited in marine, marginal marine or continental environments. Specific depositional settings may thus have included, shelf settings in marine environments, prodeltaic or interdistributary bay environments in marginal deltaic settings or lacustrine to floodplain environments in continental settings.

If mottled and disrupted bedding fabrics identified are 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.
- in lacustrine environments, perhaps within deeper water settings less subject to influx of terrigenous material.

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

Only in the interval 1950-2001m (above the main study section) can any environmental significance be inferred for image log fabrics through mudstones. In this interval, palynomorphs indicate a nearshore marine environment, and nodular pyrite cements appear common within mudstones. The nodular pyrite is not abundant within mudstones beneath this interval, where palynomorphs suggest there may have been some fresh-water influence upon the depositional environment.

Lithofacies Association II

Lithofacies Association II constitutes lithologies interpreted as comprising heterolithic, dm scale intercalations of sandstone and mudstone. Within the studied interval, heterolithic deposits typically form successions of 1-1.5 m thickness.

Heterolithic deposits predominantly occur within of facies successions which display overall upward cleaning (and coarsening) gamma ray log trend, where they overly argillaceous deposits and themselves pass upward into sandy deposits.

Sedimentary dips within heterolithic deposits are typically characterised by low angle fabrics (inclined typically < 5° sedimentary dip). Removal of tectonic tilt 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 both marine or continental settings, this style of sedimentation effectively records episodic influx of sandy detritus into a background system of suspension sedimentation. 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. In continental settings, heterolithic deposits may reflect episodic storm deposits or perhaps even seasonal "varve-type" sedimentation events within lacustrine settings. Alternately they may reflect deposition from overbank events onto floodplains in alluvial settings.

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 < 10°), and may form successions up to 9 m thick within the studied sections. The sandstones occur in the uppermost part of upward coarsening successions, where they may either rest gradationally upon heterolithic deposits of Lithofacies Association II or more sharply upon argillaceous deposits of lithofacies association I.

The sandstones of Lithofacies Association III are distinguished from those of Lithofacies Association (IV) discussed below by significantly lower sedimentary dips. Cosets of strata occur at dm-m scale. The low angle sedimentary dips characteristic of this lithofacies association often reveal the presence dm-m scale cosets which may display a relatively tight cluster of unimodal dip azimuths. No consistent dip direction is evident through the succession, although dip directions lying within the southern hemisphere of stereoplots are common (Enclosure 4). Flat lying intraset surfaces are also common within this lithofacies association, however they form a small dataset and no inferences as to their significance are possible. The relative spatial distribution of laminated versus mottled image fabrics within sandstones from this lithofacies association reveals no significant trends.

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 shallow marine environments, and also both lacustrine and marine deltas.

In shallow marine 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 also be consistent with deposition as sands within the upper parts of distributary mouth bars, in both marine or lacustrine deltas, or perhaps within crevasse splay deposits upon alluvial plains.

Lithofacies Association IV

FMS derived lithofacies are sand dominated, comprising Scm, Scm(Sl), Sm, Sl, Sm(Sl) and Sl(Sm), with very minor heterolithic and mudstone lithofacies. Association IV occurs in successions up to 5 m thick. Three 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 indicate the presence of steeply inclined cross stratification sets, distinguishing this lithofacies association from Lithofacies Association III above.

Strata containing these elevated dips occur within three main intervals: 2035-2036.5m, 2050.5-2052.6m, and 2150.5-2154m.

Coset and set boundaries occur at dm -m scale. Dip data sets are small, due to the limited thickness of Lithofacies Association IV within the studied succession. However, the data for individual accumulations of Lithofacies Association IV typically indicate unimodal distribution of azimuths for intraset surfaces, with low azimuthal dispersion. Azimuthal distributions for intraset surfaces are not consistent for the different accumulations of Lithofacies association IV.

The cross stratified sediments of lithofacies association IV may represent the deposits of channels (fluvial or distributary) within marginal marine or continental settings. 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 within deposits in the interval 2150.5-2154 m, are interpreted as reflecting 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 *circa* 1-2 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

A single occurrence of Lithofacies Association V comprises mudstones and heterolithic lithologies with varying degrees of lamination. They are indistinguishable from the lithologies of Lithofacies I and II, but are distinguished from them by their close association with lithologies interpreted as the deposits of alluvial channels (Lithofacies Association IV), suggesting that they too may be of alluvial origin. Mudstone and heterolithic lithologies that occur in association with channelised sandstones as a result of deposition of suspension fines upon floodplains, or infill of abandoned channels.

A single, thin, argillaceous interval (2148-2150m) has been assigned to Lithofacies Association V purely on the basis of its close association with 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 core calibration.

Lithofacies Association VI

Coals or highly carbonaceous mudstone lithofacies may form a very minor lithology within the studied section. Cuttings descriptions indicate the presence of coaly fragments at *circa* 2031m. The carbonaceous material recorded in these cuttings may correspond to a low density and high porosity interval observed within mudstones at circa 2027m. This may represent a thin (<30cm) coal, or highly carbonaceous mudstone.

3.6. Summary of environmental interpretations 1997-2160 m

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

Wireline logs and FMS interpretations interval suggest that it comprises a heterolithic succession of strata. A number of large scale upward cleaning (coarsening) successions are evident. The basal part of the succession also contains igneous lithologies. Details are summarised in Table 3.6.

Study interval 1997 –2160 m.			
Depth (m)	**Lithofacies Assoc.**	**Brief Description**	**Interpretation**
2160-2157.5	Igneous strata	High density, high porosity low resistivity low gamma log signature. Abundant fracturing beneath 2160m.	Uppermost strata within igneous body.
2157.5-2149m	I-> IV-V	Overall large scale upward cleaning (coarsening) succession comprising mottled and laminated mudstones, overlain by sandstones. The succession comprises 50% mudstone. Following an initial phase of mudstone deposition, a sharp based pebbly sandstone was deposited, containing steeply inclined sedimentary surfaces mainly indicating channelised deposits with transport to the east. Channelised strata are overlain by a thin (circa 2m) succession of mudstones, mottled laminated sandstones and heterolithic strata.	Palynological data indicate a continental environment. The overall upward coarsening profile commencing with mudstone deposition and terminating with alluvial channel deposits could be consistent with progradation of a lacustrine delta, or simple incision of alluvial channel sands into lacustrine or floodplain deposits. Heterolithic strata (Lithofacies Association III) overlying chanelised deposits may represent alluvial plain deposits (floodplain with thin crevasse-sandstones ?) or simple infill of the abandoned alluvial channel.
2149-2128m	Interbedded I- >III	Succession comprising 5, stacked, broadly upward coarsening successions (parasequences ?) of laminated and mottled mudstone and laminated and mottled sandstones. Overall, stacking pattern indicates an upward increase in sand content through this interval, suggesting an overall "progradational" depositional system. Low angle (typically <5º) sedimentary surfaces within sandstones display variable azimuth. Steeper intraset surfaces display a predominance of ENE azimuths.	Palynological data indicate a continental environment. The progradational stacking pattern and low-angle-parallel laminated sandstone lithologies observed may reflect deposition within a variety of continental environments. They could reflect progradation of alluvial mouthbars within a lacustrine delta or fan-delta. Alternately, they may represent an alluvial plain succession, with interbedded, parallel laminated crevasse splay sandstones.
2128-2104m	Interbedded I, II &III	Succession comprising 5, stacked broadly upward coarsening successions (parasequences?). Deposits comprise mottled and laminated mudstones, interbedded with mottled sandstones, laminated sandstones and heterolithics. Proportion of sand increases upward through stacked successions, suggesting an overall "progradational" depositional system. Sparse orientation data within sandstone lithofacies suggests ENE sediment dispersal.	Palynological data indicate a continental environment at circa 2128 m, in the lower part of this interval. Thick successions of mottled mudstones near the base of this interval may reflect deposition in lacustrine or alluvial floodplain environments.The progradational nature of lithofacies stacking suggests that deposition may have occurred within a lacustrine delta. However, similar stacking patterns and sandstones could also be deposited from progressive crevasse events from a shifting alluvial channel onto a floodplain environment.

Study interval 1997 –2160 m.			
Depth (m)	**Lithofacies Assoc.**	**Brief Description**	**Interpretation**
2104-2088.5	Stacked successions of I>III (with very minor II)	Succession comprising 3, stacked broadly upward coarsening successions (parasequences ?). Deposits comprise mottled and laminated mudstones, interbedded with mottled and laminated sandstones. The proportion of sand increases upward through stacked successions, suggesting an overall "progradational" depositional system. Sparse orientation data within sandstone lithofacies display predominance of azimuths oriented broadly to south and north, suggesting SSW and NE dispersal, and a broadly E-W depositional strike.	Palynological data from *circa* 2098m indicate a marginal marine-fresh water depositional setting, whereas palynological data from 2124m indicate a continental environmental setting. A transition from continental to more marine influenced (but still with freshwater influx) sedimentation is inferred at *circa* 2104m, where there is a change in lithofacies stacking patterns. In a marginal marine setting, subject to freshwater influx, upward coarsening facies stacking patterns of the type observed could be generated in deltaic environments. Upward coarsening successions may represent progradation of distributary mouth bars, with sandstones being deposited in the upper- portions of mouthbars. Argillaceous intervals may represent the deposits of distal mouthbars, interdistributary bays, or prodeltaic environments.
2088.5-2067.75	Stacked successions of I&III	Succession comprising 5, stacked broadly upward coarsening (parasequences ?). Deposits comprise mottled and laminated mudstones, interbedded with mottled and laminated sandstones. The proportion of sand appears to decrease upward through stacked successions, suggesting an overall "retrogradational" depositional system. Orientation data within sandstone lithofacies display predominance of azimuths oriented broadly to the south and north, suggesting southerly sediment dispersal, and a broadly E-W depositional strike.	Palynological data indicate a marginal marine-fresh water depositional setting, suggesting a possible deltaic environment. Coarsening upward facies stacking patterns of the type observed could be generated in deltaic environments. Upward coarsening successions may represent progradation of individual distributary mouth bars, with sandstones being deposited in the upper- portions of mouthbars. Argillaceous intervals may represent the deposits of distal mouthbars, or prodeltaic environments. The overall slightly retrogradational stacking pattern suggests a landward shift in depositional facies, either due to relative rise in sea-level, tectonic adjustments, or simply switching of delta lobes. Note: Similar successions could be generated in more open marine settings by shoreface progradation, but palynological data indicating possible fresh-water influence may rule out this interpretation.
Study interval 1997 –2160 m.			

Depth (m)	Lithofacies Assoc.	Brief Description	Interpretation
2067.75-2056.0m	Stacked I>II>III	Succession comprising 2, stacked broadly upward coarsening successions (parasequences ?). Deposits comprise mottled and laminated mudstones, interbedded with mottled and laminated sandstones. Overall the interval suggests a progradational stacking pattern, but is dominated by one 9.5m thick upward coarsening succession, overlying a smaller 2m scale upward coarsening successions. Dominant upward coarsening succession displays lithofacies transitions from I>II>III. The minor upward coarsening succession only displays stacking of lithofacies I and III. Orientation data is sparse Sedimentary dips are low angle, but many flat lying intraset surfaces do display a preferred NW-NNE orientation, again perhaps consistent with an approximately E-W depositional strike.	Palynological data indicate a marginal marine-fresh water depositional setting, suggesting a deltaic environment. Overall, the succession is interpreted as probably representing progradation of a deltaic mouthbar. Heterolithic and sandstone dominated parts of the main upward coarsening succession may represent progradation of the lower and upper parts of a distributary mouth bar respectively. Mudstone dominated intervals may represent the deposits of interdistributary bays, or prodeltaic environments. Note: Similar successions could be generated in more open marine settings by shoreface progradation, but palynological data indicating possible fresh-water influence may rule out this interpretation.
2056.0m-2050.5m	I>III>I>IV	Interval comprises two small-scale (3m and 2.5m) upward coarsening successions. Lowermost upward coarsening succession comprises mottled and laminated mudstones which pass upward a thin (circa 75 cm) mottled sandstone with relict lamination. The upper upward coarsening succession comprises 50cm mottled mudstones which pass upward into laminated and mottled sandstones containing sedimentary fabrics inclined at angles of up to 20º. Steeply inclined fabrics within uppermost sandstone indicate sediment dispersal to the SW.	Palynological data indicate a marginal marine-fresh water depositional setting, suggesting a possible deltaic environment. Upward coarsening successions are suggestive of progradation of deltaic mouthbars. Steeply inclined internal bedding surfaces reflect presence of cross stratification. Unimodal azimuthal distribution indicates simple bedforms, which may represent simple downstream accretion of dunes within a deltaic distributary channel, oriented NE-SW.

Study interval 1997 –2160 m.			
Depth (m)	**Lithofacies Assoc.**	**Brief Description**	**Interpretation**
2050.5-2044m	I>II Stacked	Succession apparently comprising 2, broadly upward coarsening successions (parasequences ?) of laminated - mottled mudstone and laminated - mottled sandstones. Stacking pattern indicates an upward increase in sand content through this interval, suggesting an overall "progradational" depositional system. Low angle (typically <5º, rarely up to 15º) sedimentary surfaces within sandstones display predominantly SW oriented azimuth and a broadly NW-SE depositional strike.	Palynological data indicate a marginal marine-fresh water depositional setting, suggesting a possible deltaic environment. Possible proximal distributary moth bars. Note similar succession could be generated by shelf-shoreface progradation.
2044-2001m	Mainly I>III stacked. Some I>II>III	A succession of 7 stacked upward coarsening successions (parasequences). Stacking pattern indicates an marked upward increase in sand content through successive parasequences, (30% sandstone in the lowest, to > 90% sandstone in the uppermost), suggesting an overall "progradational" depositional system. Stacking pattern indicates an upward increase in sand content through this interval, suggesting an overall "progradational" depositional system. Succession is varied, comprising laminated and mottled sandstones and mudstones, with minor heterolithics. One minor coaly interval may also be present at circa 2026.5m. Sedimentary dips are low, typically <10º. NE oriented azimuths predominate within sandstone lithologies. A minor interval at 2036-2036.5m, near the top of the lowest parasequence contains NE oriented intraset surfaces of sedimentary dip in excess of 25º.	Palynological data indicate a marginal marine-fresh water depositional setting. Stacked upward coarsening successions of this type could be generated by progradation of deltaic mouthbars, or marine shelf-shoreface successions (or possibly both). If of deltaic origin, argillaceous and heterolithic intervals represent lower distributary mouth bar deposits whereas sandstones represent upper distributary mouth bars. Mudstone dominated intervals could also represent the deposits of alluvial delta plains (suggested by minor coal horizon), interdistributary bays, or prodeltaic environments. Steeper sedimentary dips (circa 2036m) could represent a minor channel or simply more steeply inclined cross stratification within a mouthbar sand. If of more fully marine origin, thick sandstones at top of succession may represent shoreface sandstones, whereas argillaceous deposits could represent shelf facies. Sedimentary dips suggest a broadly NW-SE oriented depositional strike.

Study interval 1997 –2160 m.			
Depth (m)	**Lithofacies Assoc.**	**Brief Description**	**Interpretation**
2001 – 1997m (top of studied interval)	I	Mottled mudstones and mottled mudstones with relict lamination. Interval forms part of 2 large scale (>20m thick) upward coarsening successions, which dominate the upper part of logged interval from (2001m-1950m, outside study section). Mudstones contain abundant pyrite mottling.	Palynological data indicate a marginal marine depositional setting. A subtle change in dip azimuth, palynology, and consistent change in mudstone cementation fabrics (i.e. presence of pyrite cements) suggests a possible unconformity at the base of this succession. Deposits are interpreted as being of marine origin, possible a shelf (to shoreface) succession.

Table 3.6 Summary of deposits in the study interval 1997-2160m.

3.7. Net sand content

The lithofacies types identified using FMI images were used to quantify net sand content within the studied interval (1997-2158 m). The results are summarised in Figure 3.14 and Table 3.7 below.

FMS Determined Lithofacies	% Content within study interval 1997-2158 m
Sc	0.4%
Sm	22.8%
Sl	1.6%
Sl(Sm)	7.6%
Sm(Sl)	18.9%
Scm	0.5%
Scm(Sl)	0.4%
Ml	0%
Mm	20.1%
Ml(Mm)	4.2%
Mm(Ml)	19.4%
Hl	0.4%%
Hm	0.2%
Hl(Hm)	1.9%%
Hm(Hl)	1.5%
Coal	0.2%

Table 3.7 Lithofacies types identified using FMS images in study interval.

4. BEDFORM ORIENTATION AND SEDIMENT DISPERSAL

Following sub-division of the succession into the 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 Enclosure 4.

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 wide (often 360º) azimuthal spread, indicative of the original deposition of these lithologies as "flat lying" effectively parallel stratified sediments. Beneath 2104m depth, these argillaceous sediments are interpreted as of probable continental origin, being deposited in lacustrine or alluvial environments. Above 2104m, argillaceous lithologies are mainly interpreted to have been deposited in shallow marine deltaic settings (prodelta or distributary mouth bar) or in shelf-shoreface environments.

Sedimentary dips within sandstones of lithofacies association III are also variable. beneath 2104 m these sediments are interpreted to be of largely continental origin, perhaps being deposited as alluvial sandstones, or parts of lacustrine deltas. Flat lying intraset surfaces and intraset surfaces reveal few consistent trends, and data sets are small and biased.

Above 2104m, where palynological data suggest a marginal marine – freshwater setting, and deposits are largely interpreted as of deltaic origin. Flat lying intraset surfaces (ISSF) show very little consistency of orientation within successive sandstones. However, in some intervals, intraset surfaces (and flat lying intraset surfaces) may display a preferred orientation. Very generally, these orientations often suggest a broadly NW-SE depositional strike, and NE transport directions appear to be quite common (although sediment dispersal appears to have varied considerably through the succession).

4.2. Arenaceous sediments of Lithofacies Association IV

The low-moderate gamma ray log response (<60 API) typical of Lithofacies Association IV, indicates that these successions may contain a significant proportion of potentially high reservoir quality sandstones. 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 from the image log obviously provides 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. The image log data also provide an indication of lithofacies stacking within the channel fill.

Only three intervals of channelised deposits assigned to lithofacies association IV has been identified within the four intervals studied in detail.

The intervals of interpreted channelised deposits occur at:

- 2154-2149m (high confidence)
- 2050.75-2052.6m (possible)
- 2036-2036.5m (very low confidence)

The orientation of bedding surfaces within these intervals are summarised in Table 4.1, below.

Channelised Deposits				
Depth (m) of coset or group of cosets	**Orientation of ISS's**	**Orientation SB's**	**Orientation CSB's**	**Comments**
2036-2036.5m *Possible minor channel with flow to NE*	NE		NE	Possible minor channelised interval. However, may represent more steeply dipping foresets in mouthbar deposits. Simple down current accretion.
2050.75-2052.6m *Possible channel with flow to SW*	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.
2154-2150.5m *Broadly Easterly ? sediment dispersal.* *Conglomeratic basal channel 2152.5-2154m* *Sandy channel fill 2152.5-2150.5m*	W NW NE	SE ENE		Lower conglomeratic channel fill has intraset surfaces of variable orientation. Consistent north-easterly oriented surfaces indicate downstream accretion surfaces.

Table 4.1 Bedding orientations, interpreted channelised deposits in the study interval.

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 1950-2214 m			
Zone I	1950-2001 m	2.7°/307°	Change in shale dip at 2001 m
Zone II	2001-2071.8 m	1.8°/310°	Fault boundary at 2071.8m
Zone III	2071.8-2157.5 m	4.3°/016°	Top of igneous section
Zone IV	2157.5-2214 m	-	Igneous, tectonic tilt is undefined

2. Both conductive and resistive fractures were observed in FMS image logs for White Ibis-1. The orientational spread of the fracture population is considerable, the dominant strike appears to be oriented WSW-ENE. This trend is most obvious in the sedimentary strata. While present also in the igneous rocks at the base of the logged section, this trend is one of several ill-defined trends at these stratigraphical levels.

3. The sedimentary succession is highly heterolithic, comprising sandstones, mudstones and dm scale interbedded heterolithic intervals composed of dm 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.
   II. Heterolithic intercalations of sandstone siltstone and mudstone, typically occurring within the lower-mid parts of upward coarsening facies successions.
   III. Stratified sandstones with mottled image fabric and low angle (typically <5º) internal bedding surfaces, typically occurring towards the top of upward coarsening facies successions.
   IV. Successions of stratified sandstones and pebbly sandstones with internal bedding fabrics inclined at angles of up to 25 or more.
   V. Thin mudstone- heterolithic successions interbedded with lithofacies association IV.
   VI. Thin coaly (carbonaceous) intervals.

5. The lithofacies and lithofacies stacking patterns interpreted from FMS data are not diagnostic in terms of a specific depositional environment. The studied succession has been interpreted as having been deposited in marginal marine (largely deltaic or possibly shelf –shoreface settings) or continental origin (alluvial and possible lacustrine settings). These environmental interpretations have been strongly influenced by palynological data provided for the study.

6. Sandstones of Lithofacies Association III, together with sandstones and pebbly sandstones of Lithofacies association IV are likely to form the main reservoir intervals.

7. Palaeotransport analyses of sandstones from Lithofacies Association III reveal them to be characterised by low angle internal stratification fabrics with very wide ranging sedimentary dip azimuth, suggesting they were originally deposited as “flat

lying' strata. These sediments typically occur at the top of upward coarsening facies successions, and may have been deposited in a variety of settings. Inferred environments include deltaic mouthbars, or shoreface in marginal marine settings, alluvial sands, and deltaic mouthbars in lacustrine environments in continental settings. 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 a NW-SE depositional strike within successions both of inferred marine or continental origin.

8. Palaeotransport analyses of sandstones from Lithofacies Association IV reveals them to be characterised by internal stratification fabrics with variable azimuth. Lithofacies Association IV is interpreted as representing channelised deposits. Only one interval is interpreted with any confidence (2154-2150.5m), and this has internal stratification suggesting broadly ENE drainage. The relationship between intra-set lamination and set/coset boundaries suggest that channel fills are relatively simple, and that channels are mainly infilled by simple downstream accreting bedforms. Other possible channelised deposits at 2050.75-2052.6m and 2036-2036.5m display NE and SW drainage respectively.

9. In the absence of a detailed core calibration, environmental interpretations are highly speculative. However, observed lithofacies stacking patterns do appear to be consistent with an interpretation of deposition of strata within a marginal marine-deltaic settings and lacustrine delta / alluvial settings.

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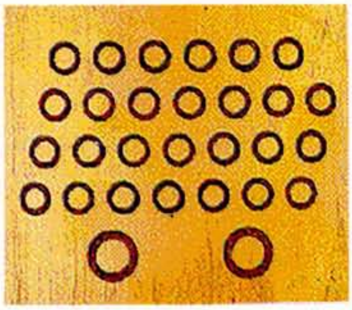
FIGURES

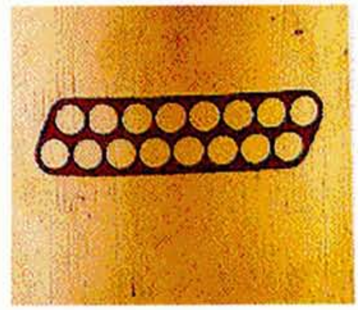
FMS PAD CONFIGURATIONS

Early generation 2-arm FMS
27 electrodes per pad

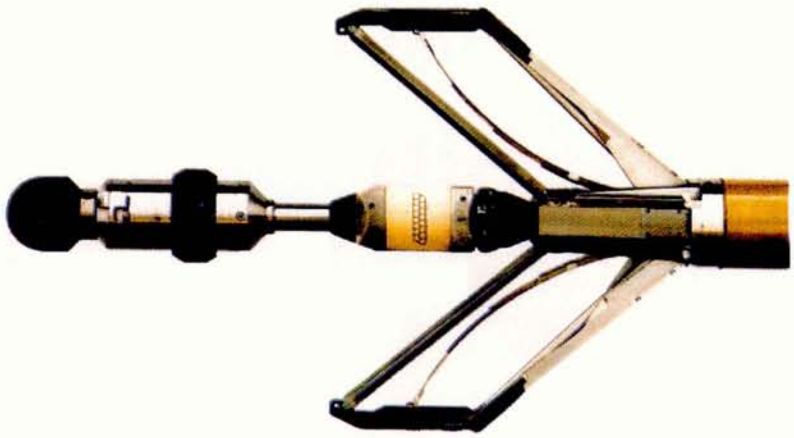


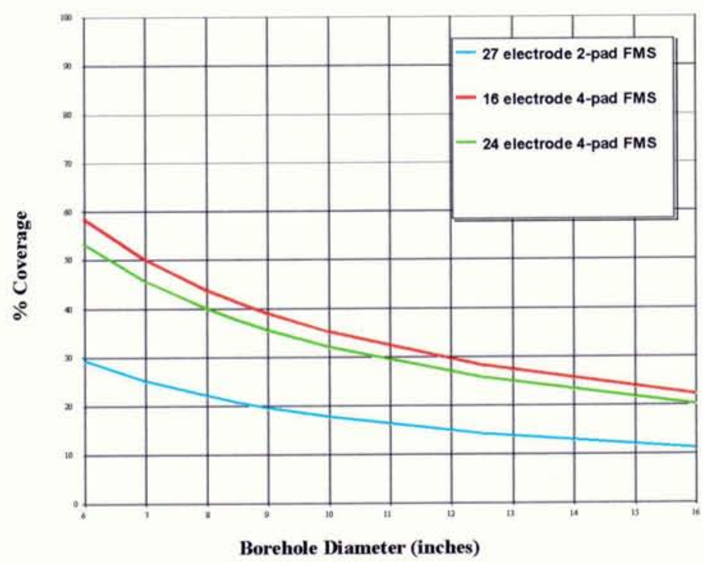
7 cm

First generations of 4-arm FMS
16 electrodes per pad



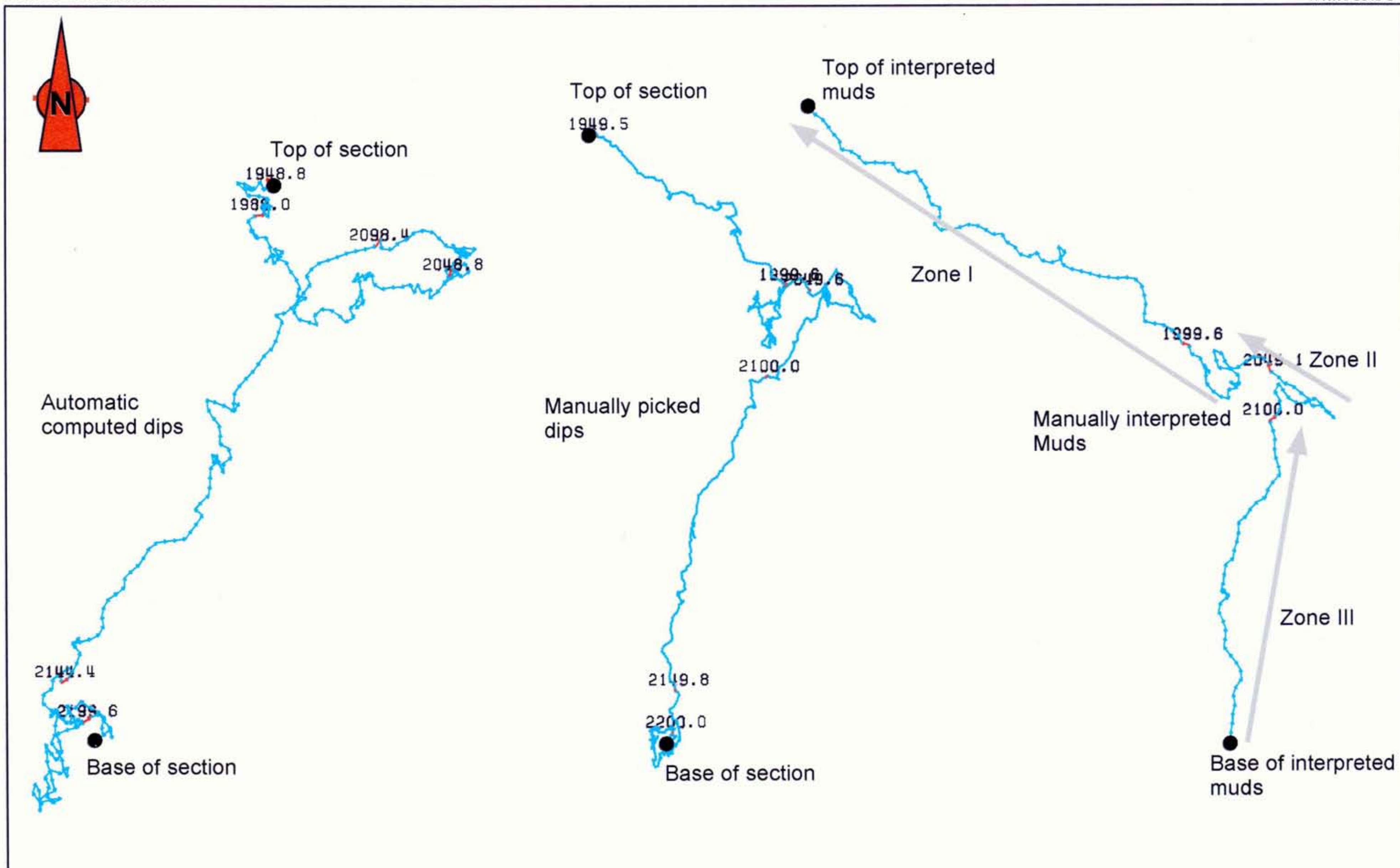
7 cm





Z&S (ASIA) LTD

Figure 2.1 The FMS Tool.



Z&S (ASIA) LTD

Figure 3.1 Cumulative dip azimuth plots of the automatic computed dips, manually picked dips and shale bedding, for the studied section 1948-2214 m.

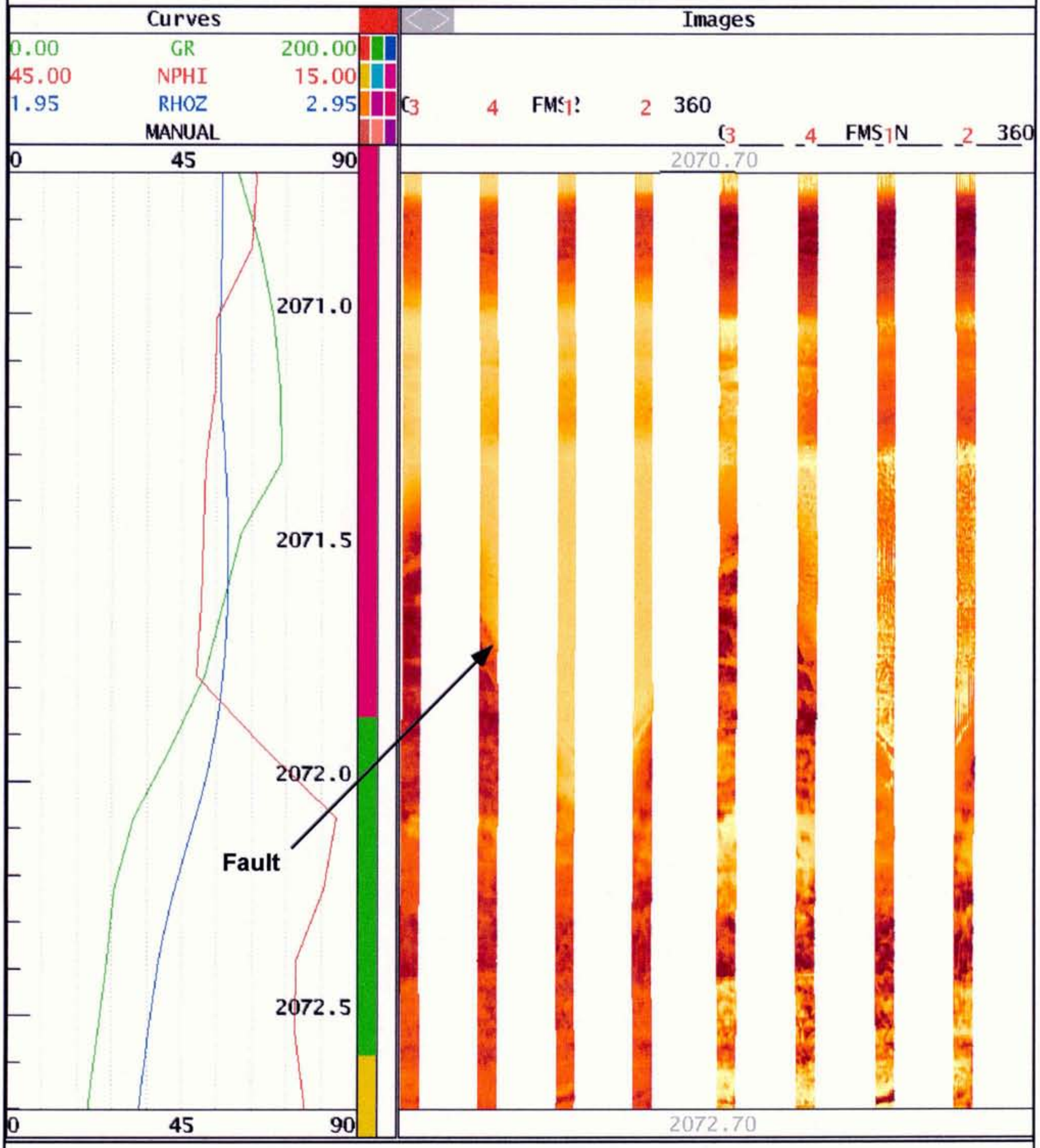


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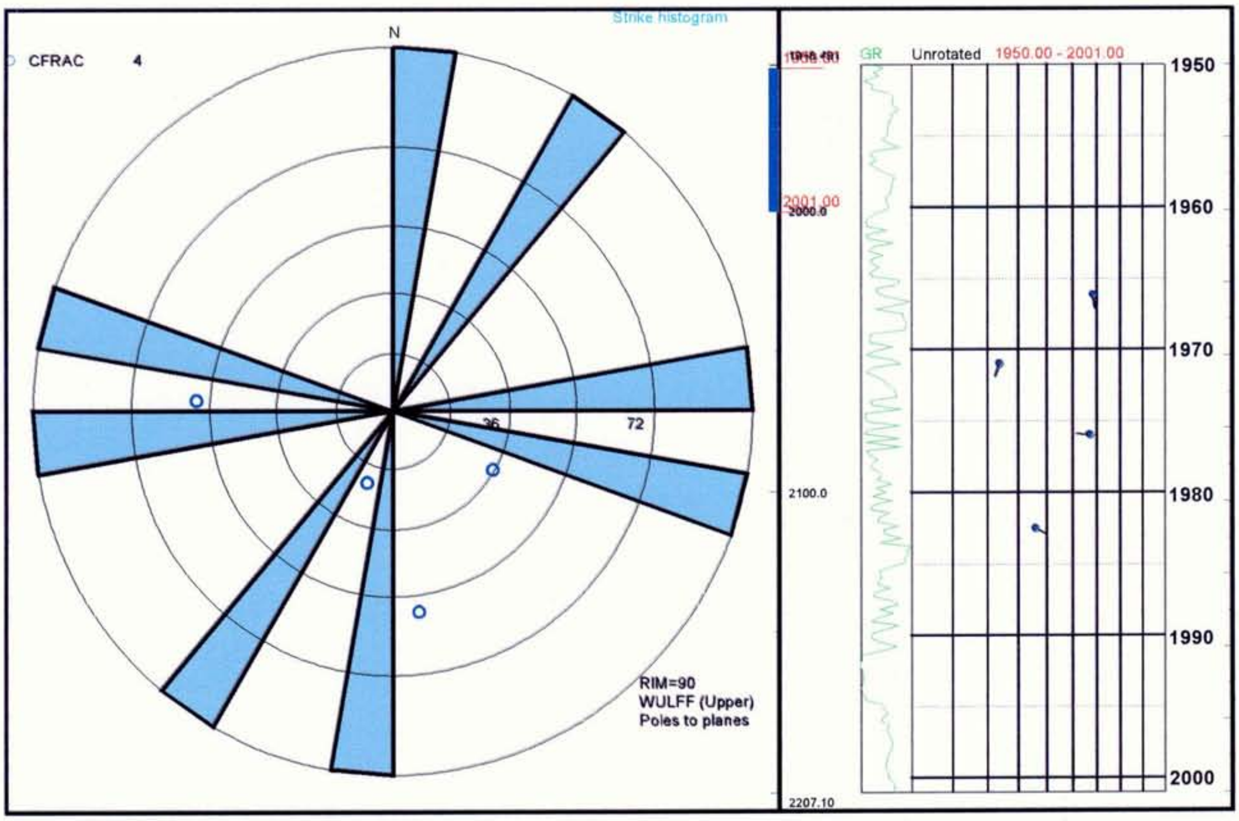
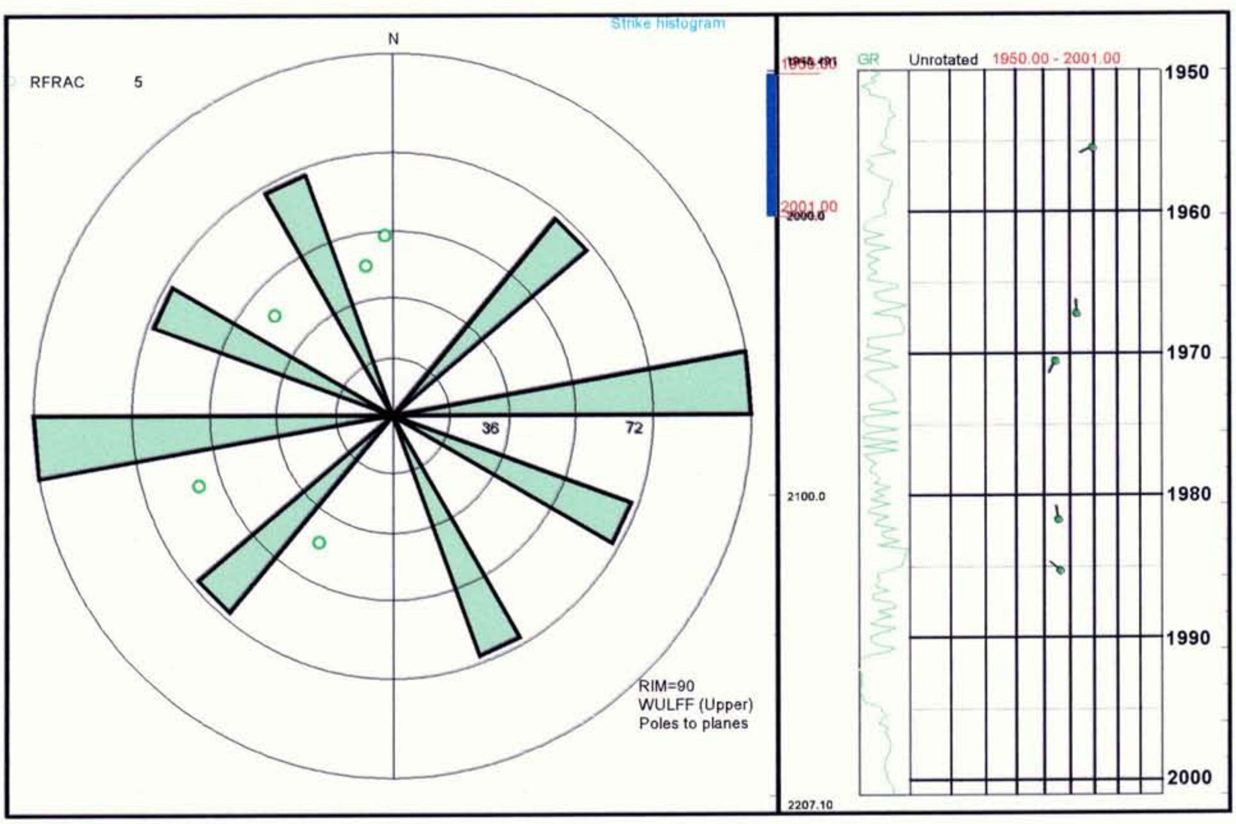
Figure 3.2 NW-SE trending fault at 2071.8 m, the fault plane trend is 57°/213°.



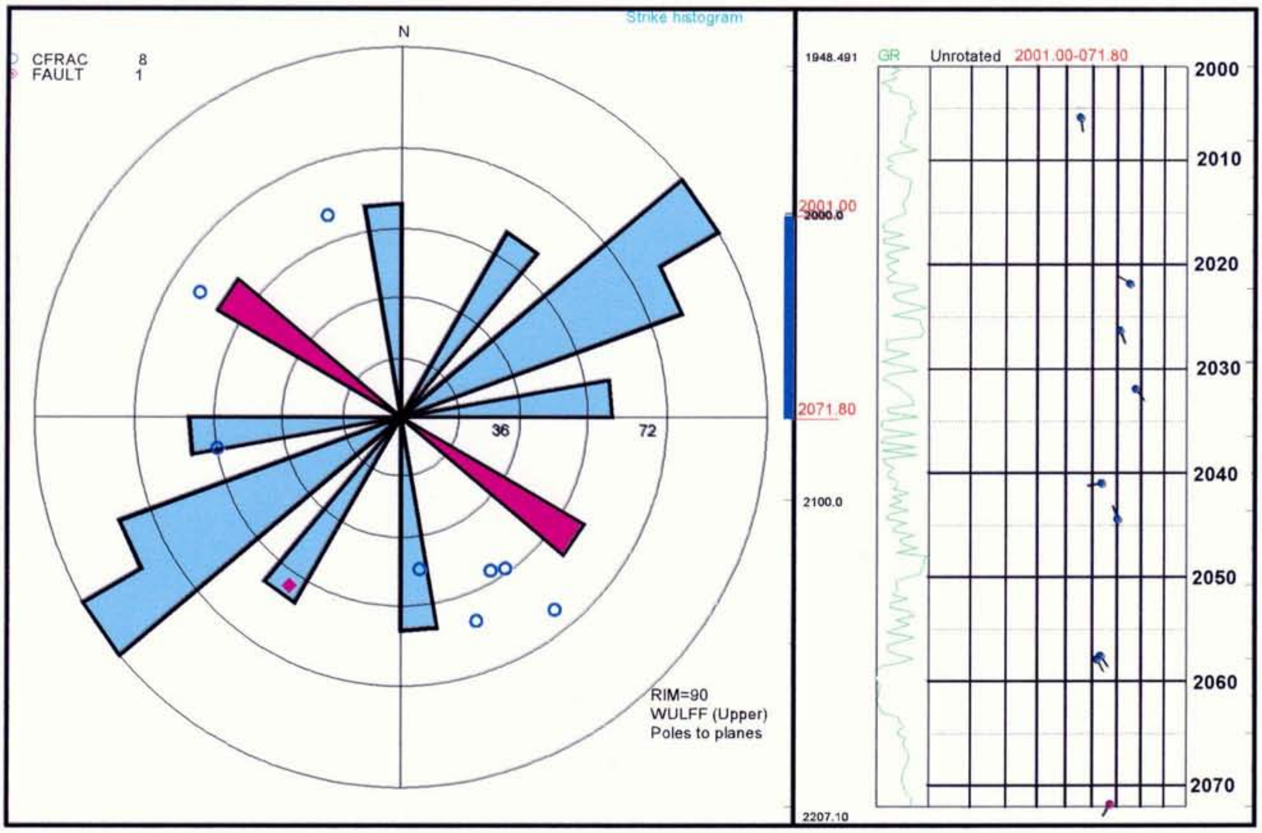
Conductive fractures



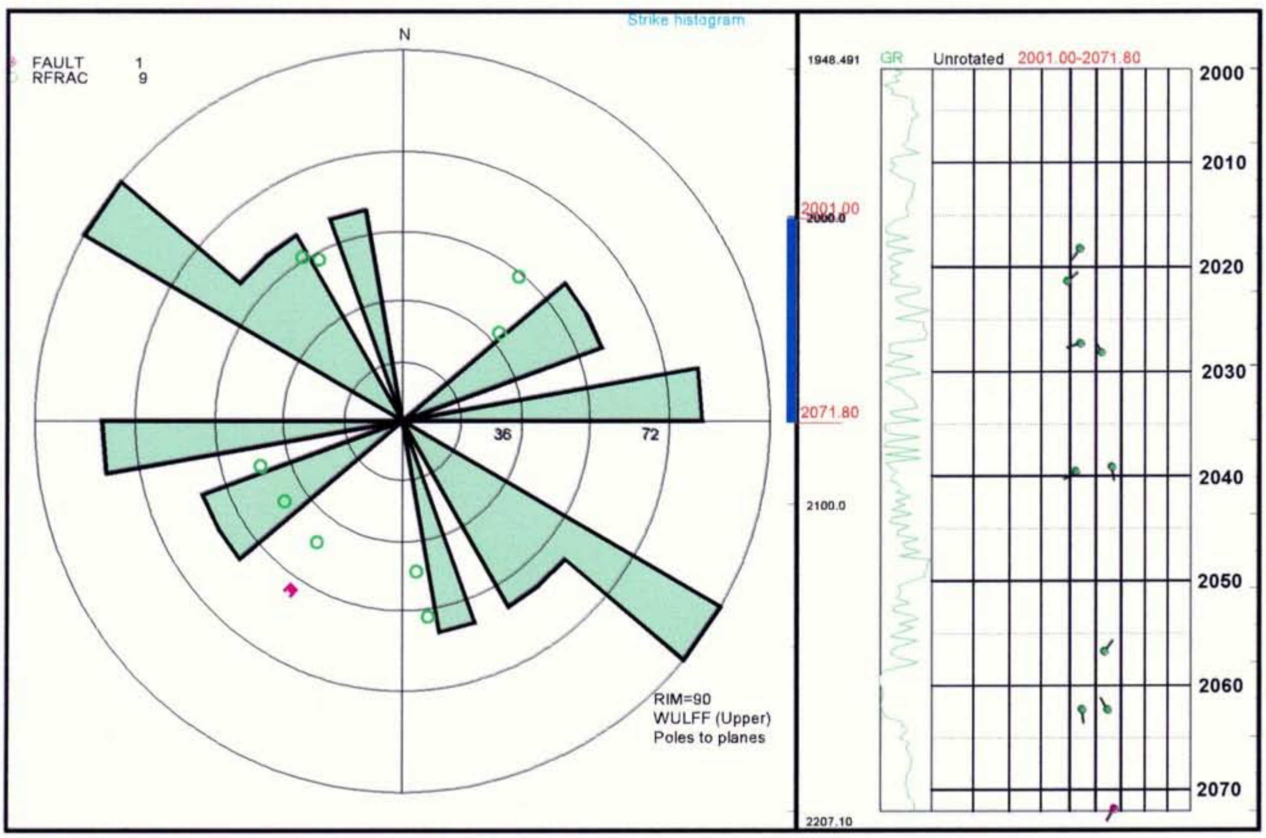
Resistive fractures

Z&S (ASIA) LTD

Figure 3.3 Stereoplots of conductive and resistive fractures strikes for structural zone I (1950-2001 m).



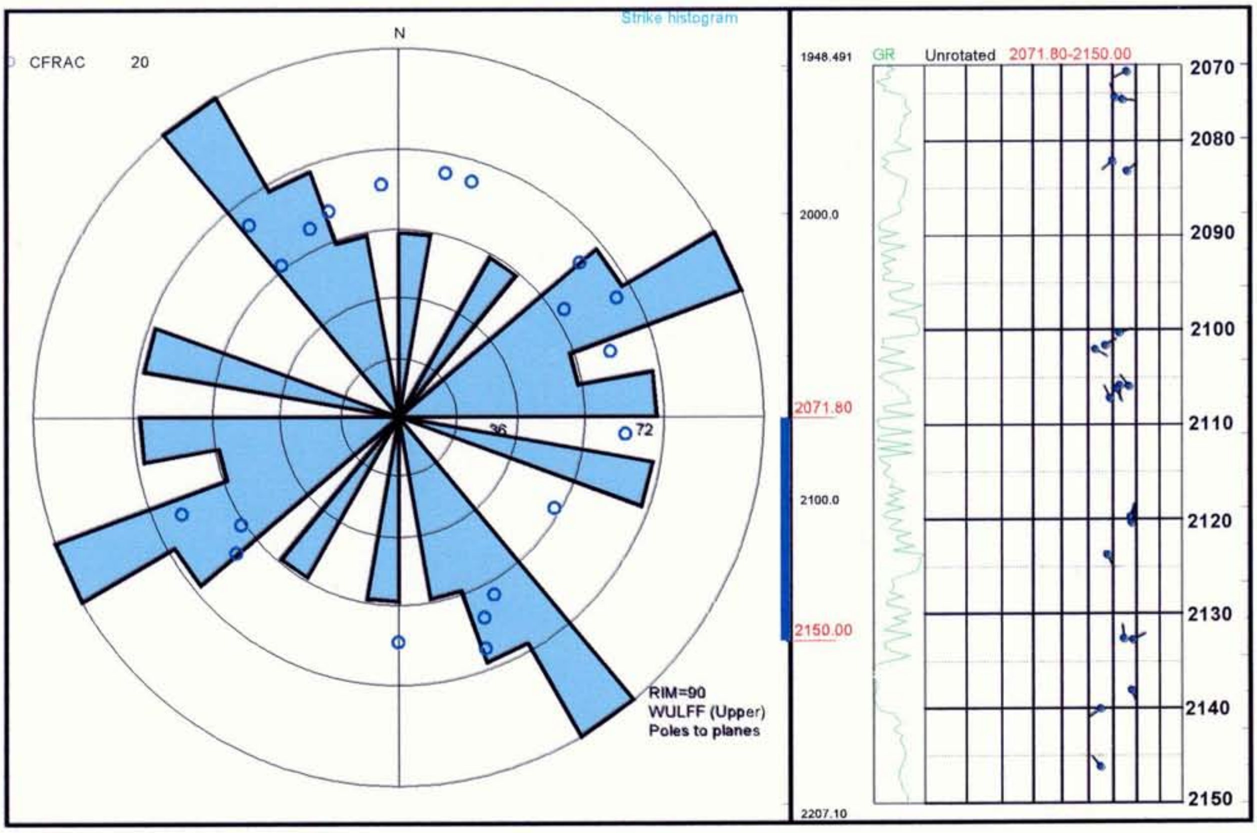
Conductive fractus & fault



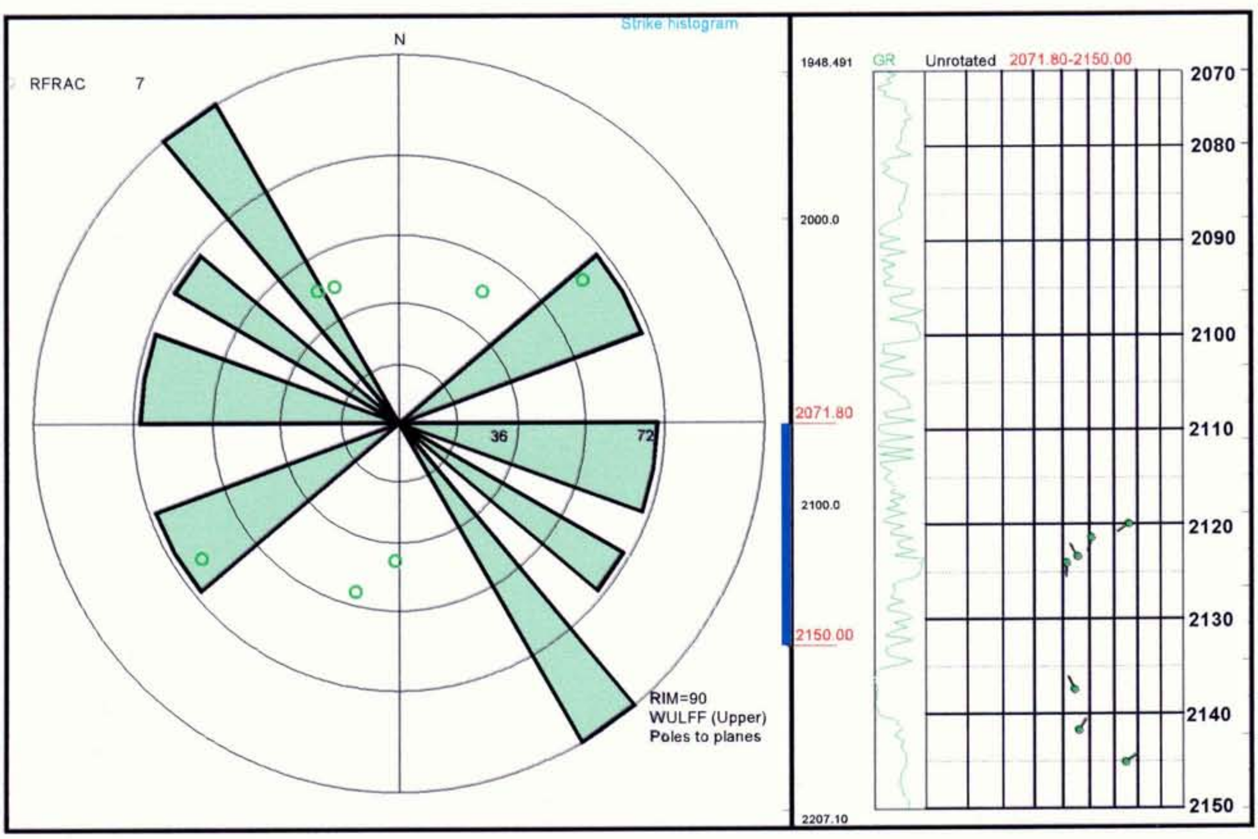
Resistive fractures & fault

Z&S (ASIA) LTD

Figure 3.4 Stereoplots of conductive and resistive fractures strikes for structural zone II (2001-2071.8 m) .



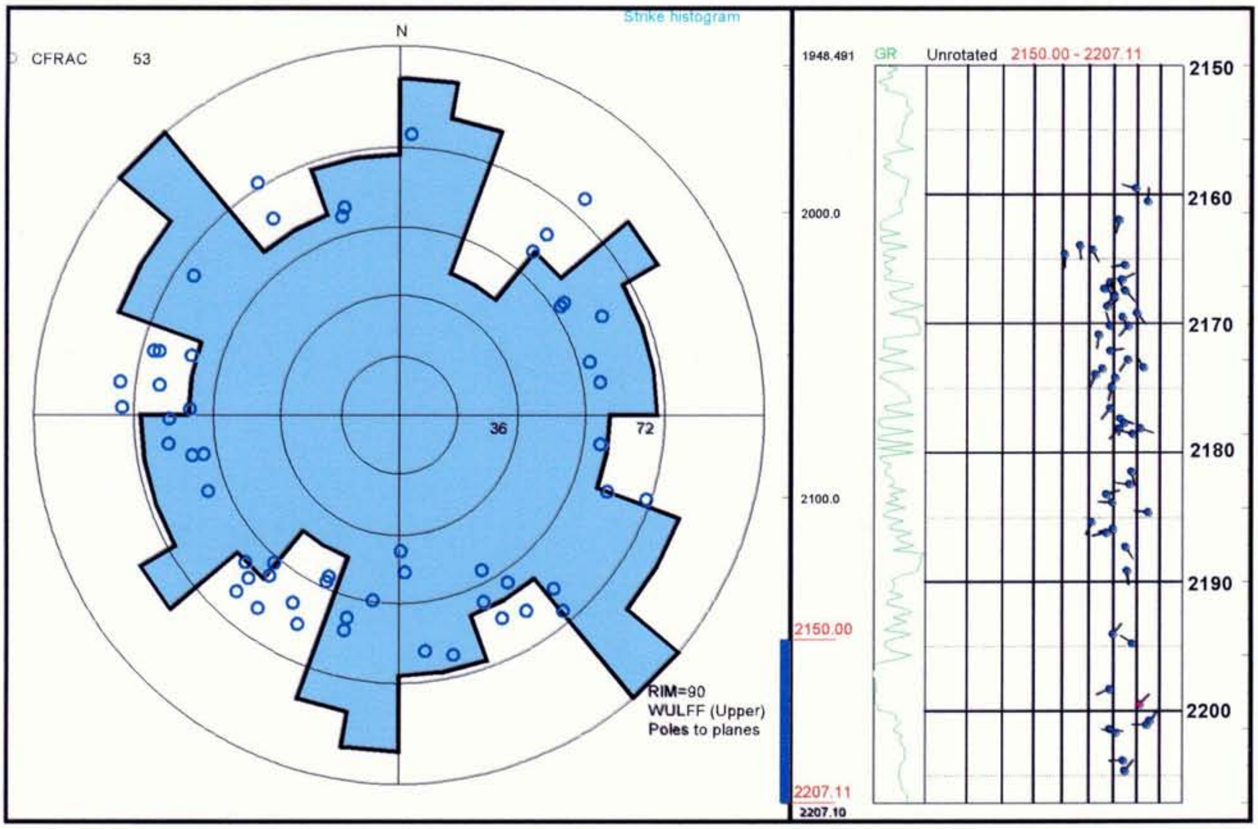
Conductive fractures



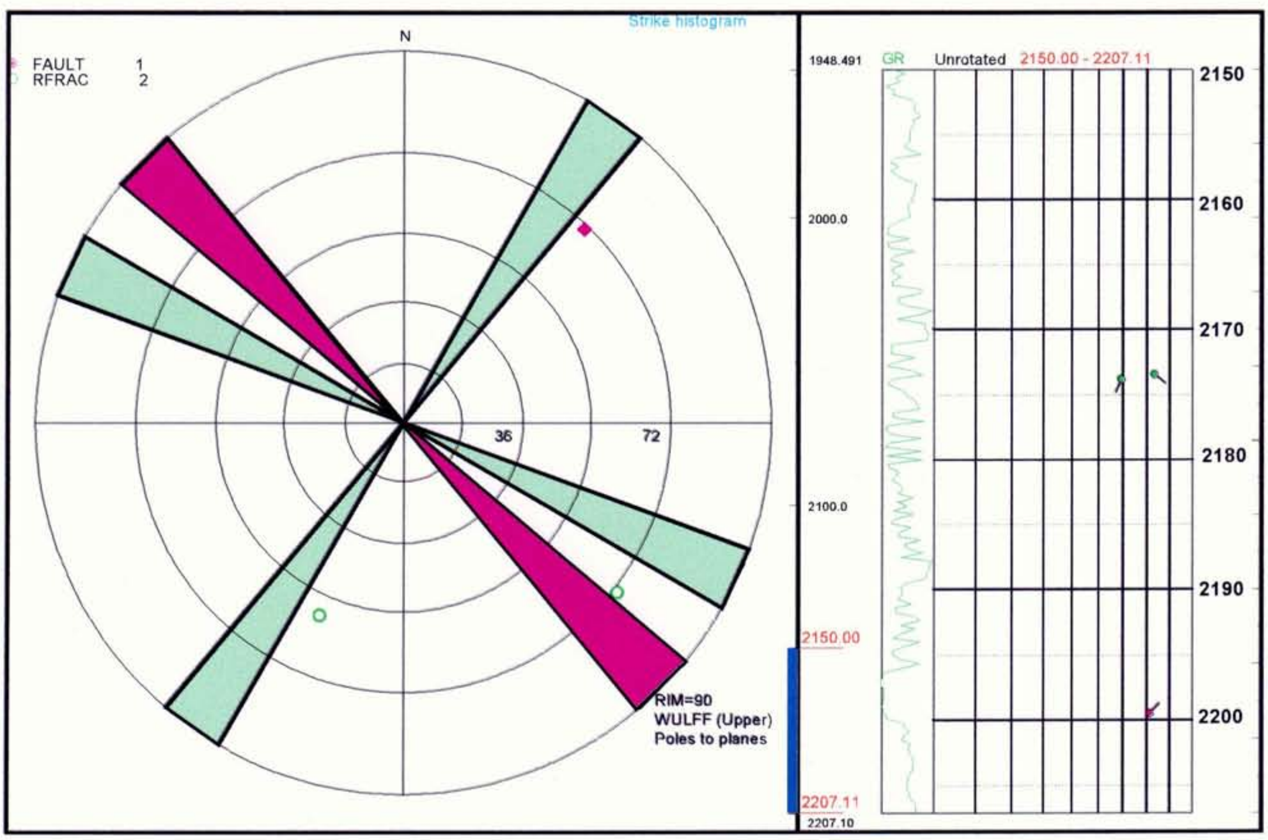
Resistive fractures

Z&S (ASIA) LTD

Figure 3.5 Stereoplots of conductive and resistive fractures strikes for structural zone III (2071.8-2150 m).



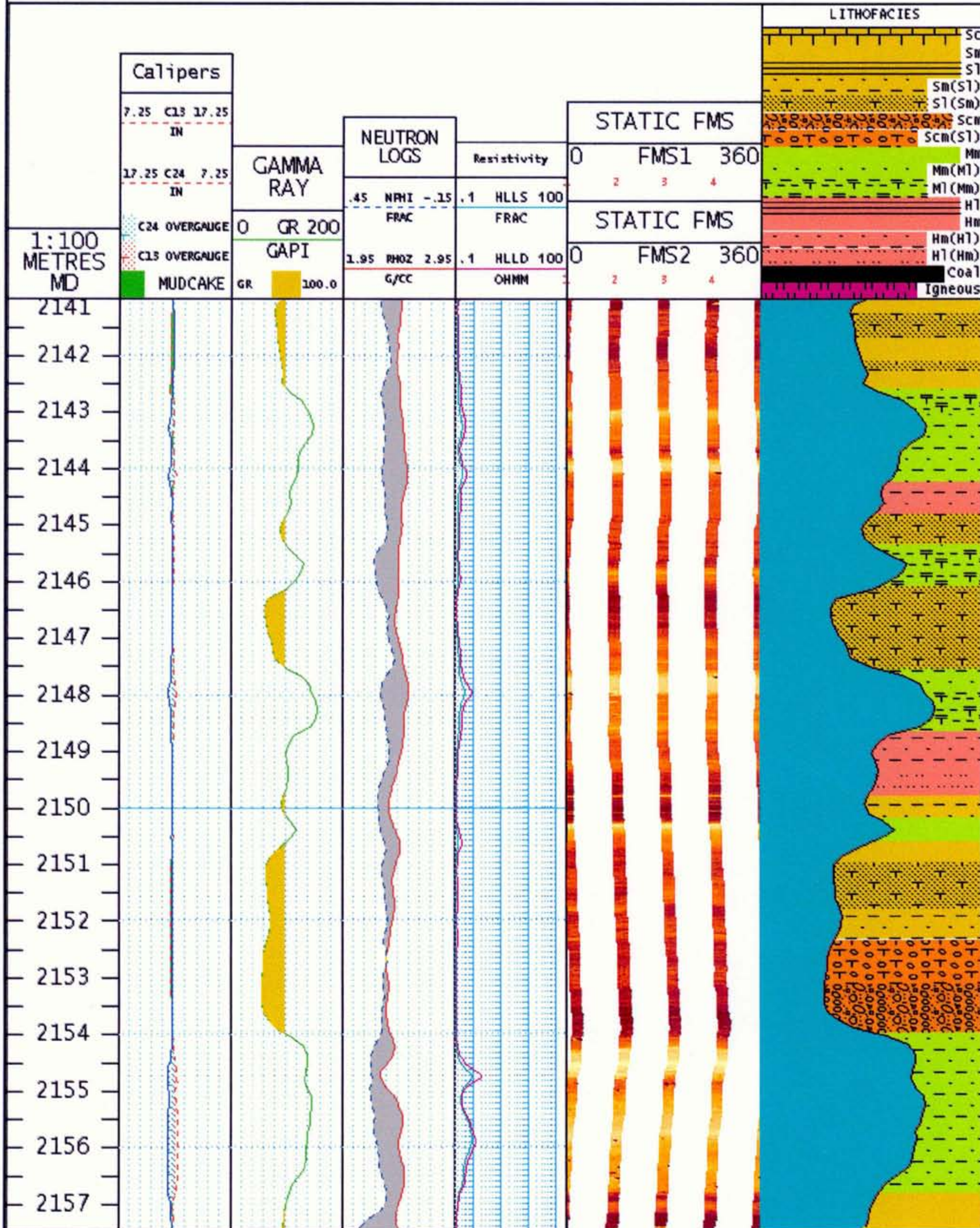
Conductive fractures



Resistive fractures & fault

Z&S (ASIA) LTD

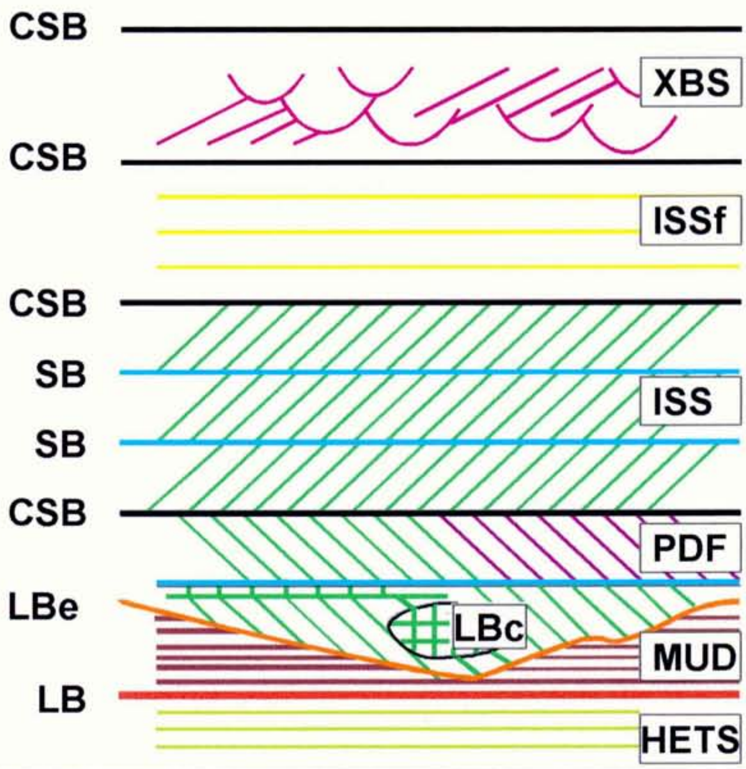
Figure 3.6 Stereoplots for conductive and resistive fractures strikes for structural zone IV (2150-2207 m).



Z&S (ASIA) LTD

Figure 3.7 Example of lithofacies identified from FMS images.

CODE	DESCRIPTION	COLOUR	TADPOLE
LB	lithological boundary	red	
LBc	cemented lithological boundary	pink	
LBe	erosional lithological boundary or surafce	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	
MUDS	mudstone lamination	brown	
RFRAC	resistive fracture	yellow	
CFRAC	conductive fracture	violet	
FAULT	fault	turquoise	



Z&S (ASIA) LTD

Figure 3.8 Dips were picked and categorised according to the illustrated scheme.

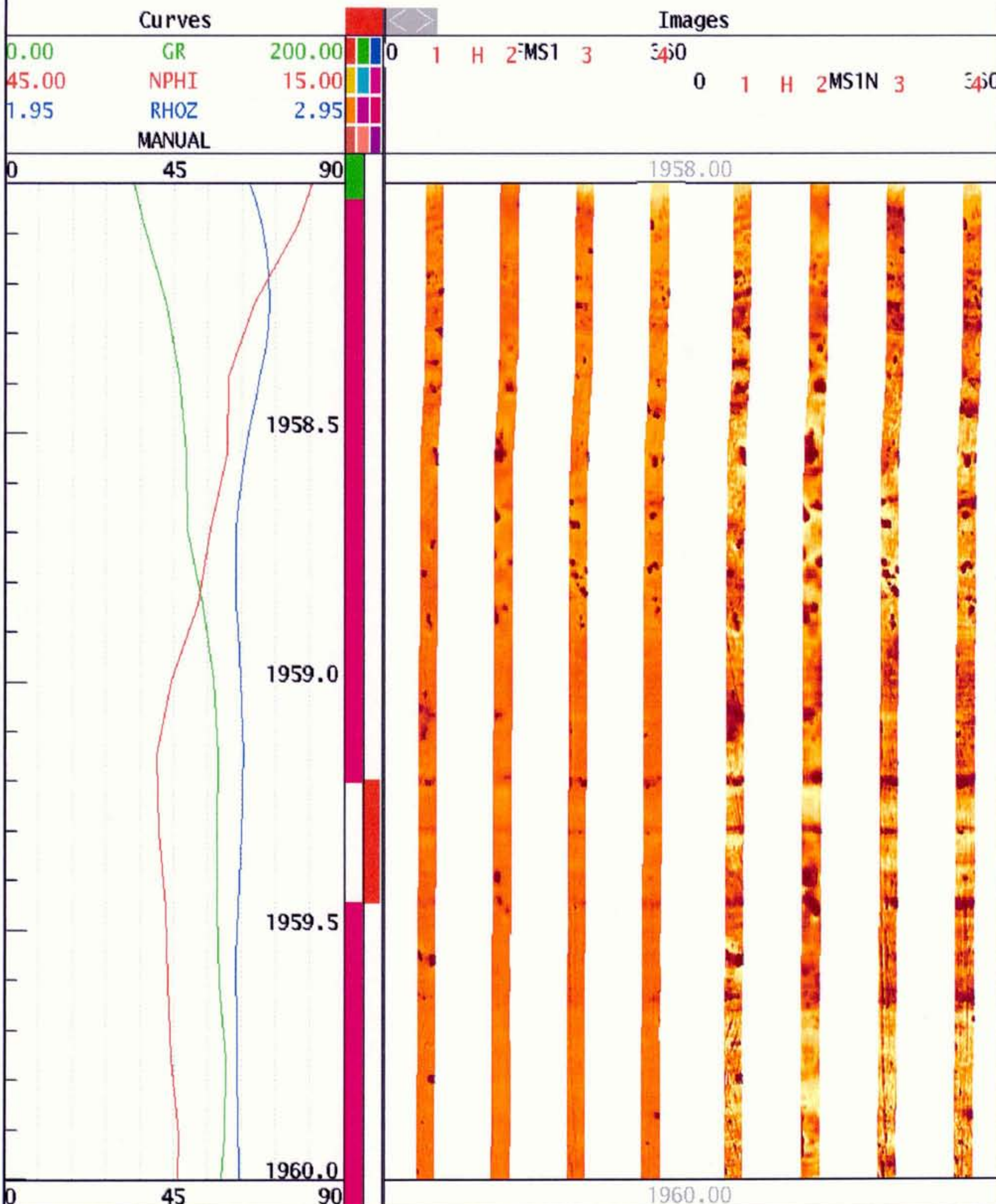


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Figure 3.9 FMS image illustrating pyrite nodules in mottled mudstones (Mm) 1958 - 1959 m.

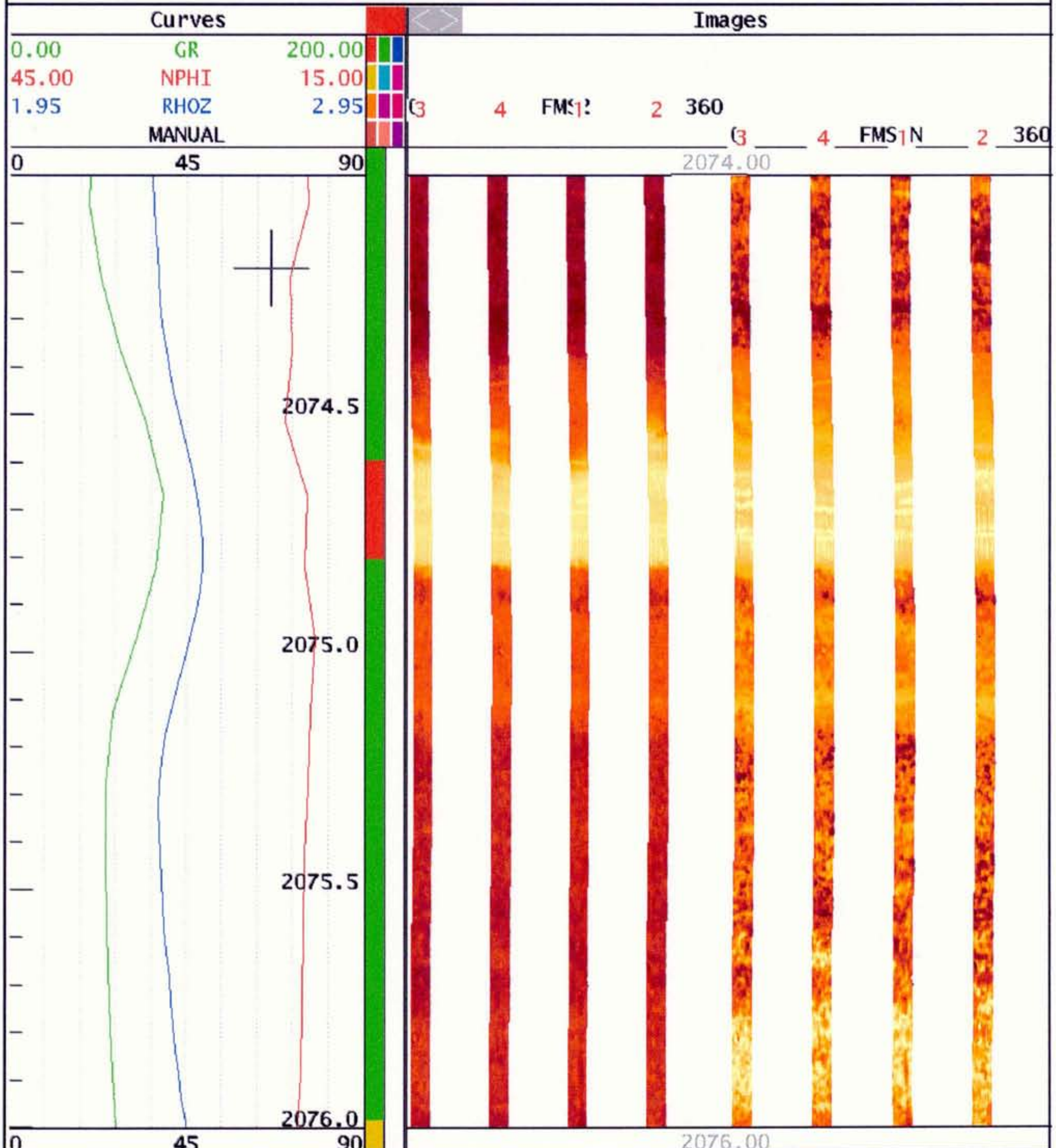

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Figure 3.10 FMS image illustrating mottled sandstones with a cemented bed, 2074.6-2074.8 m.

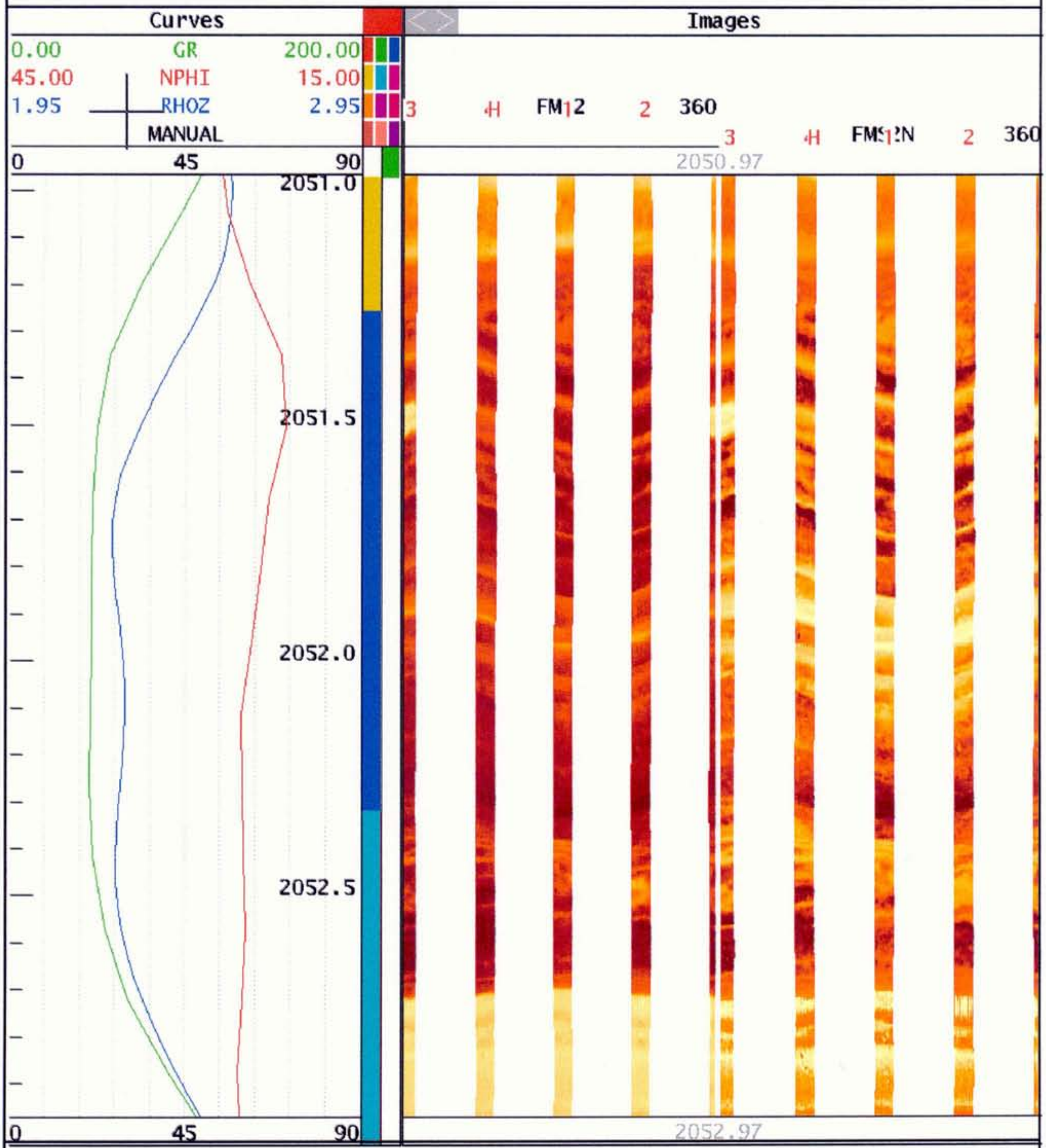

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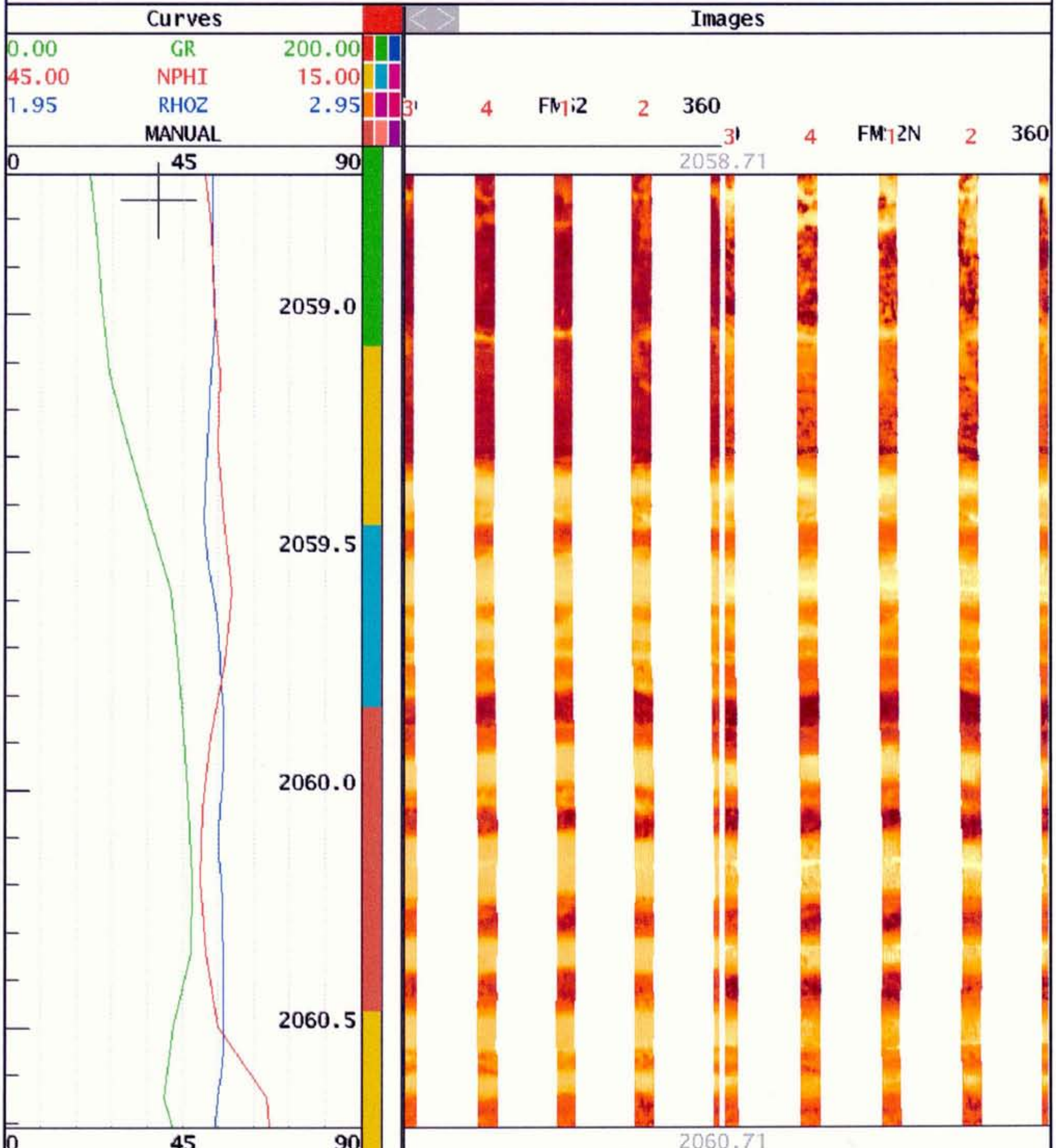
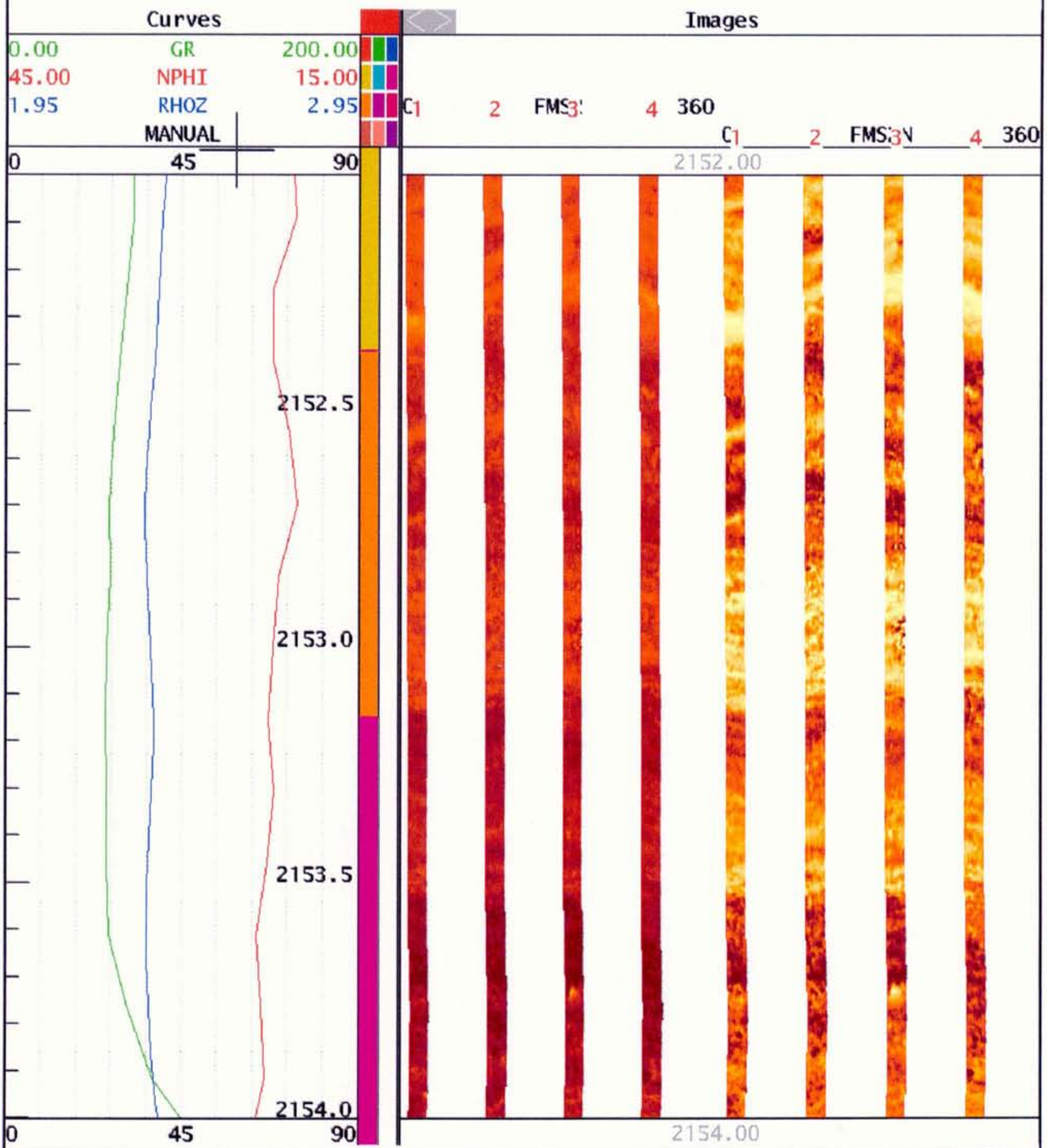
Figure 3.11 FMS image through well laminated sandstone lithofacies, Sm(Sl), 2051.0-2051.3 m; Sl, 2051.3-2052.4 m, and Sl(Sm), 2052.4-2053.0 m.



Z&S (ASIA) LTD

Figure 3.12 FMS image through dm-cm scale heterolithic and sandstone litho-facies with well developed lamination fabric (Hl) .



Z&S (ASIA) LTD

Figure 3.13 FMS images illustrating sandstone with coarse scale mottled fabric, Scm 2153.1-2154 m.

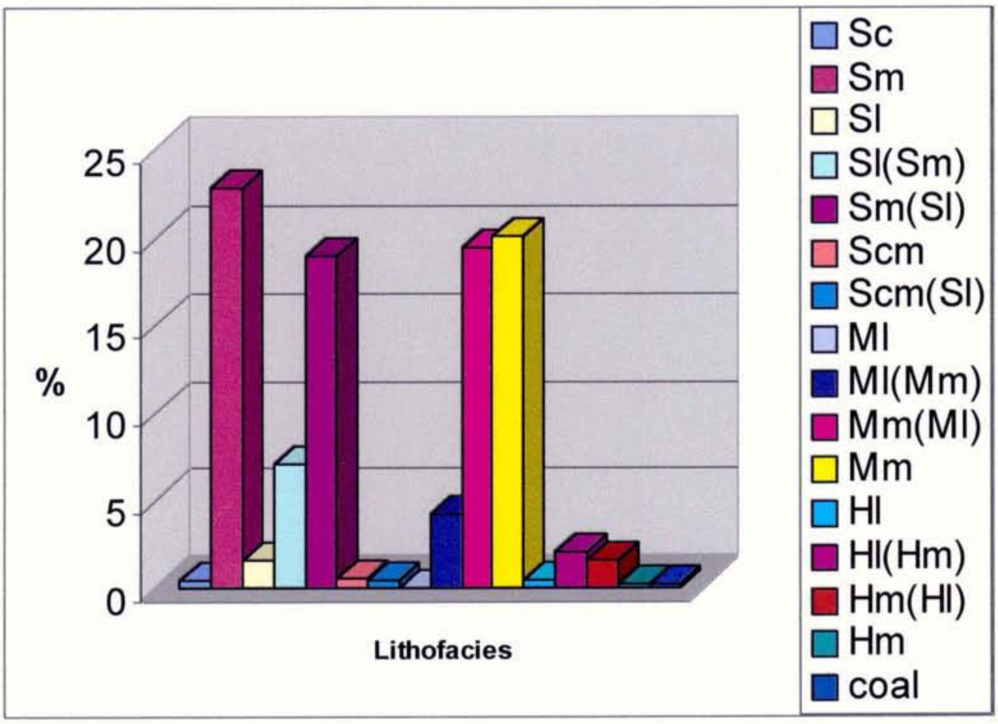


Figure 3.14 Lithofacies percentage in the studied interval (1997-2158 m).

APPENDICES

Appendix 1 - Fracture Listing

depth (meters)	dip	azimuth	Fracture type
1955.5183	59.46	249.96	Resistive
1966.1389	58.31	172.29	Conductive
1967.1989	52.67	357.85	Resistive
1970.5327	44.19	209.94	Resistive
1970.9516	23.76	199.21	Conductive
1975.9553	57.05	272.87	Conductive
1981.6999	45.28	350.15	Resistive
1982.4826	35.93	120.24	Conductive
1985.2914	46.05	310.09	Resistive
2005.9004	45.13	172.49	Conductive
2018.1944	43.61	214.98	Resistive
2021.3345	39.01	48.38	Resistive
2021.8412	65.30	301.55	Conductive
2026.3049	61.10	159.16	Conductive
2027.2944	43.81	252.30	Resistive
2028.1372	51.91	332.44	Resistive
2031.9475	67.78	140.89	Conductive
2039.0767	56.16	172.21	Resistive
2039.5105	42.09	235.53	Resistive
2040.9961	53.62	260.25	Conductive
2044.4377	60.09	339.97	Conductive
2056.7306	53.18	39.57	Resistive
2057.5013	53.23	144.87	Conductive
2057.8658	51.69	149.12	Conductive
2062.276	44.50	174.29	Resistive
2062.3035	54.49	328.31	Resistive
2072.7077	65.85	245.95	Conductive
2075.4	60.87	341.29	Conductive
2075.6292	64.05	94.37	Conductive
2082.1071	59.90	230.13	Conductive
2083.1802	66.00	50.13	Conductive
2100.2791	62.62	73.19	Conductive
2101.6409	56.80	57.54	Conductive
2102.0399	52.74	120.09	Conductive
2105.8803	62.86	179.88	Conductive
2105.9511	66.75	321.94	Conductive
2106.1816	61.42	156.50	Conductive
2107.212	58.76	334.83	Conductive
2119.7594	67.50	17.69	Conductive
2119.9347	66.17	235.58	Resistive
2120.4123	67.85	11.20	Conductive
2121.3712	50.71	194.24	Resistive
2123.3791	45.41	328.27	Resistive
2123.7321	57.56	151.32	Conductive
2124.0346	41.20	181.39	Resistive
2132.6149	64.49	355.93	Conductive
2132.723	68.42	61.85	Conductive
2137.4256	44.17	334.71	Resistive
2138.0868	67.88	159.05	Conductive
2140.0206	54.89	235.63	Conductive
2141.7381	45.82	33.11	Resistive
2145.1125	64.83	52.76	Resistive
2146.1778	54.79	322.23	Conductive

depth (meters)	dip	azimuth	Fracture type
2159.5014	69.21	284.42	Conductive
2160.5292	74.46	2.59	Conductive
2161.9537	62.12	194.14	Conductive
2163.9259	46.31	177.43	Conductive
2164.2541	51.26	151.39	Conductive
2164.5873	40.61	178.82	Conductive
2165.4615	64.69	262.74	Conductive
2166.5909	63.45	64.44	Conductive
2166.8158	58.40	155.14	Conductive
2167.2491	57.19	146.48	Conductive
2167.3008	56.03	56.59	Conductive
2167.4228	64.55	327.08	Conductive
2167.4615	64.93	137.84	Conductive
2167.7735	60.23	345.17	Conductive
2167.8937	60.00	226.23	Conductive
2168.6716	57.22	56.27	Conductive
2169.1898	69.80	139.57	Conductive
2169.4921	63.70	152.62	Conductive
2170.1608	58.37	343.86	Conductive
2170.1625	66.13	222.63	Conductive
2170.856	53.86	187.77	Conductive
2172.1267	58.49	81.03	Conductive
2172.7918	65.98	216.16	Conductive
2173.3857	72.71	328.42	Conductive
2173.4313	73.22	128.19	Resistive
2173.4749	55.38	220.14	Conductive
2173.7897	59.14	203.28	Resistive
2173.9407	52.49	203.35	Conductive
2174.182	60.66	209.42	Conductive
2174.9172	59.17	194.22	Conductive
2176.5506	58.54	218.83	Conductive
2177.3521	62.74	110.01	Conductive
2177.6817	64.46	205.83	Conductive
2178.1029	71.34	108.69	Conductive
2178.1317	62.13	222.68	Conductive
2178.5418	68.06	284.72	Conductive
2181.4642	67.57	166.87	Conductive
2182.4387	66.65	276.96	Conductive
2183.2081	57.04	74.83	Conductive
2183.8336	59.41	271.47	Conductive
2184.6109	74.84	276.64	Conductive
2185.3323	51.03	203.32	Conductive
2185.8982	59.71	258.85	Conductive
2186.1872	56.98	258.53	Conductive
2187.2774	65.03	146.47	Conductive
2189.1312	65.68	173.34	Conductive
2194.0517	59.76	39.75	Conductive
2194.7819	67.97	303.80	Conductive
2198.3162	58.43	248.20	Conductive
2200.7495	75.55	41.11	Conductive
2201.0753	74.12	271.47	Conductive
2201.4024	58.47	98.28	Conductive
2201.6829	60.90	285.71	Conductive
2203.8389	64.12	268.93	Conductive
2204.6222	64.77	39.73	Conductive

Appendix 2 - Lithofacies Tops

Top depth (meters)	Lithofacies
1995.12	Mm
1998.49	Mm(Ml)
1999.59	Mm
2001.49	Sm
2002.09	Sm(Sl)
2002.57	Sm
2002.96	Sm(Sl)
2003.71	Sm
2005.89	Sm(Sl)
2007.36	Mm(Ml)
2007.73	Sm
2008.47	Sm(Sl)
2008.85	Sm
2009.29	Sm(Sl)
2011.05	Sm
2011.45	Mm(Ml)
2012.45	Mm
2013.38	Sm
2013.75	Sm(Sl)
2014.26	Sm
2014.64	Sm(Sl)
2014.91	Sm
2015.35	Sl(Sm)
2016.01	Hl(Hm)
2016.51	Mm(Ml)
2017.02	Mm
2017.64	Sm(Sl)
2018.54	Sm
2019.77	Mm
2020.05	Mm(Ml)
2020.28	Mm
2020.84	Sm(Sl)
2021.63	Sm
2022.18	Sl
2023.07	Sm(Sl)
2023.44	Sm
2024.34	Mm
2025.71	Mm(Ml)
2026.30	coal
2026.66	Mm
2027.53	Mm(Ml)
2028.03	Sm(Sl)
2028.66	Mm(Ml)
2029.09	Sm
2029.33	Sl
2029.94	Hm
2030.29	Hm(Hl)
2031.14	Mm(Ml)
2031.51	Mm
2033.17	Mm(Ml)

Top depth (meters)	Lithofacies
2033.68	Mm
2035.01	Sm(Sl)
2035.30	Sl(Sm)
2035.54	Sm
2035.88	Sl(Sm)
2036.69	Mm
2038.97	Mm(Ml)
2039.95	Mm
2040.86	Mm(Ml)
2041.92	Mm
2043.44	Mm(Ml)
2044.11	Sm(Sl)
2045.46	Sm
2045.84	Sm(Sl)
2046.02	Sm
2046.38	Sl(Sm)
2046.71	Sc
2046.94	Sl(Sm)
2047.35	Sm
2048.74	Mm(Ml)
2049.40	Sm(Sl)
2049.59	Sm
2050.57	Mm(Ml)
2050.97	Sm(Sl)
2051.26	Sl
2052.32	Sl(Sm)
2053.03	Mm
2053.84	Sm(Sl)
2054.37	Mm(Ml)
2055.86	Sm(Sl)
2056.72	Sm
2056.93	Sm(Sl)
2057.39	Sm
2059.07	Sm(Sl)
2059.44	Sl(Sm)
2059.82	Hl
2060.47	Sm(Sl)
2060.82	Mm(Ml)
2062.21	Ml(Mm)
2062.88	Mm
2063.67	Mm(Ml)
2063.97	Mm
2064.56	Mm(Ml)
2065.66	Sm
2066.01	Mm
2067.47	Mm(Ml)
2067.71	Sm
2068.22	Sm(Sl)
2068.84	Sm
2069.47	Sl(Sm)
2069.73	Sm
2070.47	Mm
2071.86	Sm
2072.59	Sm(Sl)

Top depth (meters)	Lithofacies
2073.52	Sm
2074.60	Sc
2074.80	Sm
2075.99	Sm(Sl)
2076.33	Mm(Ml)
2077.27	Mm
2078.10	Sm(Sl)
2078.57	Sl(Sm)
2078.83	Sm
2079.98	Sm(Sl)
2081.19	Mm
2081.69	Sm
2082.19	Sm(Sl)
2082.42	Sm
2082.59	Sm(Sl)
2083.01	Sm
2083.89	Mm
2084.63	Mm(Ml)
2084.82	Sm
2085.41	Sm(Sl)
2085.81	Sm
2086.17	Sm(Sl)
2086.87	Sm
2087.68	Sm(Sl)
2088.01	Ml(Mm)
2088.53	Sm(Sl)
2089.32	Sm
2089.76	Sm(Sl)
2091.31	Sm
2092.14	Sm(Sl)
2092.48	Sm
2092.90	Sm(Sl)
2093.72	Sl(Sm)
2094.05	Sm
2094.43	Hl(Hm)
2094.83	Sm(Sl)
2095.39	Sm
2096.21	Sm(Sl)
2096.46	Mm(Ml)
2098.40	Sm(Sl)
2099.74	Mm(Ml)
2100.01	Ml(Mm)
2100.69	Mm
2101.18	Sm(Sl)
2102.33	Mm(Ml)
2102.98	Ml(Mm)
2103.60	Mm
2103.99	Sm
2104.36	Sm(Sl)
2104.65	Sl(Sm)
2105.03	Sm
2106.56	Sl(Sm)
2107.58	Mm(Ml)
2108.03	Ml(Mm)

Top depth (meters)	Lithofacies
2108.67	Hl(Hm)
2109.46	Sm
2109.95	Hl(Hm)
2110.44	Sm
2111.71	Mm(Ml)
2112.48	Mm
2113.71	Hl(Hm)
2114.25	Hm(Hl)
2114.64	Sl(Sm)
2115.47	Ml(Mm)
2116.30	Mm
2117.39	Ml(Mm)
2118.04	Sl(Sm)
2118.49	Sm
2118.73	Mm
2120.51	Mm(Ml)
2121.00	Mm
2121.86	Mm(Ml)
2124.17	Mm
2125.53	Mm(Ml)
2126.19	Mm
2126.60	Mm(Ml)
2128.04	Sm
2129.36	Sm(Sl)
2129.91	Sm
2130.30	Sl(Sm)
2130.69	Mm(Ml)
2131.18	Ml(Mm)
2131.56	Sm
2132.04	Sc
2132.24	Sm
2132.82	Sm(Sl)
2134.38	Mm(Ml)
2135.05	Mm
2135.48	Mm(Ml)
2136.01	Sm
2136.77	Sm(Sl)
2137.56	Sl(Sm)
2138.07	Sm(Sl)
2138.77	Mm(Ml)
2139.74	Mm
2140.86	Sm
2141.26	Sl(Sm)
2141.68	Sm
2142.10	Sl(Sm)
2142.27	Sm
2142.58	Ml(Mm)
2143.00	Mm(Ml)
2144.25	Hm(Hl)
2144.83	Sl(Sm)
2145.37	Ml(Mm)
2146.11	Sm(Sl)
2146.11	Sl(Sm)
2147.55	Mm(Ml)

Top depth (meters)	Lithofacies
2148.02	Ml(Mm)
2148.69	Hm(Hl)
2149.36	Hl(Hm)
2149.82	Sm(Sl)
2150.21	Mm
2150.64	Sm
2151.01	Sl(Sm)
2151.81	Sm(Sl)
2152.37	Scm
2152.37	Scm(Sl)
2153.15	Scm
2154.01	Mm(Ml)
2156.85	Sm
2157.50	base of study

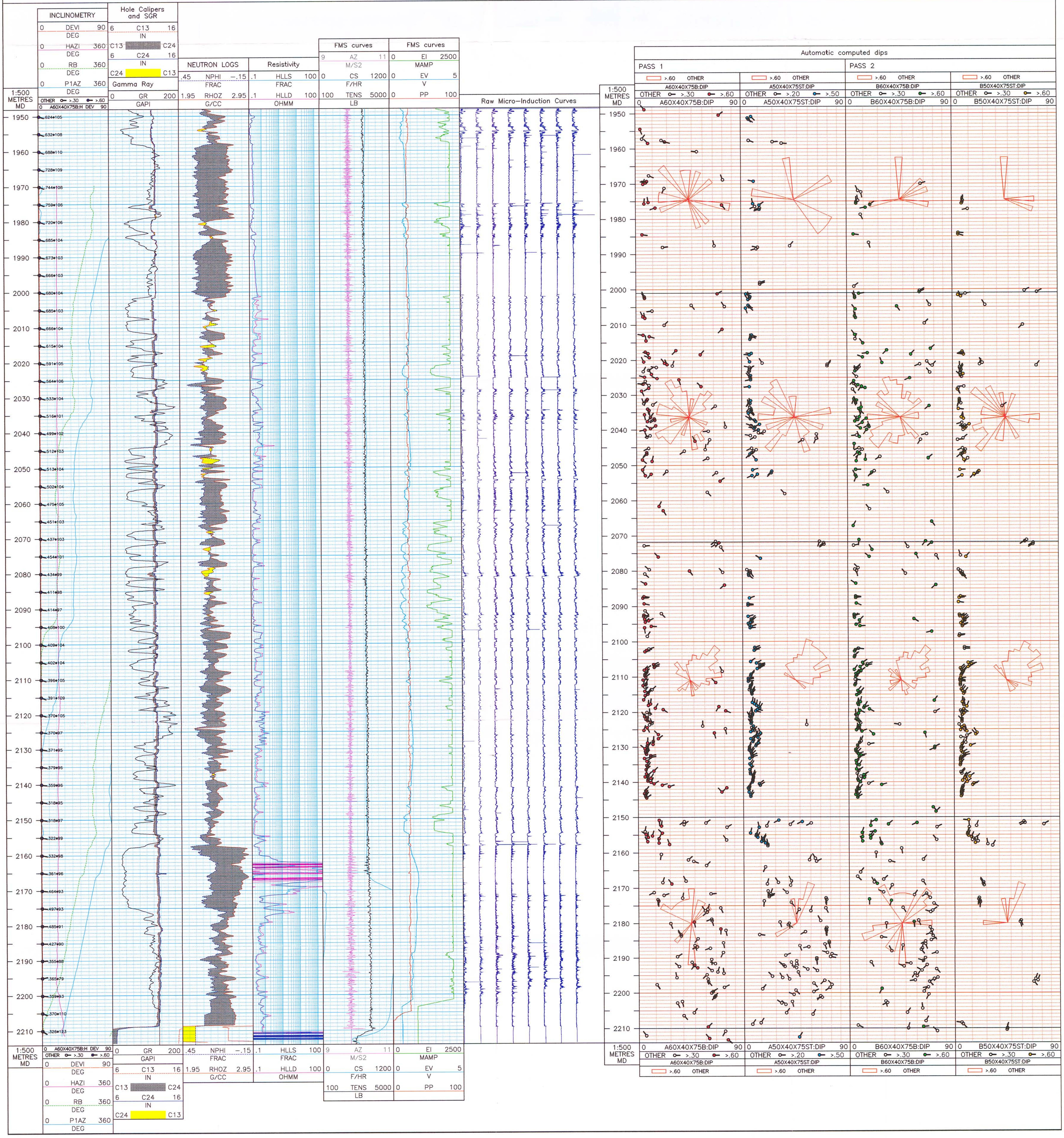
ENCLOSURES

PREMIER OIL AUSTRALIA
WHITE IBIS 1

Enclosure 1

1:500 QUALITY CONTROL PLOT

BIT SIZE: 12.25 IN
BH TEMP: 94 DEGC
BOREHOLE FLUID TYPE: WATER
BOREHOLE SALINITY: 43000 PPM
MUD DENSITY: 1.09 G/CC
MUD PH: 9
MUD TYPE: KCl – PHPA
MUD VISCOSITY: 41 S
SURF. LATITUDE: 39 57' 49.607" S
SURF. LONGITUDE: 145 15' 17.234" E
MAGNETIC DECLINATION: 12.3651 DEG
MAGNETIC INCLINATION: –70.8554 DEG
RUN DATE: 26–JUN–1998
DEPTH RANGE: 1948.00–2214.00 METRES

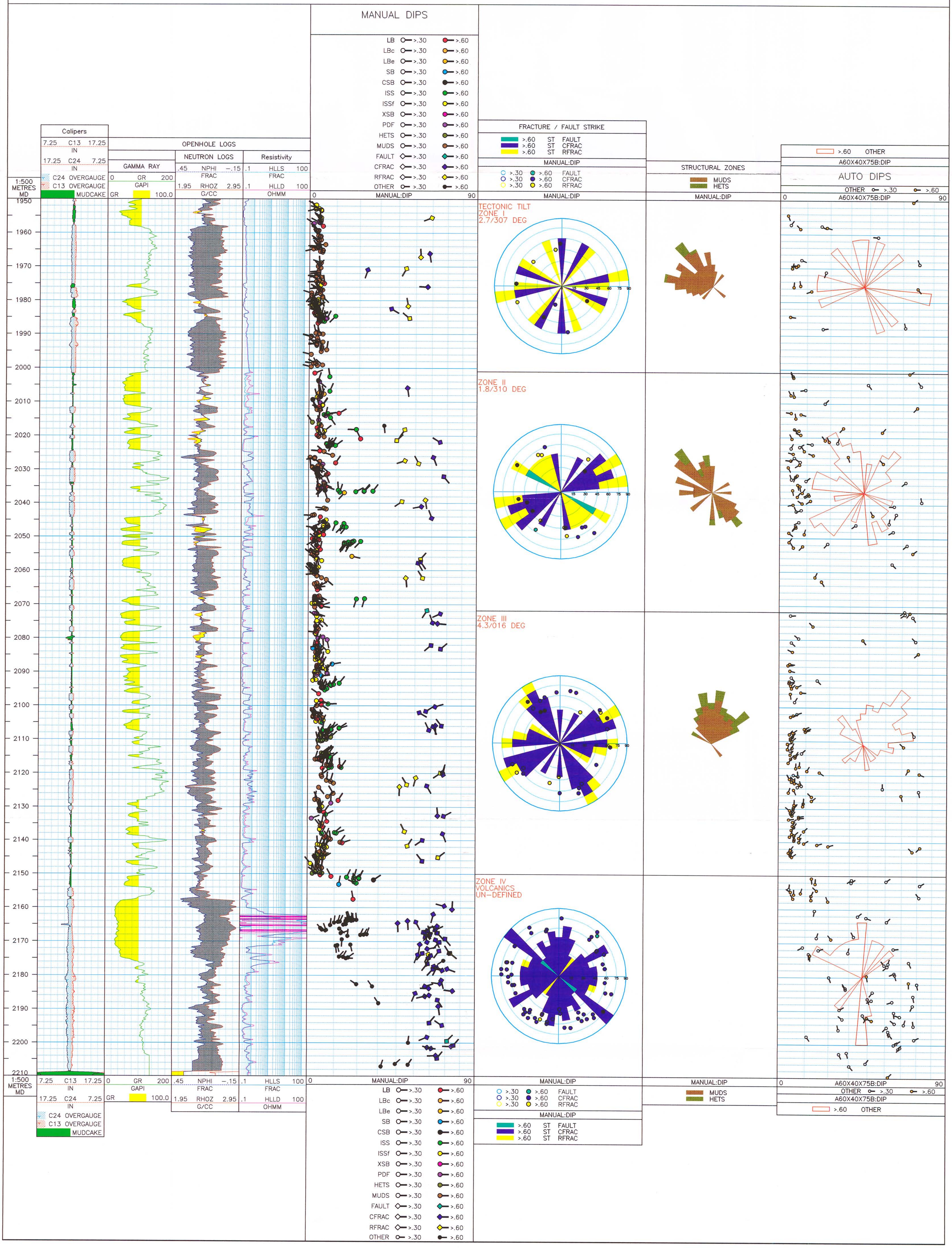


Premier Oil Australia
WHITE IBIS 1

Enclosure 2

1950.00–2210.00 METRES

1:500 STRUCTURAL SUMMARY PLOT



Premier Oil Australia
White Ibis 1

Enclosure 3

1950.00–2215.00 METRES

1:200 Data Overview Plot

Premier Oil Australia
White Ibis 1

Enclosure 4

1997.00–2157.50 METRES

1:100 Sedimentological Composite Plot

Palynology comments

Lower Lygistepollenites balmei Zone, early Palaeocene marginally marine (1991.7) to possible freshwater (1998.2–2098.1 m).

Upper Tricolpites longus Zone, late Maastrichtian, non–marine lacustrine

Comments

A subtle change in dip azimuth, palynology and consistent change in mudstone cementation fabrics suggests a possible unconformity at the base of succession.

Stacked upward coarsening successions could be generated by propogradation of deltaic mouthbars and/or marine shellf shoreface successions.

Possible proximal distributary mouth bars.

Upward coarsening successions suggests progradation of deltaic mouthbars.

This succession is interpreted as probably representing progradation of a deltaic mouthbar.

Coarsening upward facies stacking patterns could be generated in deltaic environments.

Upward coarsening successions may represent progradation of distributary mouth bars with sandstones being deposited in the upper portions of the mouth bars.

Thick successions of mudstones near the base of this interval may reflect deposition in lacustrine or fluvial floodplain environments.

The progradational stacking pattern and low–angle–parallel laminated sandstone lithologies may reflect deposition within a variety of continental environments.

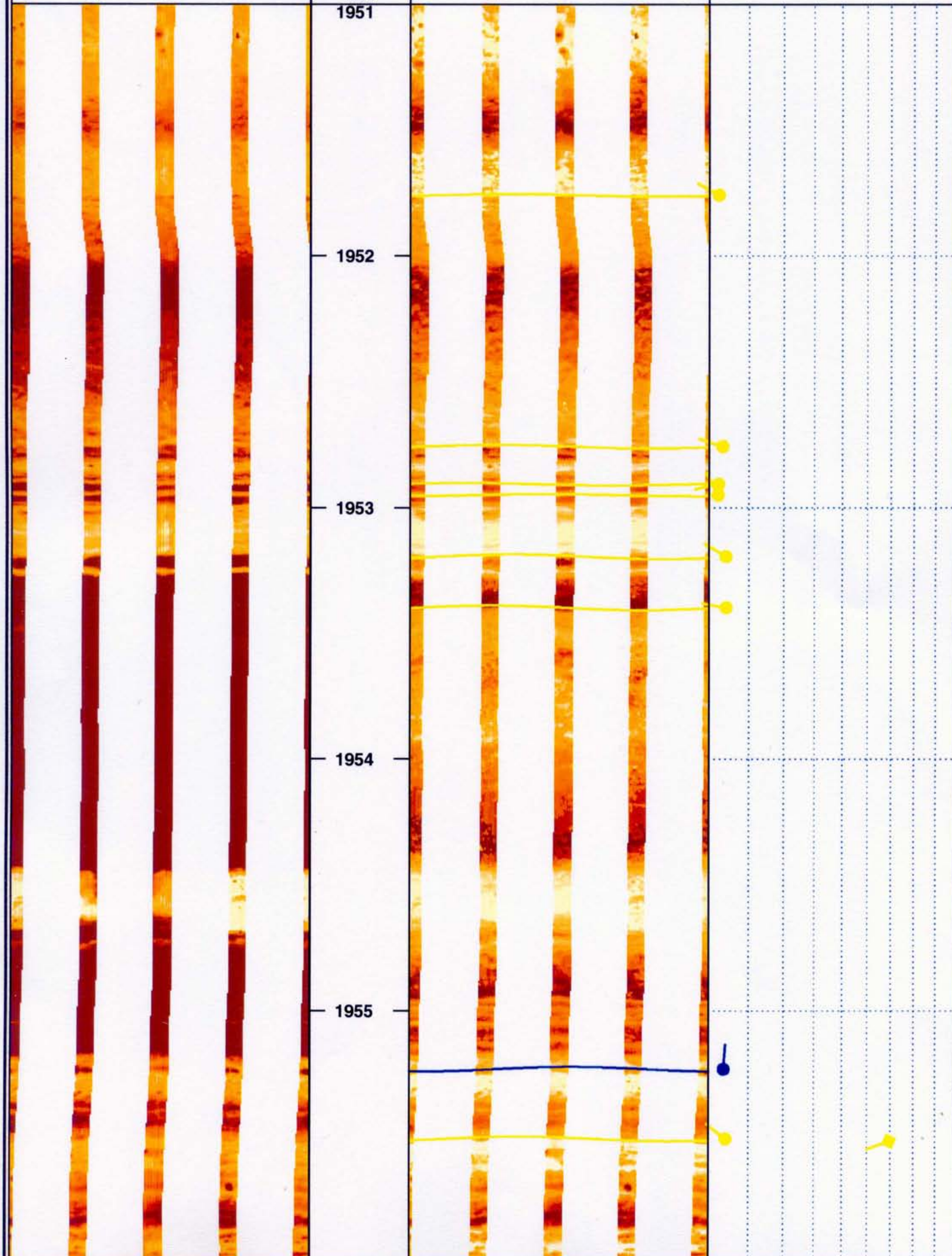
The overall upward coarsening commencing with mudstone deposition could be consistent with progradation of lacustrine delta.

A4 IMAGE ATLAS

Premier Oil Australia

White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS1 360		0 FMS1N 360	



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Premier Oil Australia

White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS1 360		0 FMS1N 360	

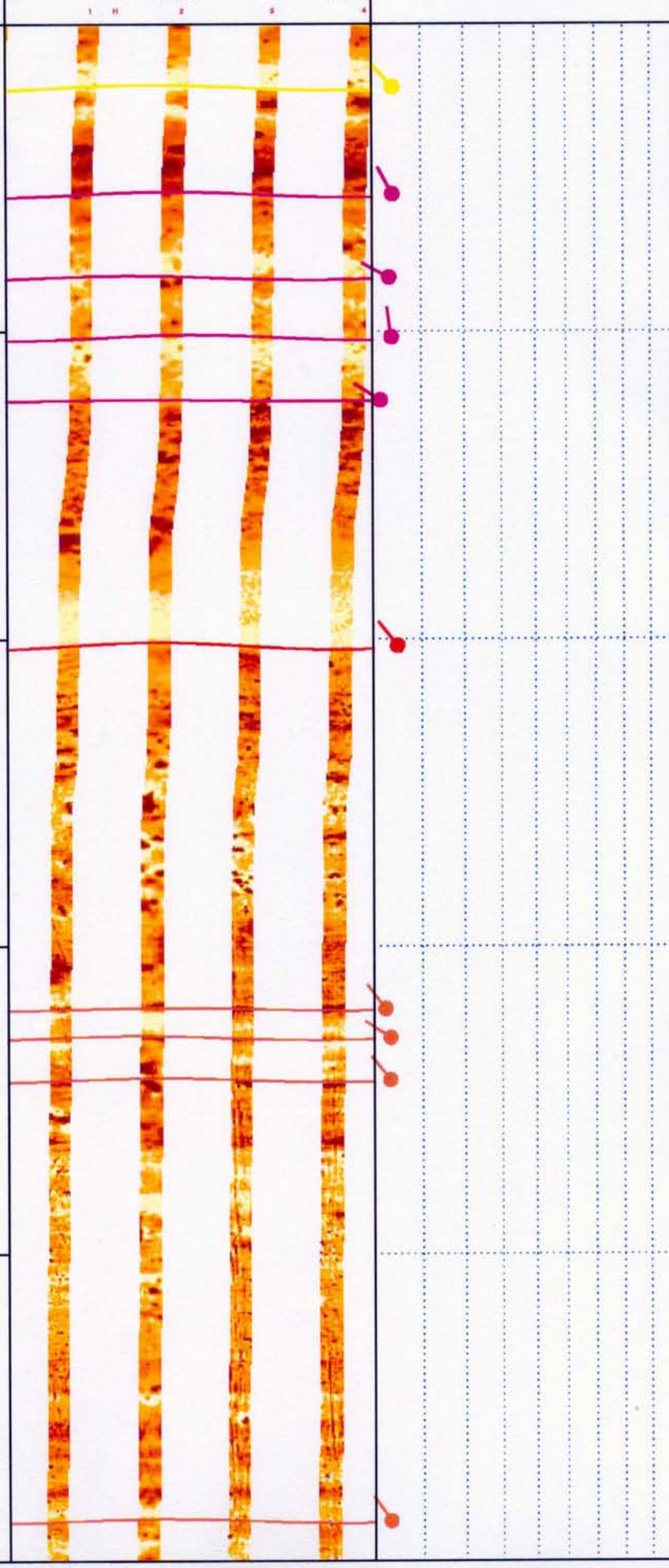
1956

1957

1958

1959

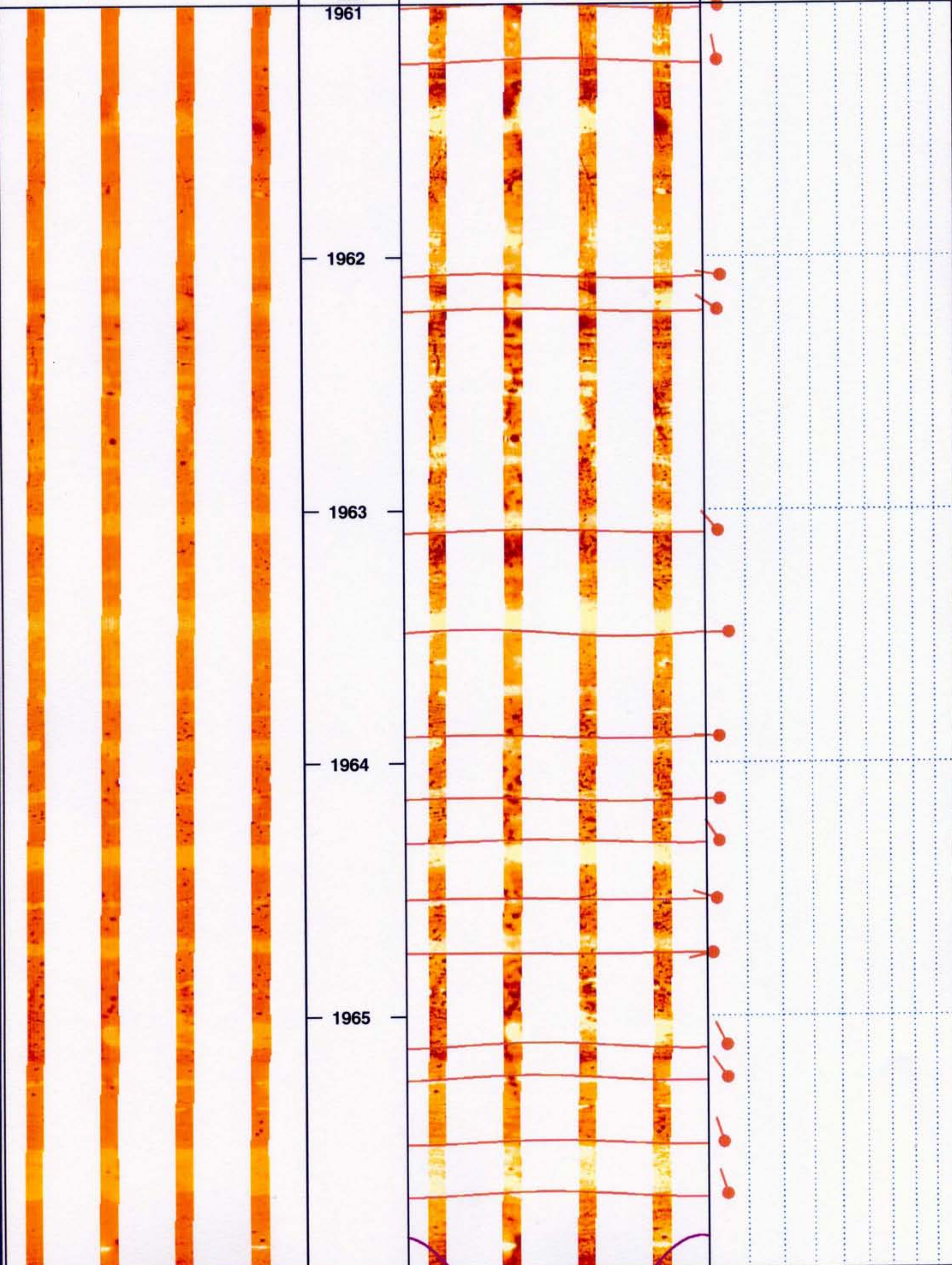
1960



Premier Oil Australia

White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS1 360		0 FMS1N 360	



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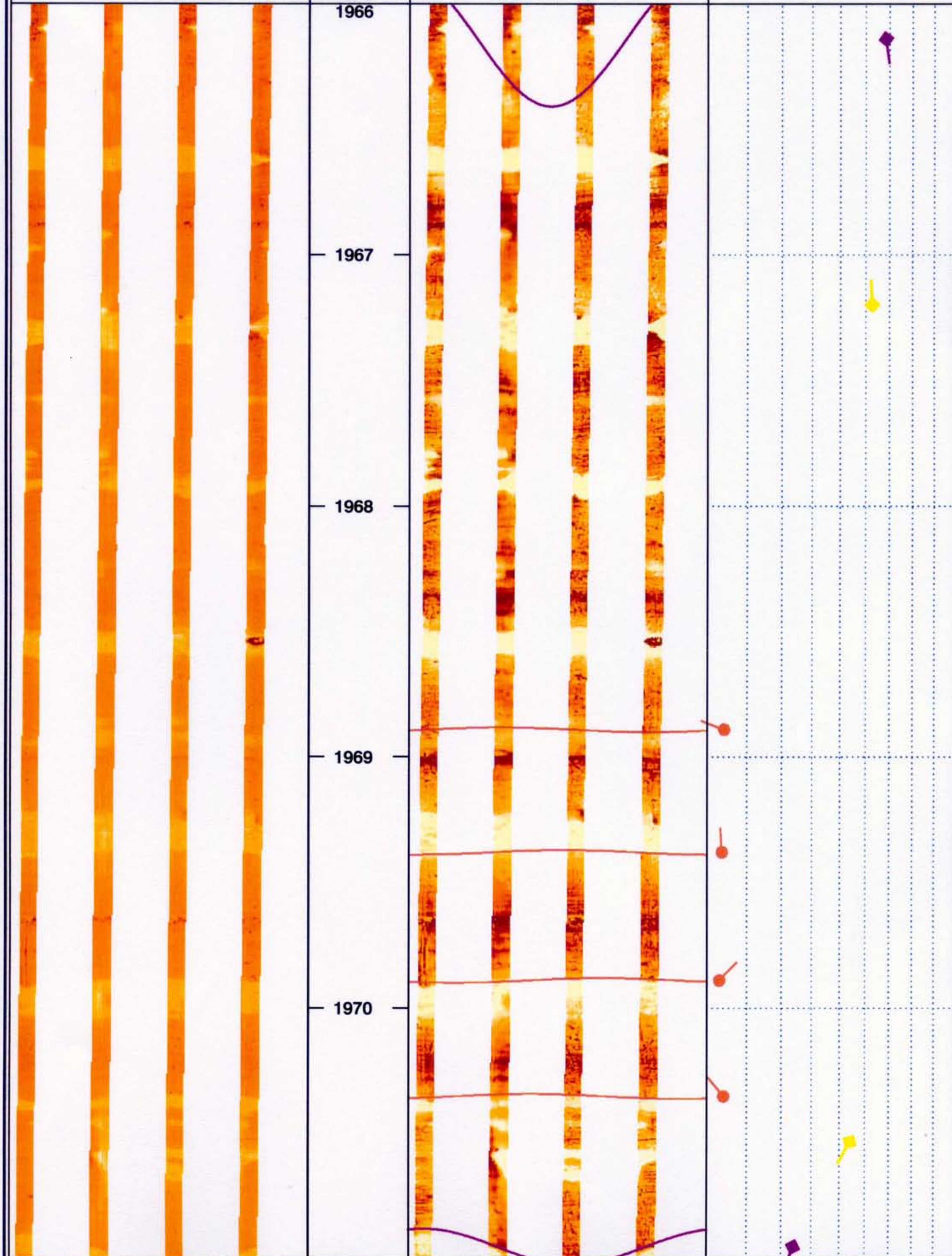
Premier Oil Australia | White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS1 360		0 FMS1N 360	



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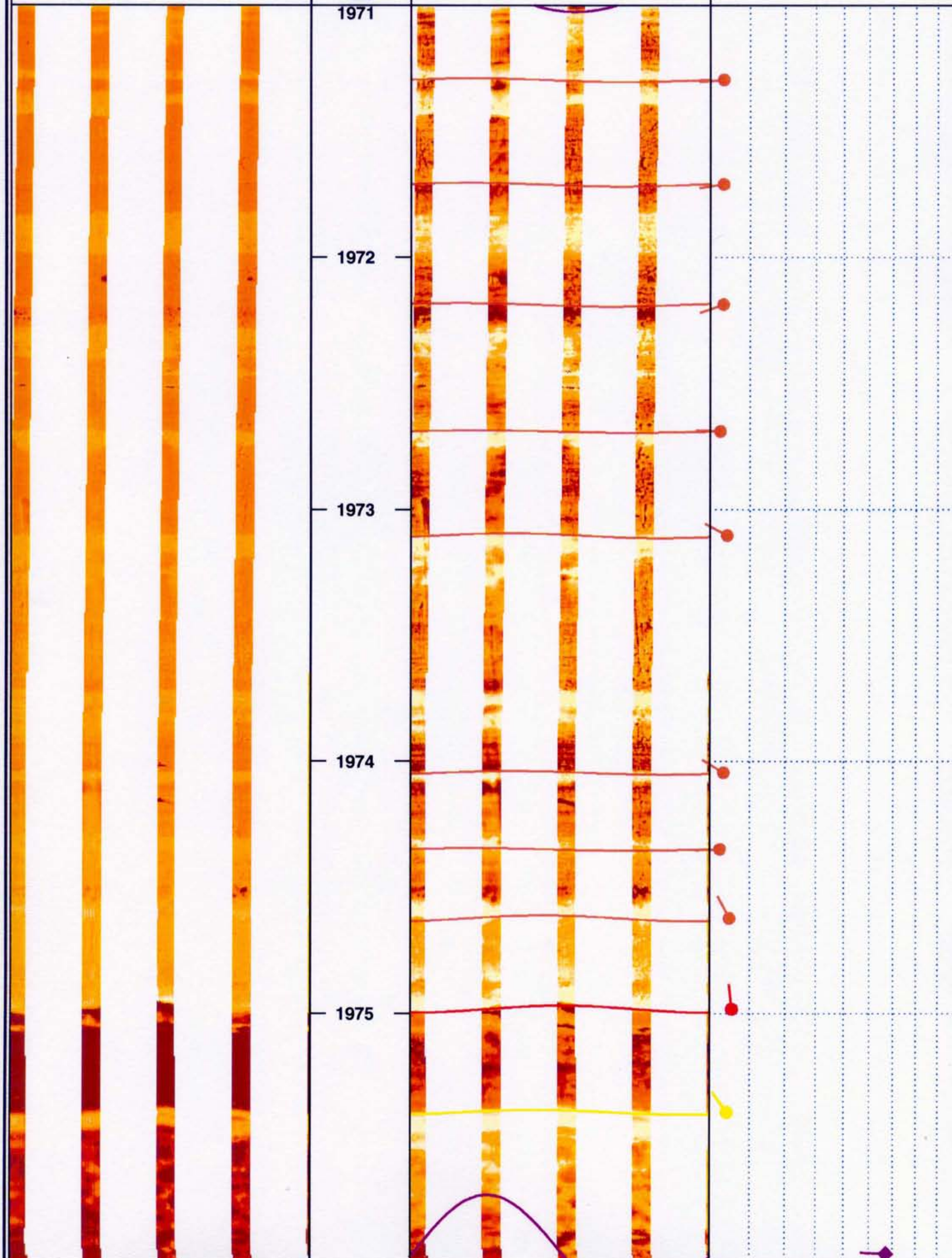
Premier Oil Australia | White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS1 360		0 FMS1N 360	



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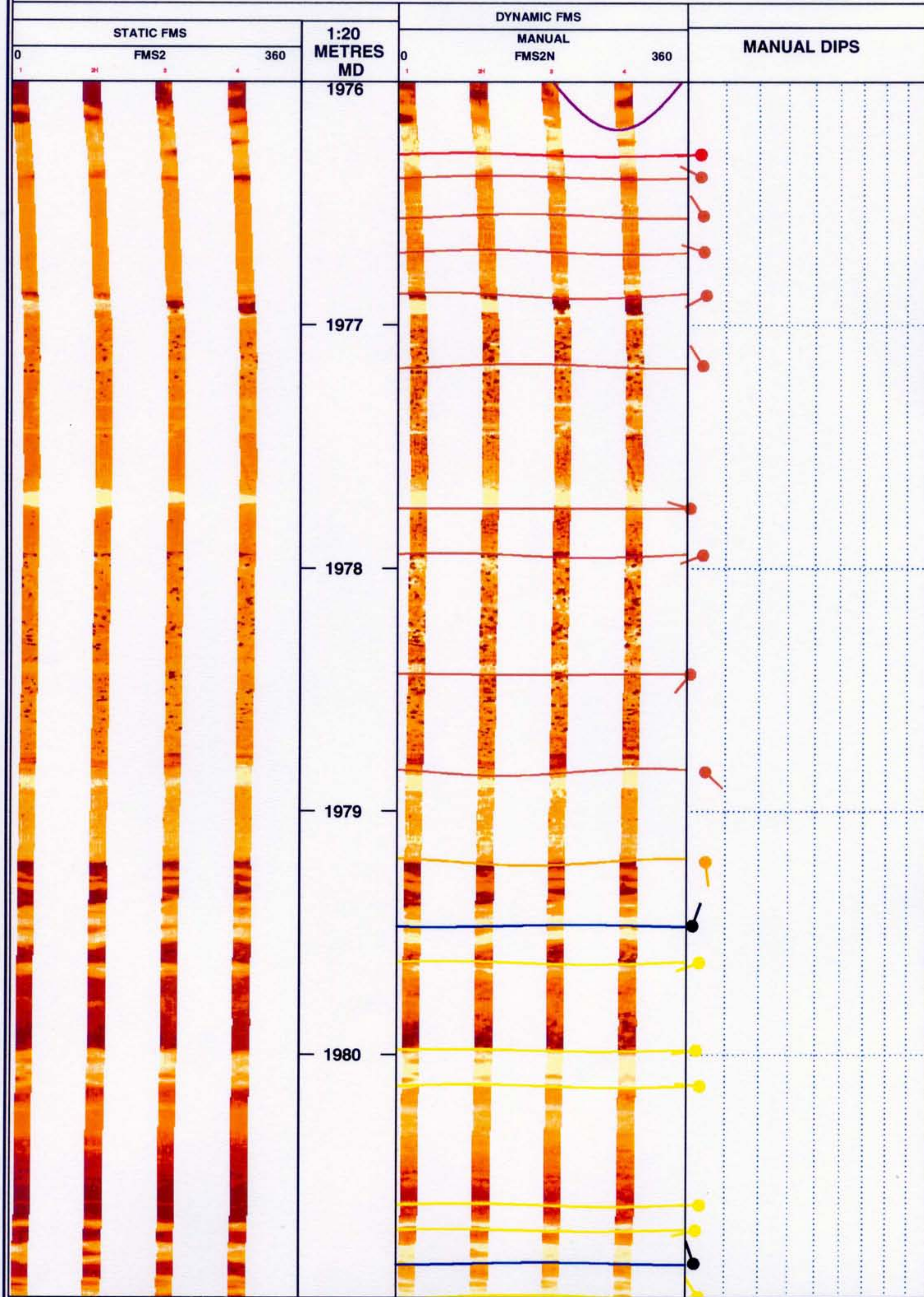
Premier Oil Australia | White Ibis 1



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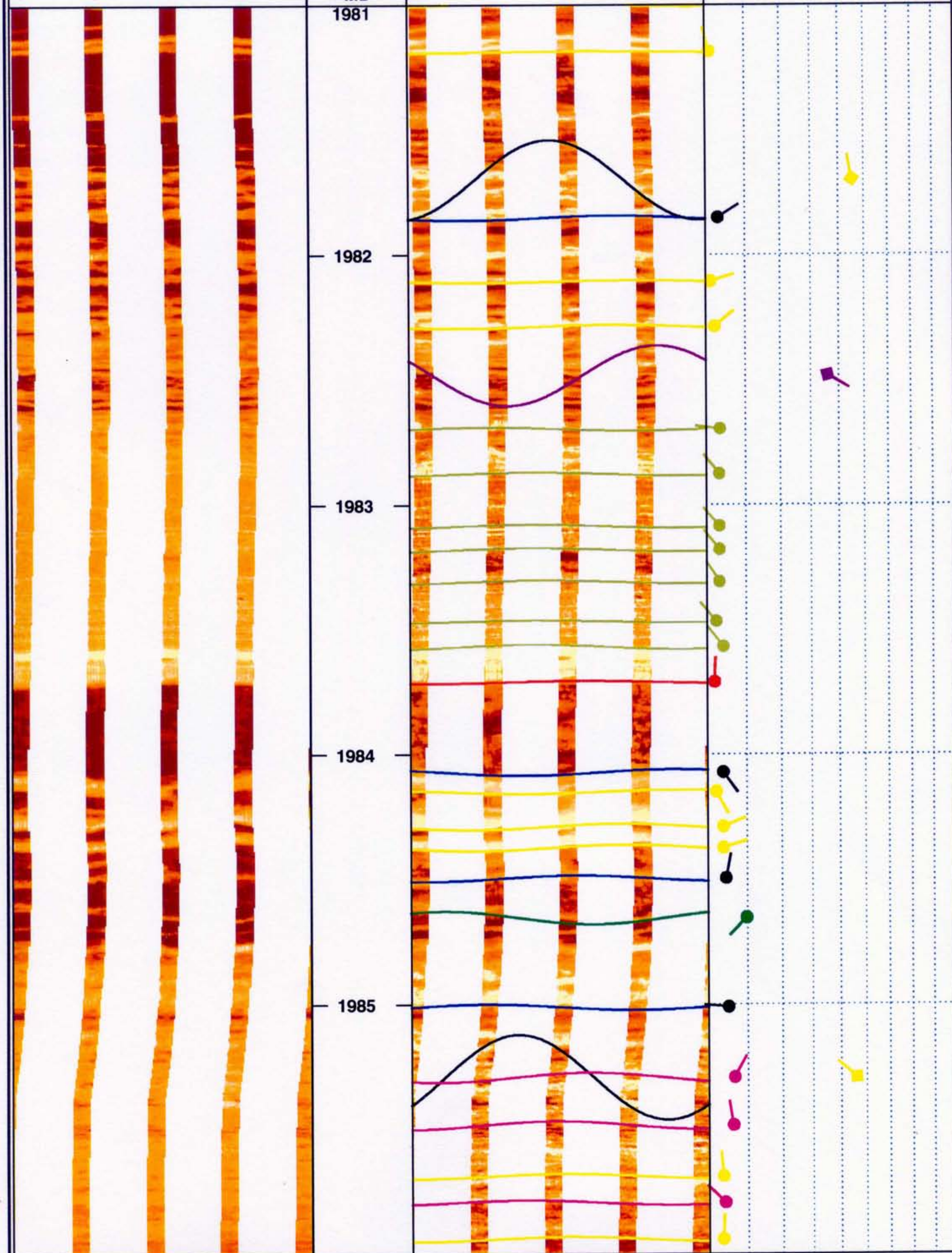
Premier Oil Australia

White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	



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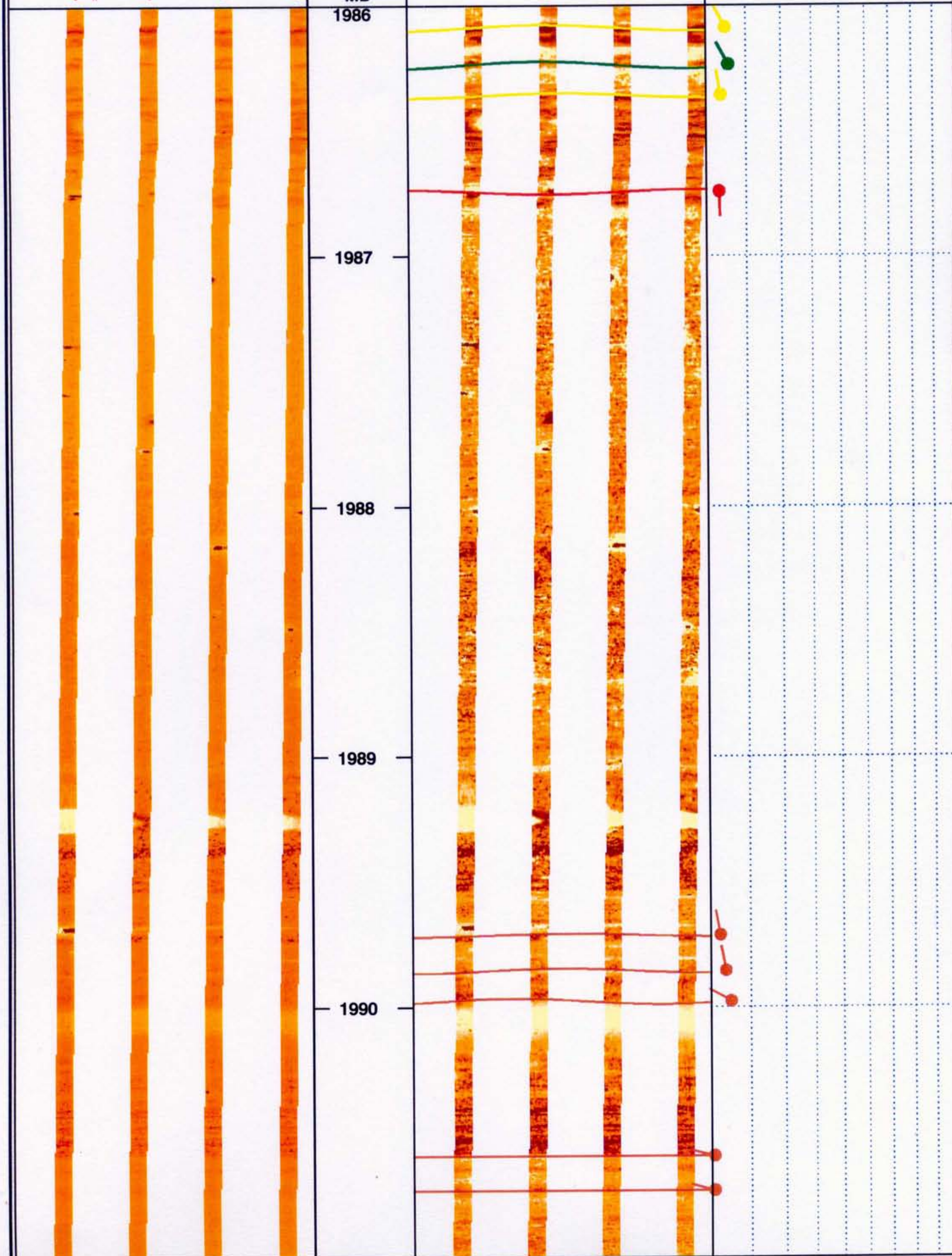
Premier Oil Australia

White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	



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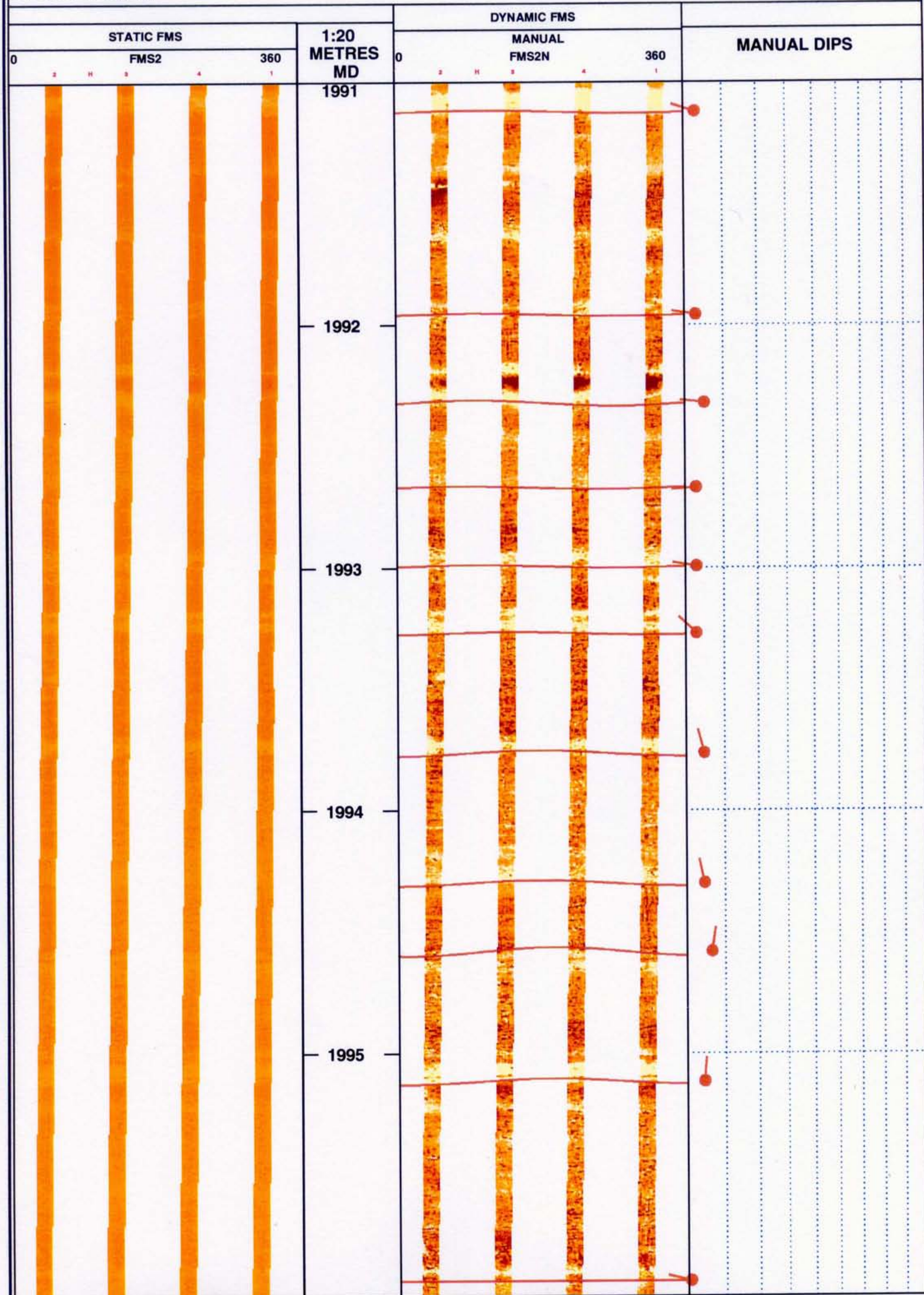
Premier Oil Australia

White Ibis 1



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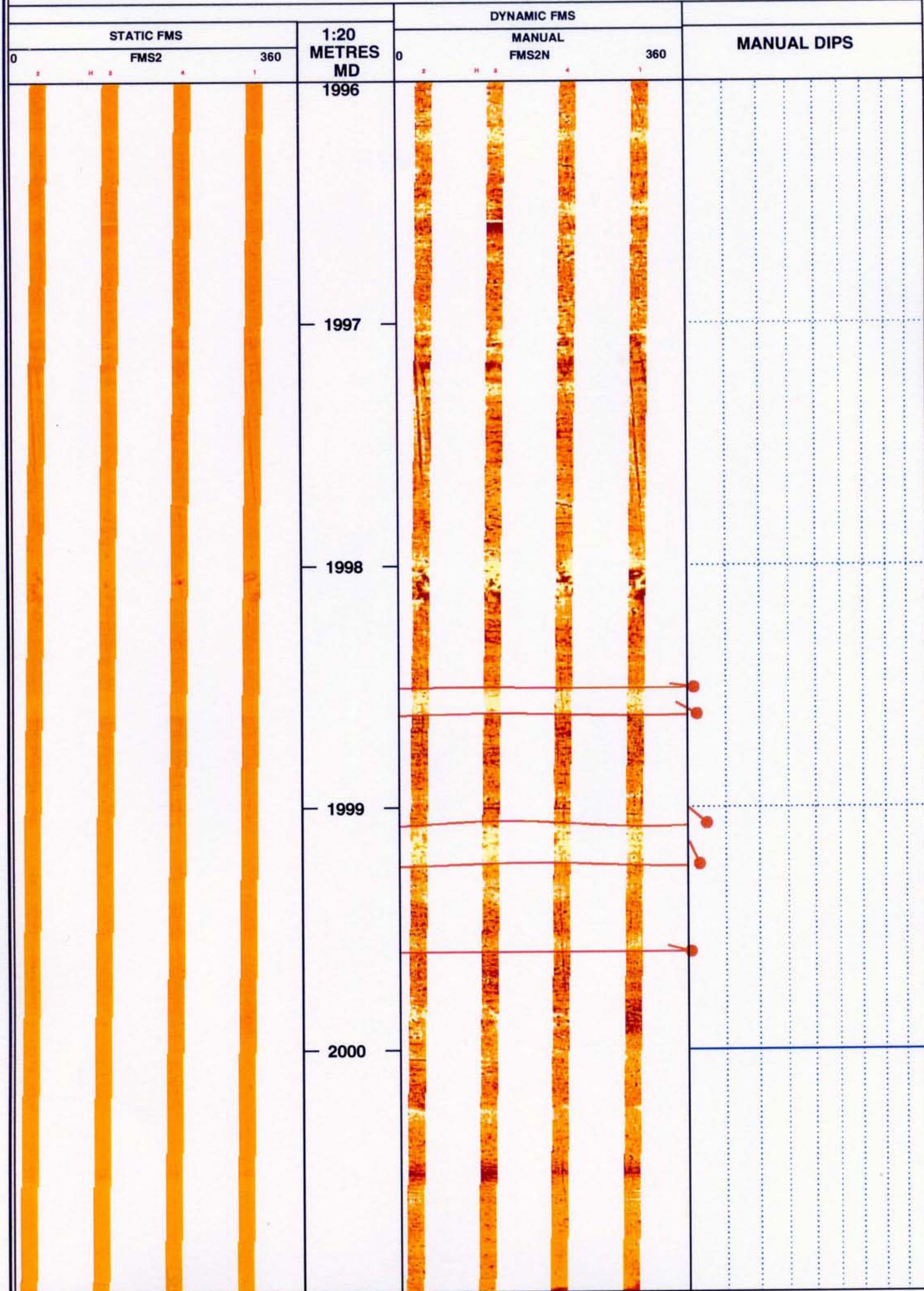
Premier Oil Australia

White Ibis 1



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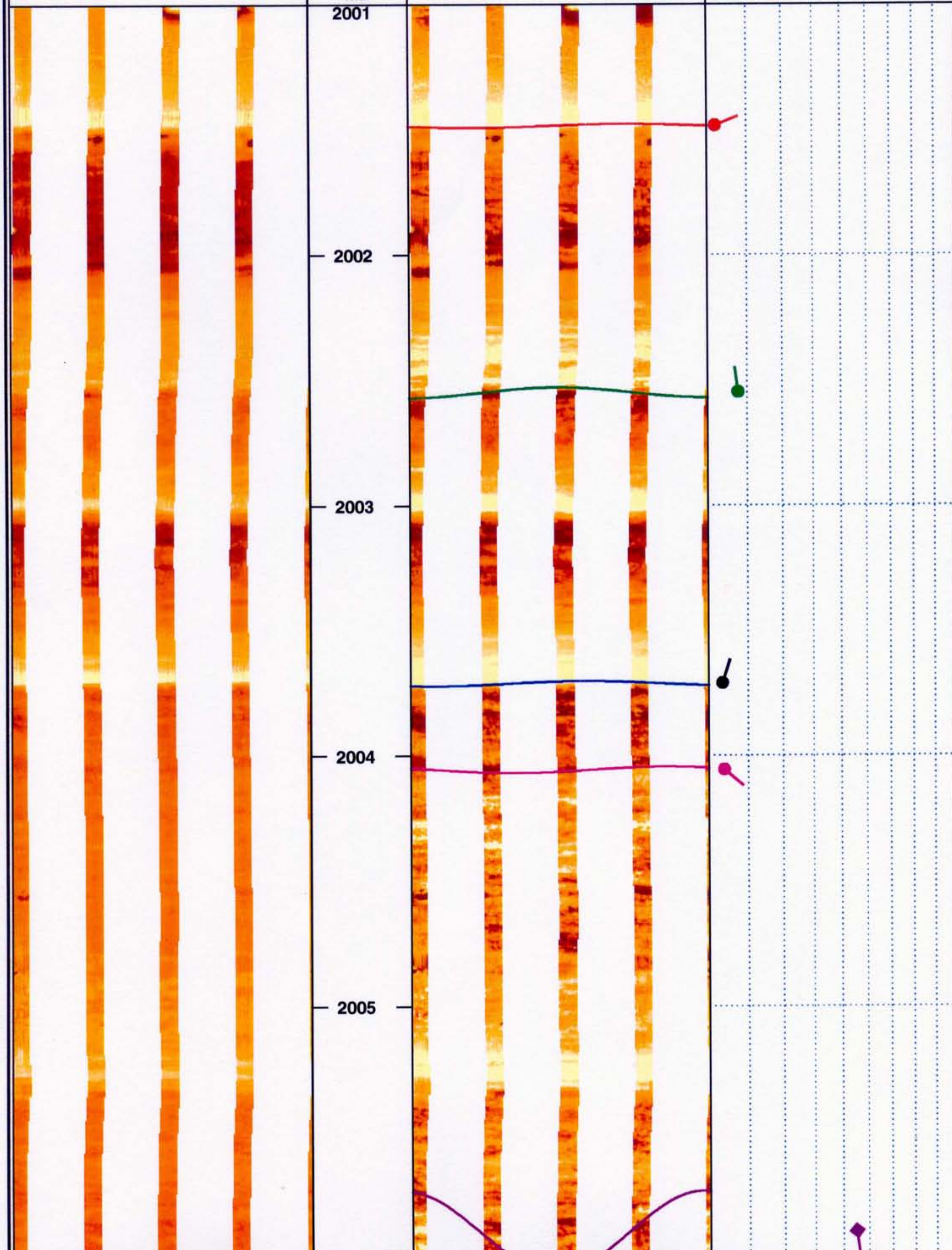
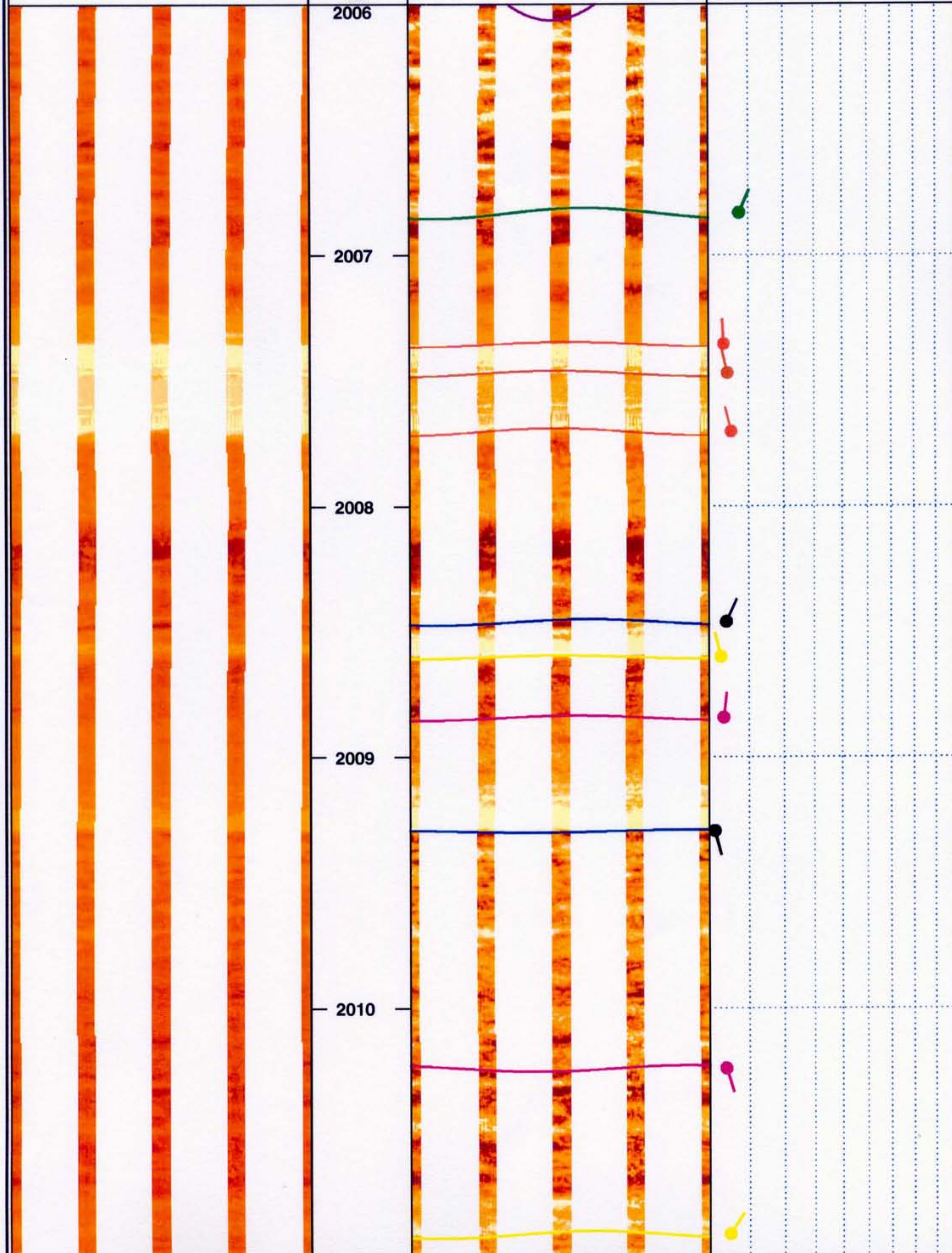
STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	



Premier Oil Australia

White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	



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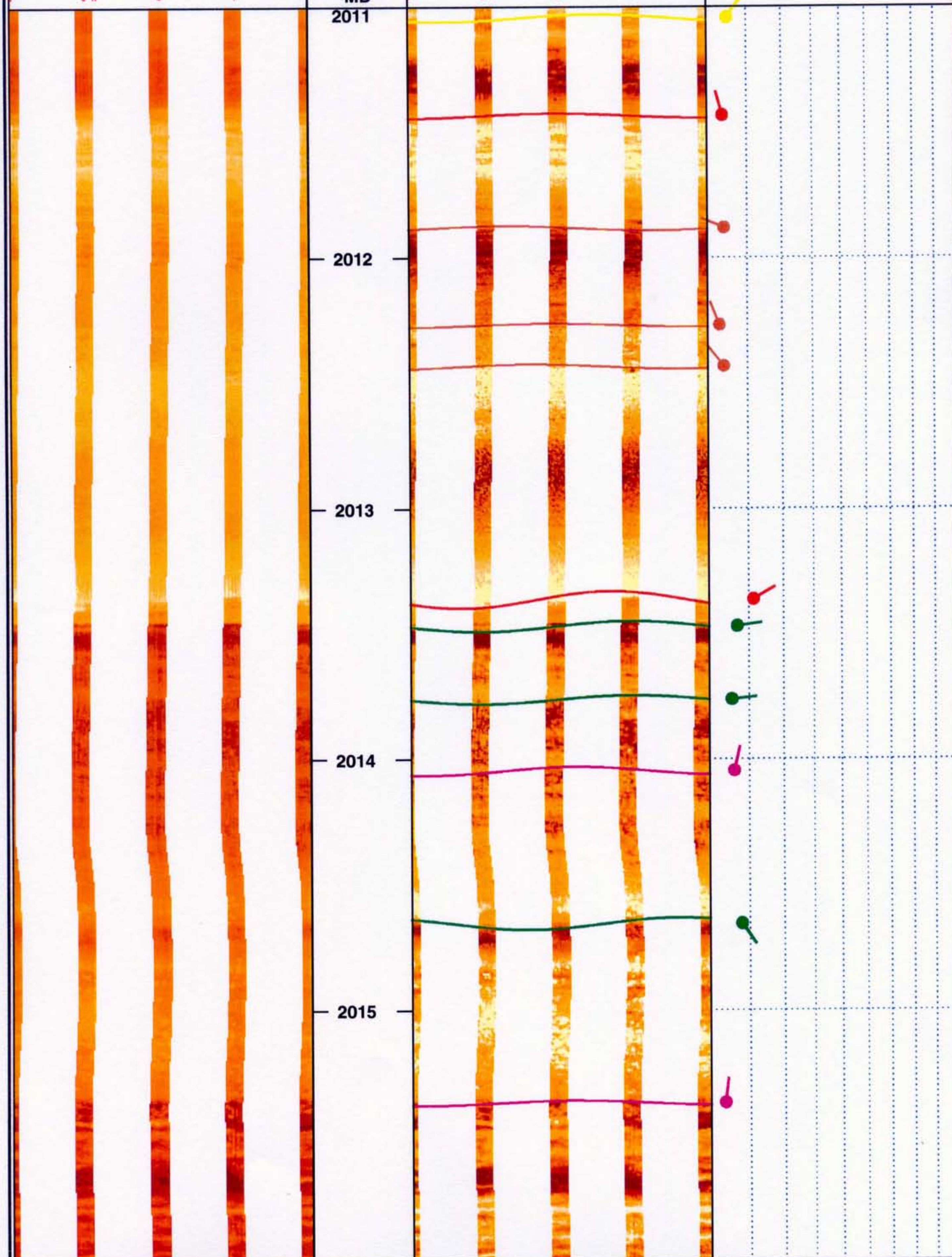
Premier Oil Australia | **White Ibis 1**

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	



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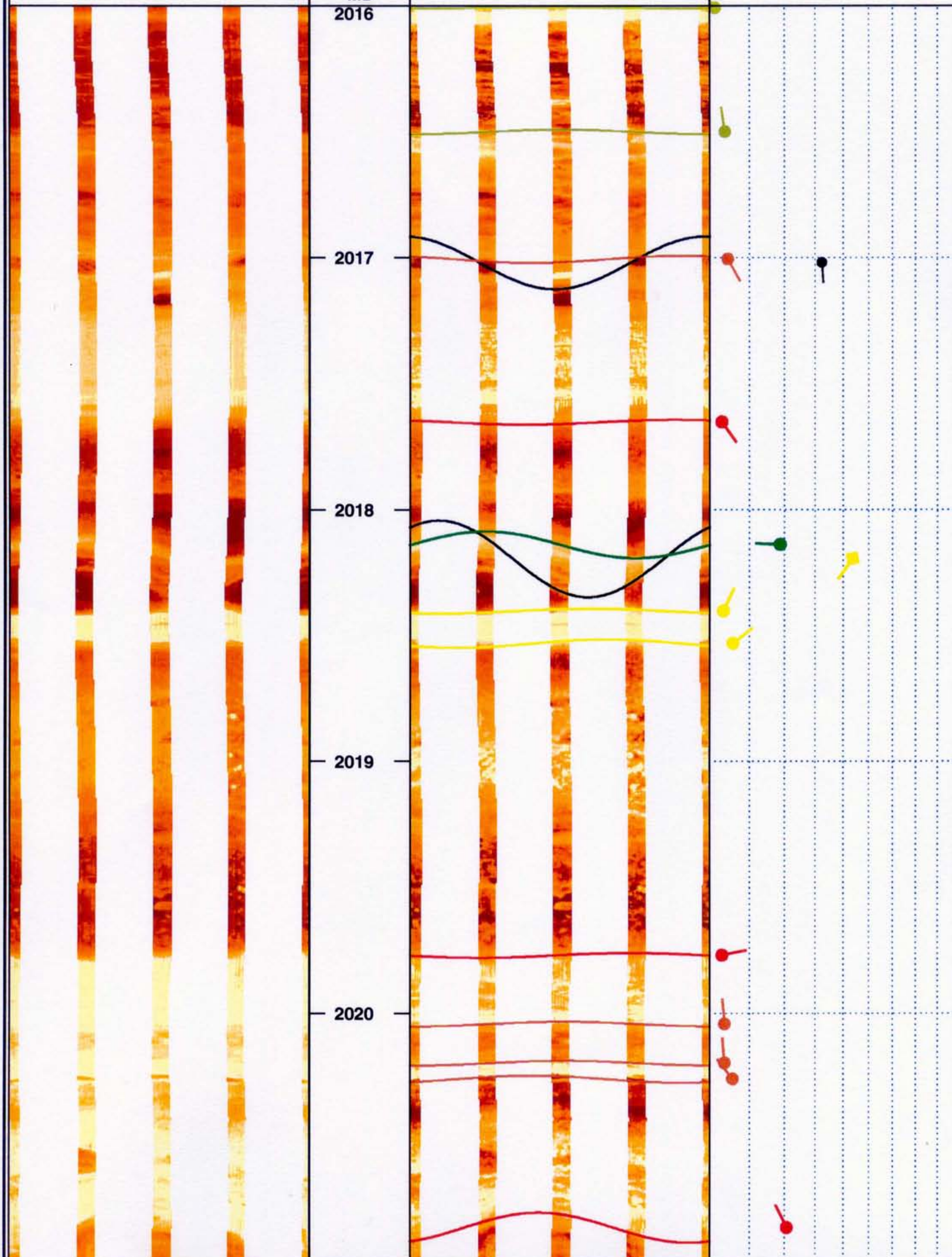
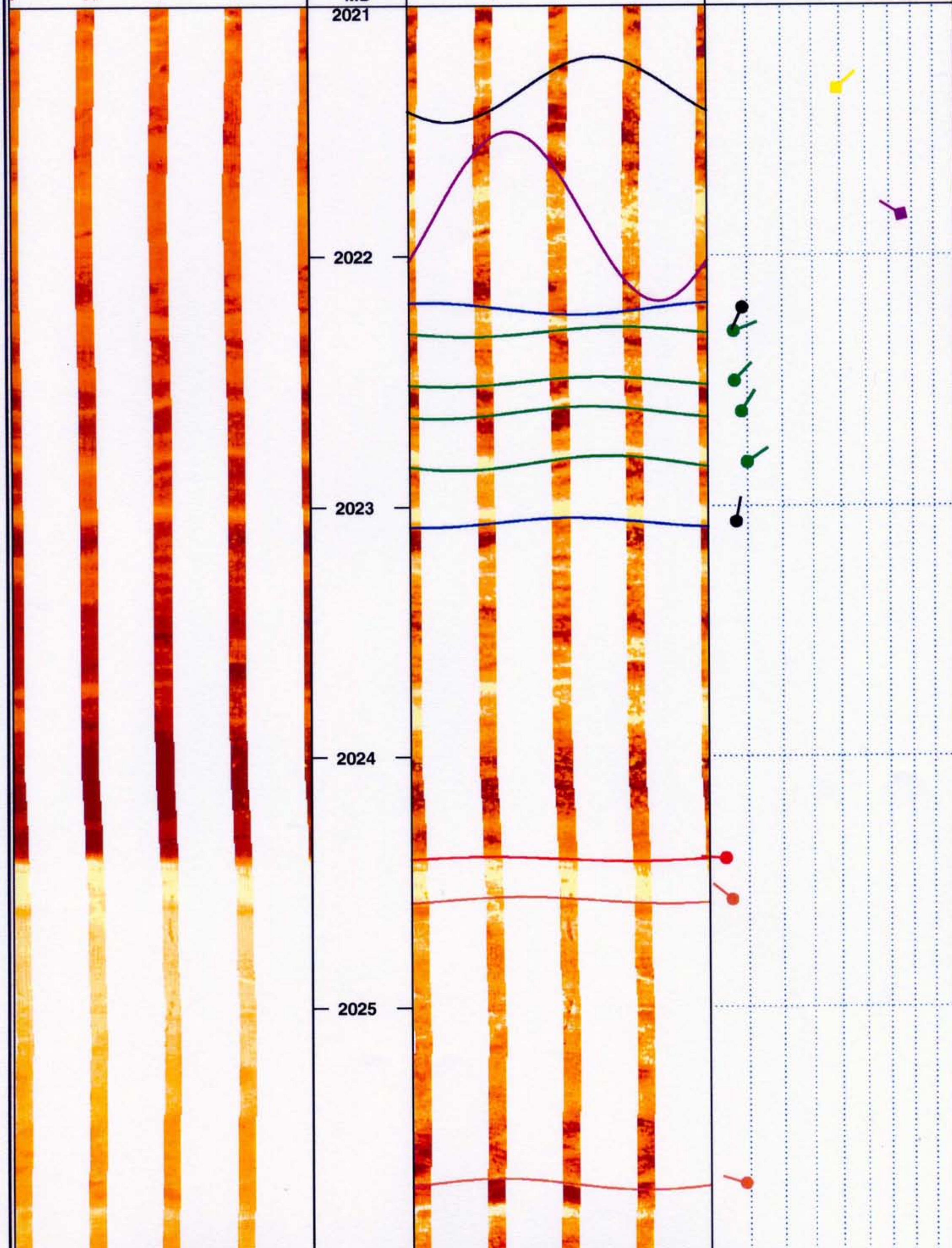
Premier Oil Australia | White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	



Premier Oil Australia | White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS	MANUAL DIPS
FMS2 (0 – 360)		MANUAL FMS2N (0 – 360)	



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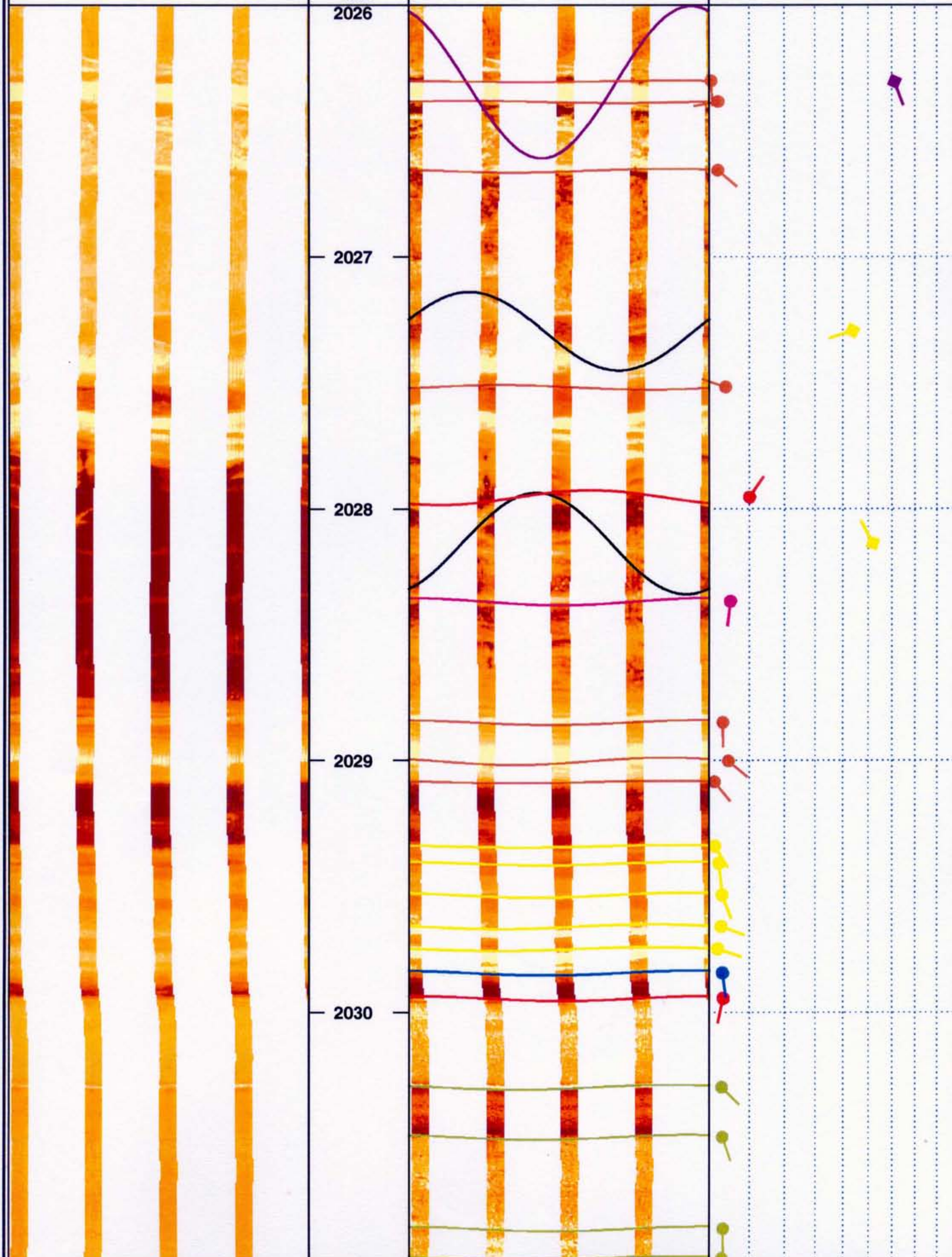
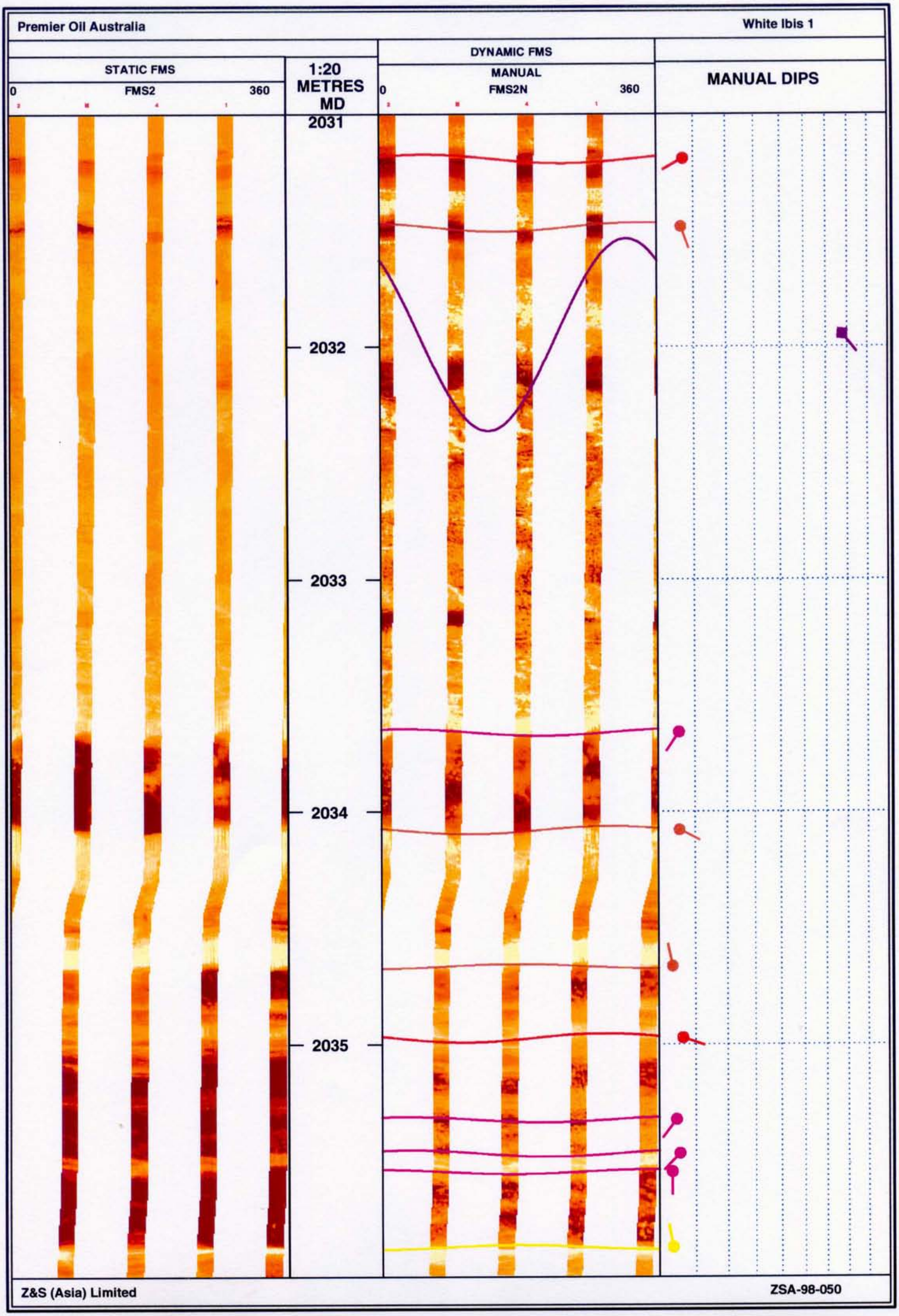
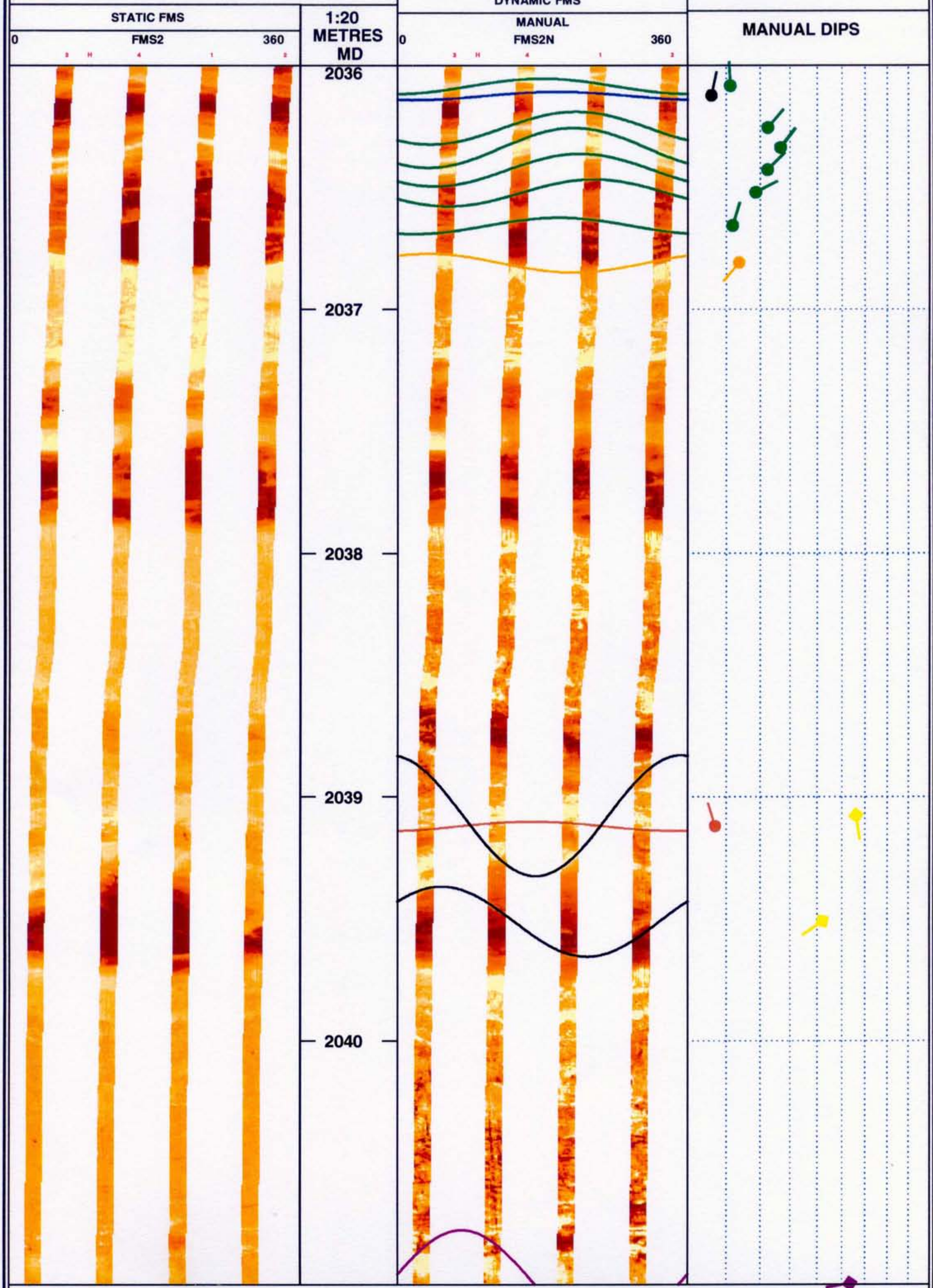
Premier Oil Australia | White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	
2 3H 4 1		2 3H 4 1	



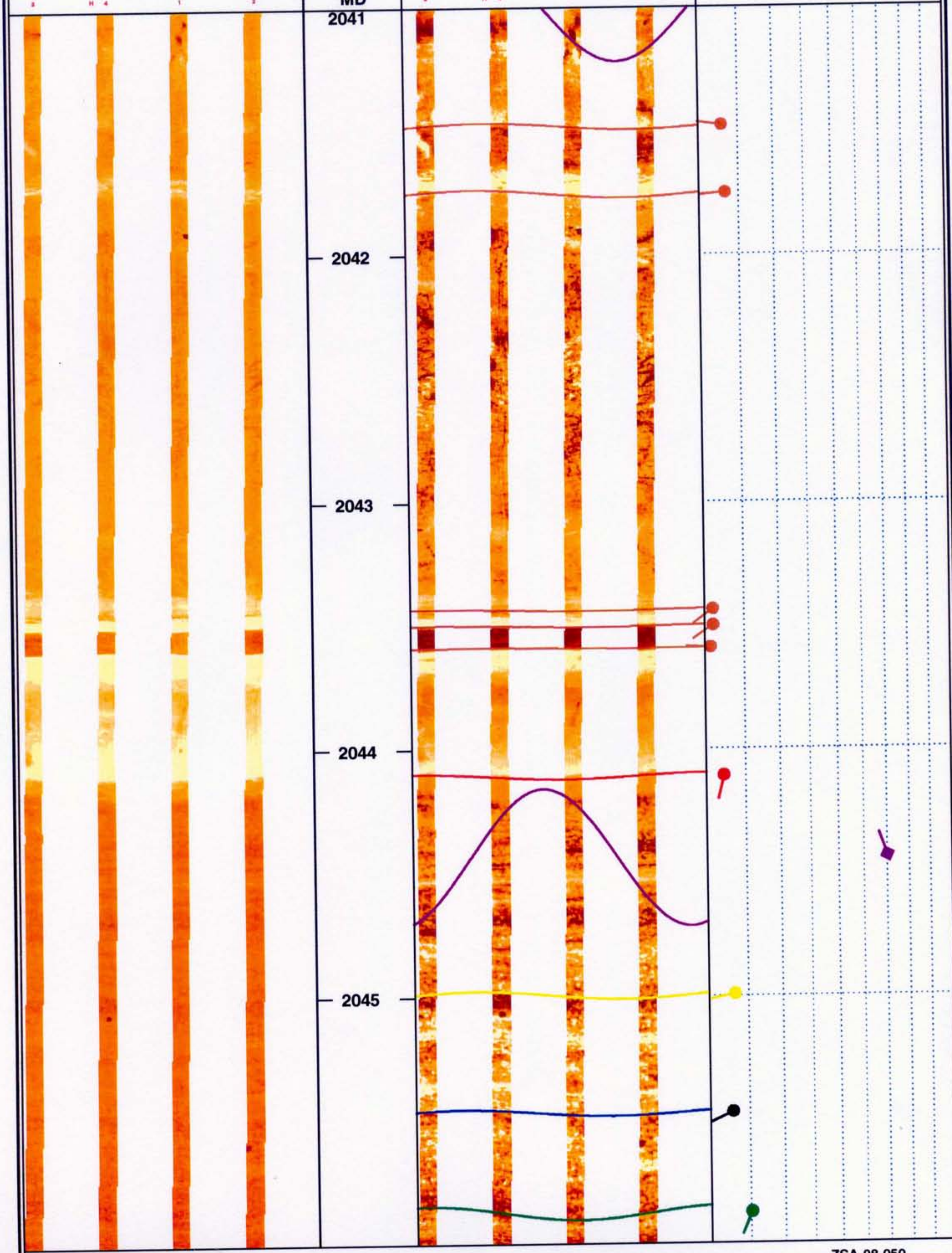

Premier Oil Australia
White Ibis 1
DYNAMIC FMS
STATIC FMS
1:20
METRES
MD
MANUAL
MANUAL DIPS
0
FMS2
360
0
FMS2N
360
2031
2032
2033
2034
2035
Z&S (Asia) Limited
ZSA-98-050


STATIC FMS
0
FMS2
360
1:20
METRES
MD
2036
2037
2038
2039
2040
DYNAMIC FMS
MANUAL
0
FMS2N
360
MANUAL DIPS

Premier Oil Australia

White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	



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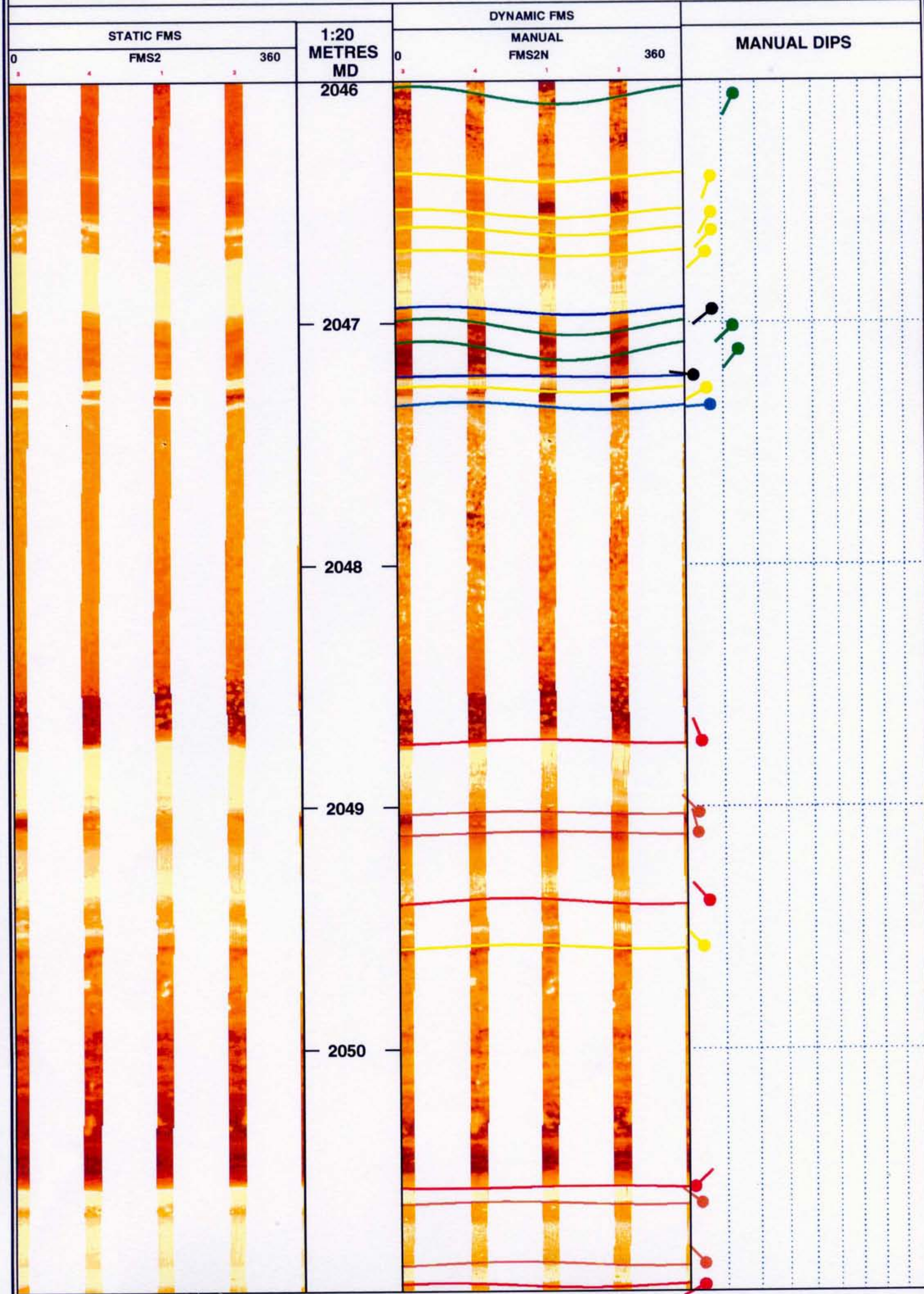
White Ibis 1



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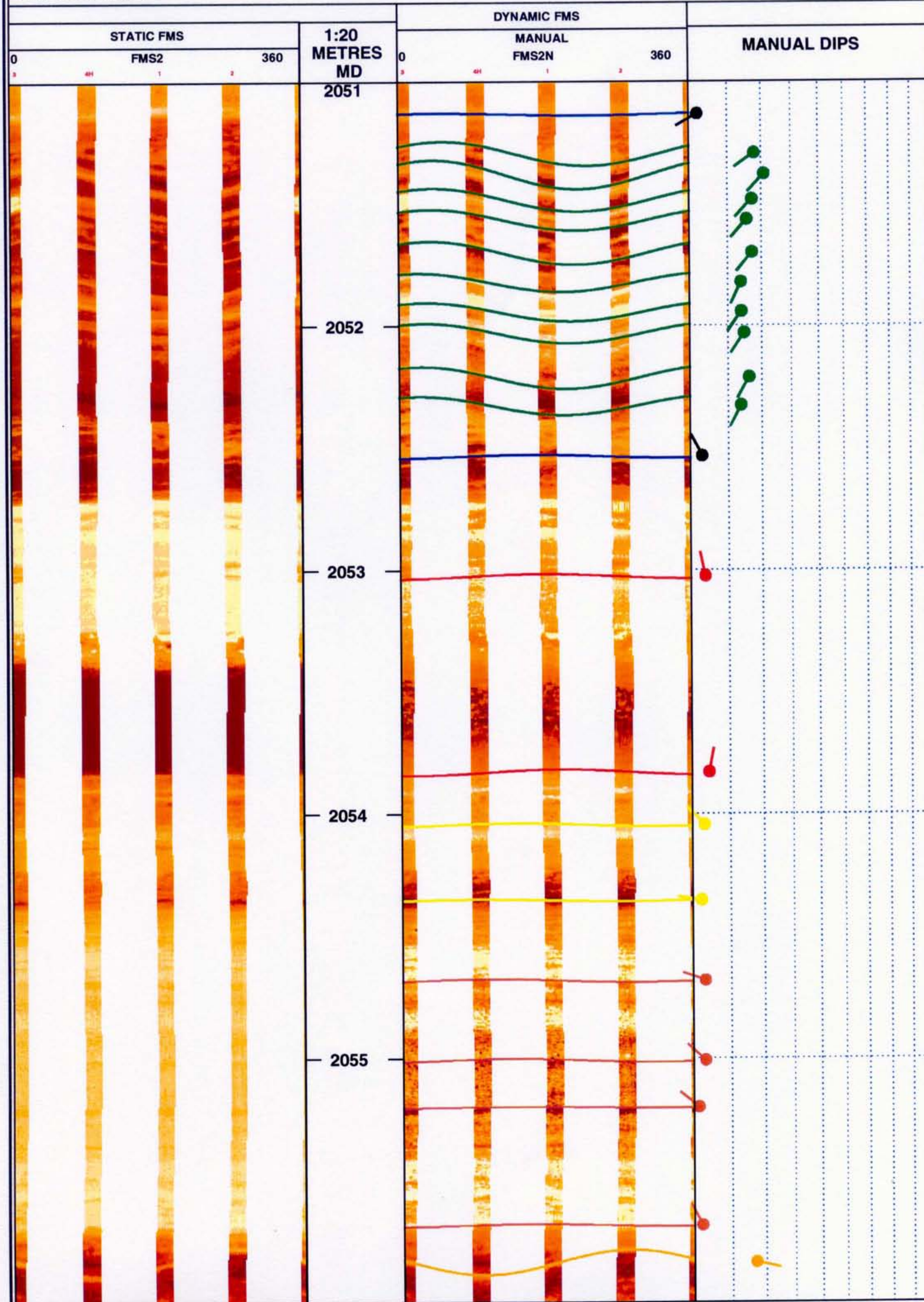
Premier Oil Australia

White Ibis 1



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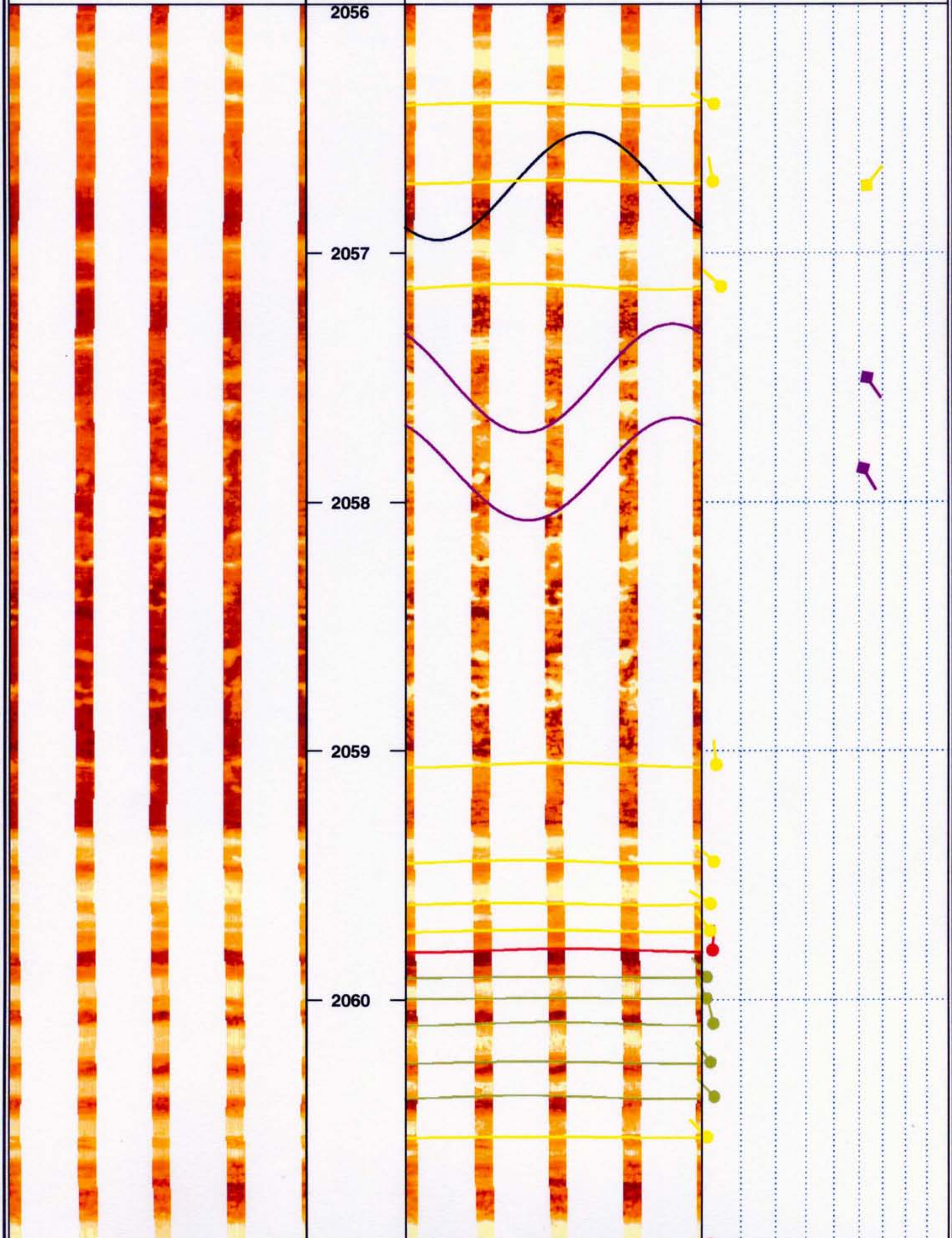
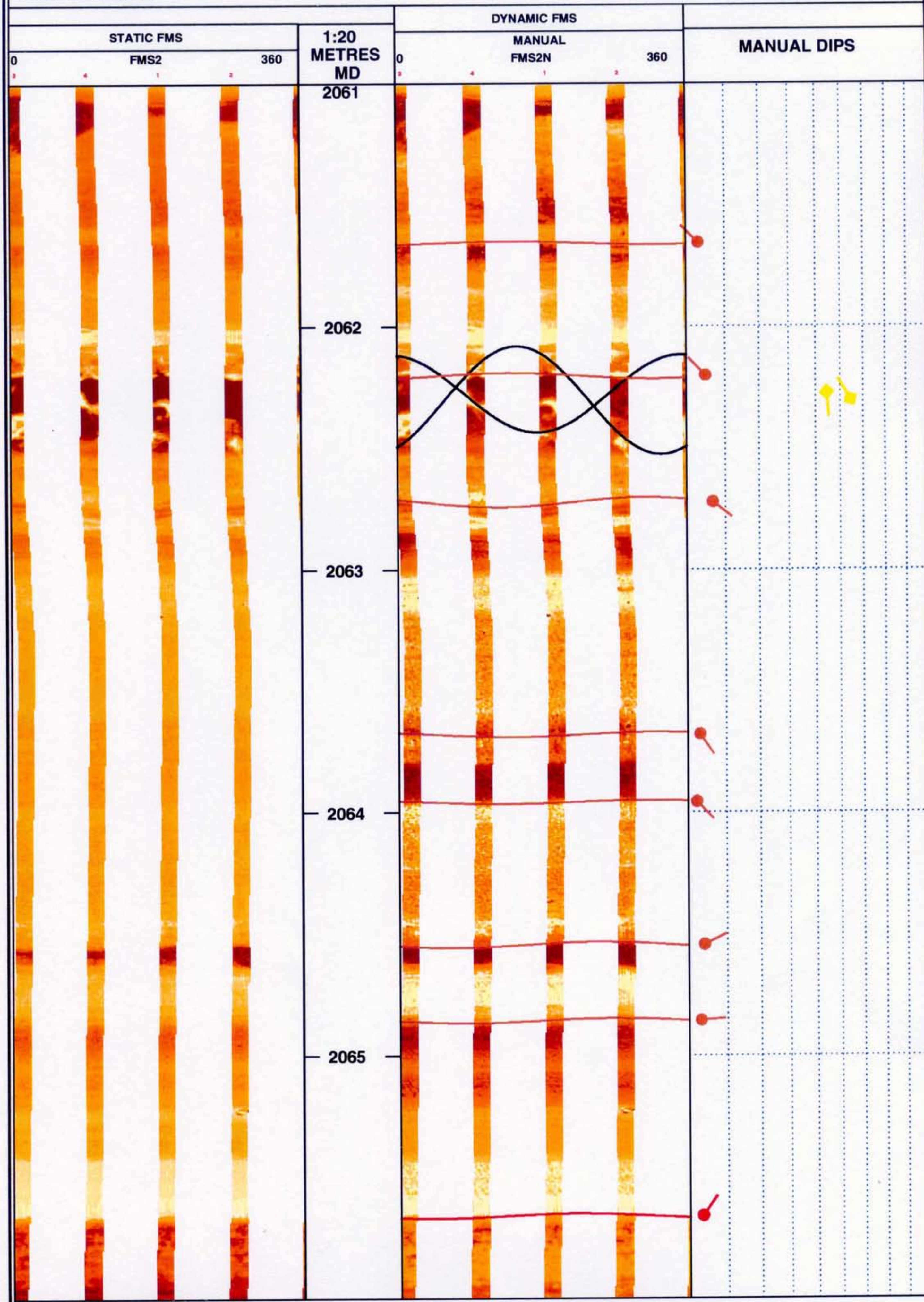
Premier Oil Australia | White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	



Premier Oil Australia | White Ibis 1



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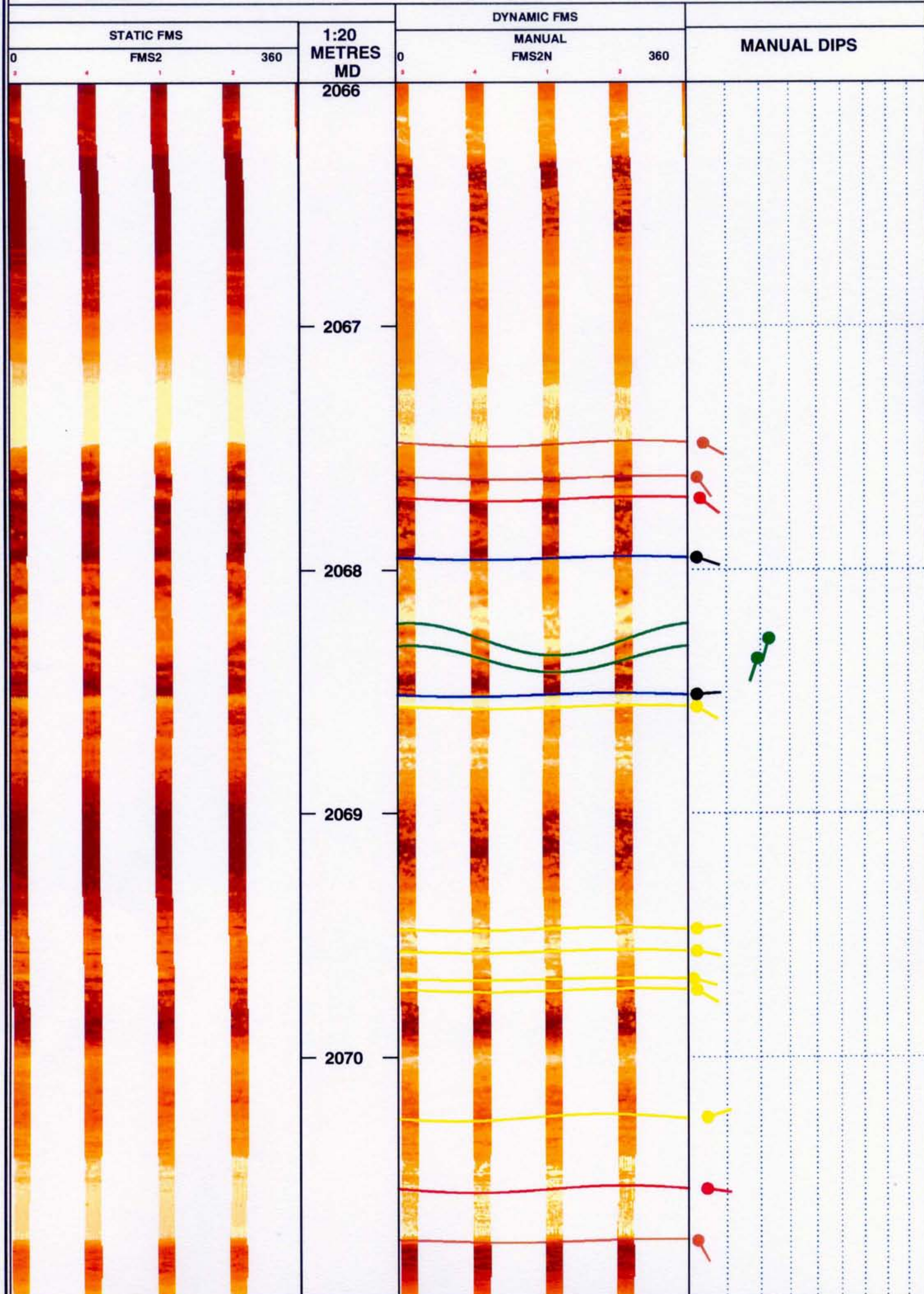
Premier Oil Australia

White Ibis 1



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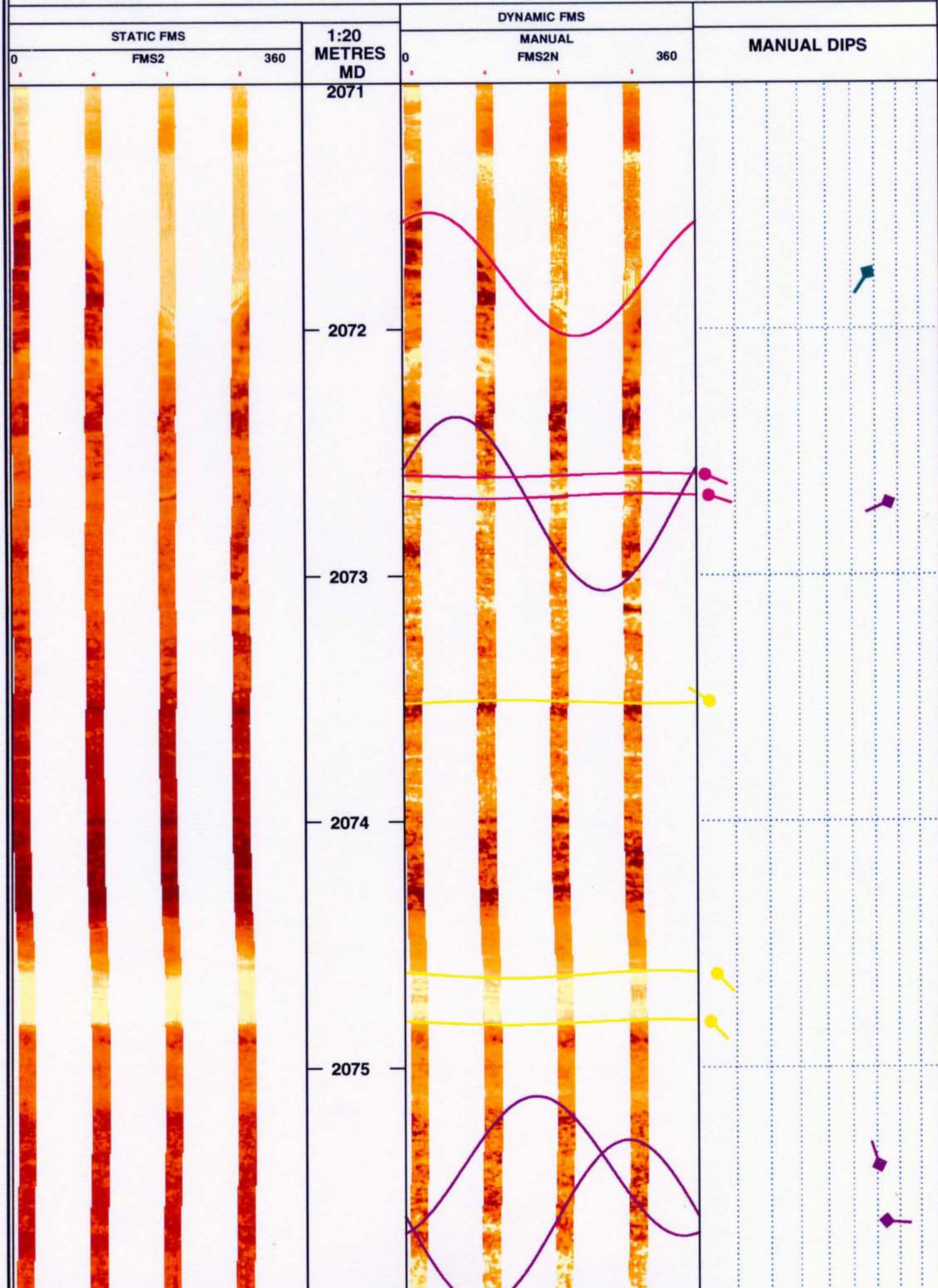
Premier Oil Australia

White Ibis 1



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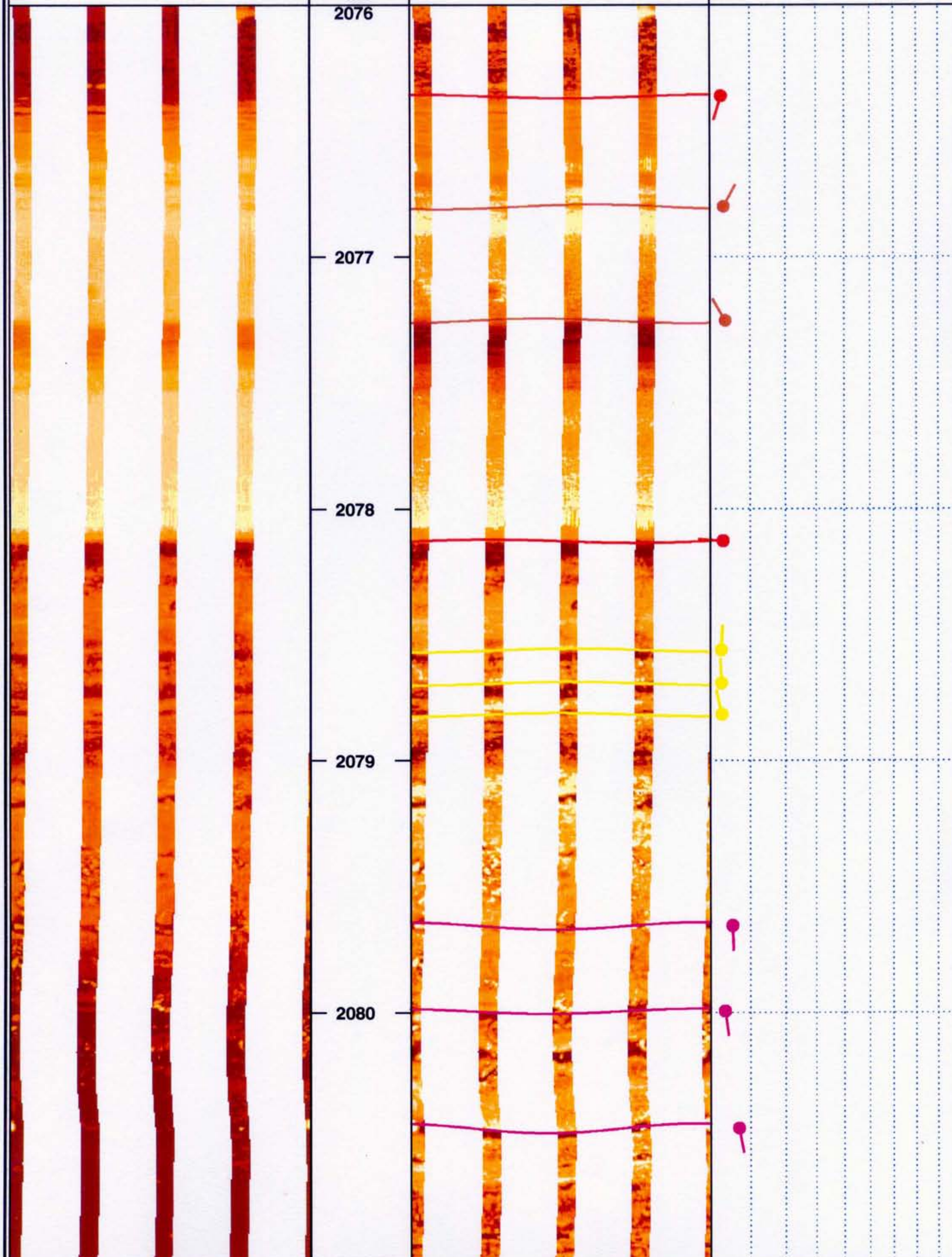
Premier Oil Australia | White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS	MANUAL DIPS
0 FMS2 360		MANUAL 0 FMS2N 360	

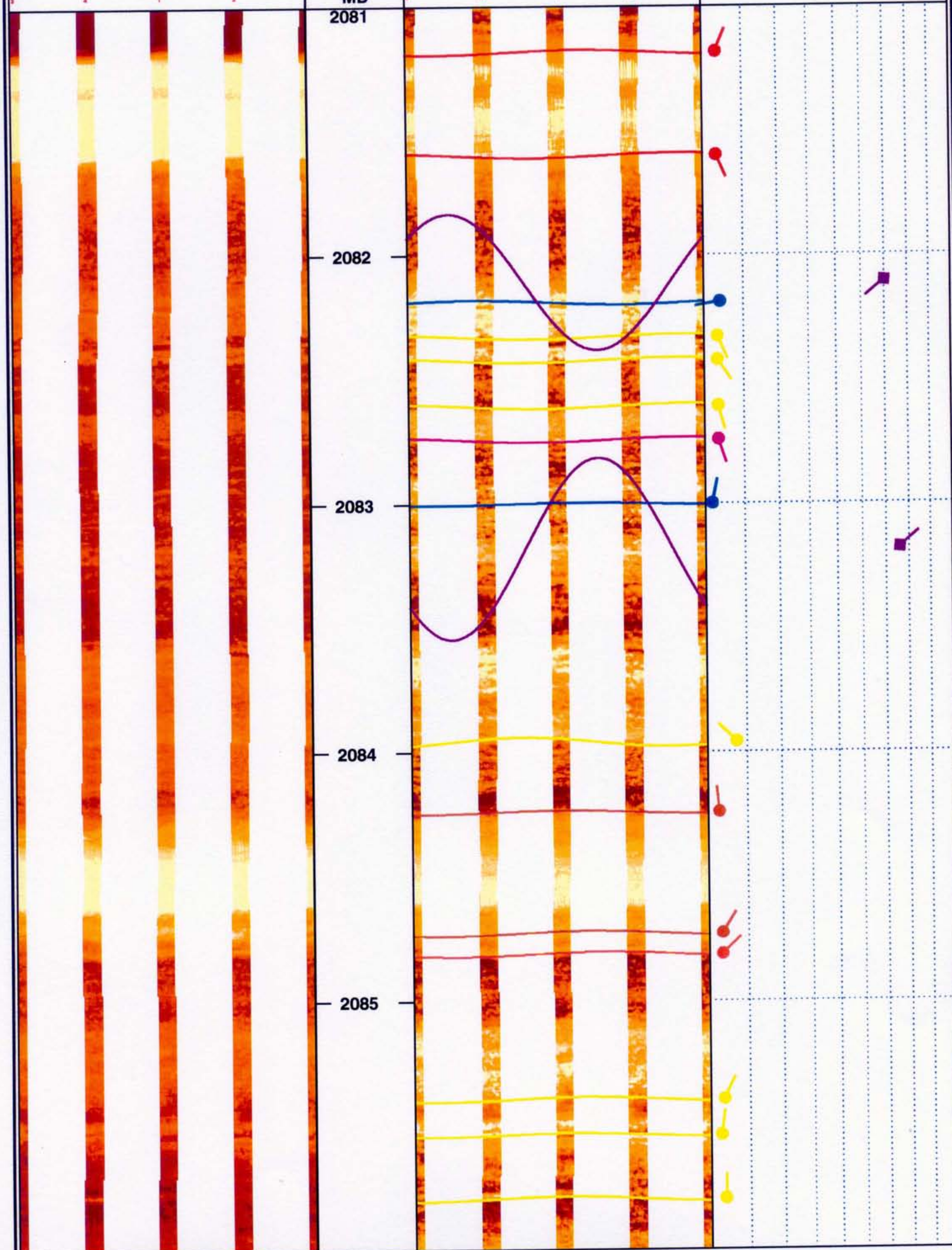


Z&S (Asia) Limited | ZSA-98-050

Premier Oil Australia

White Ibis 1

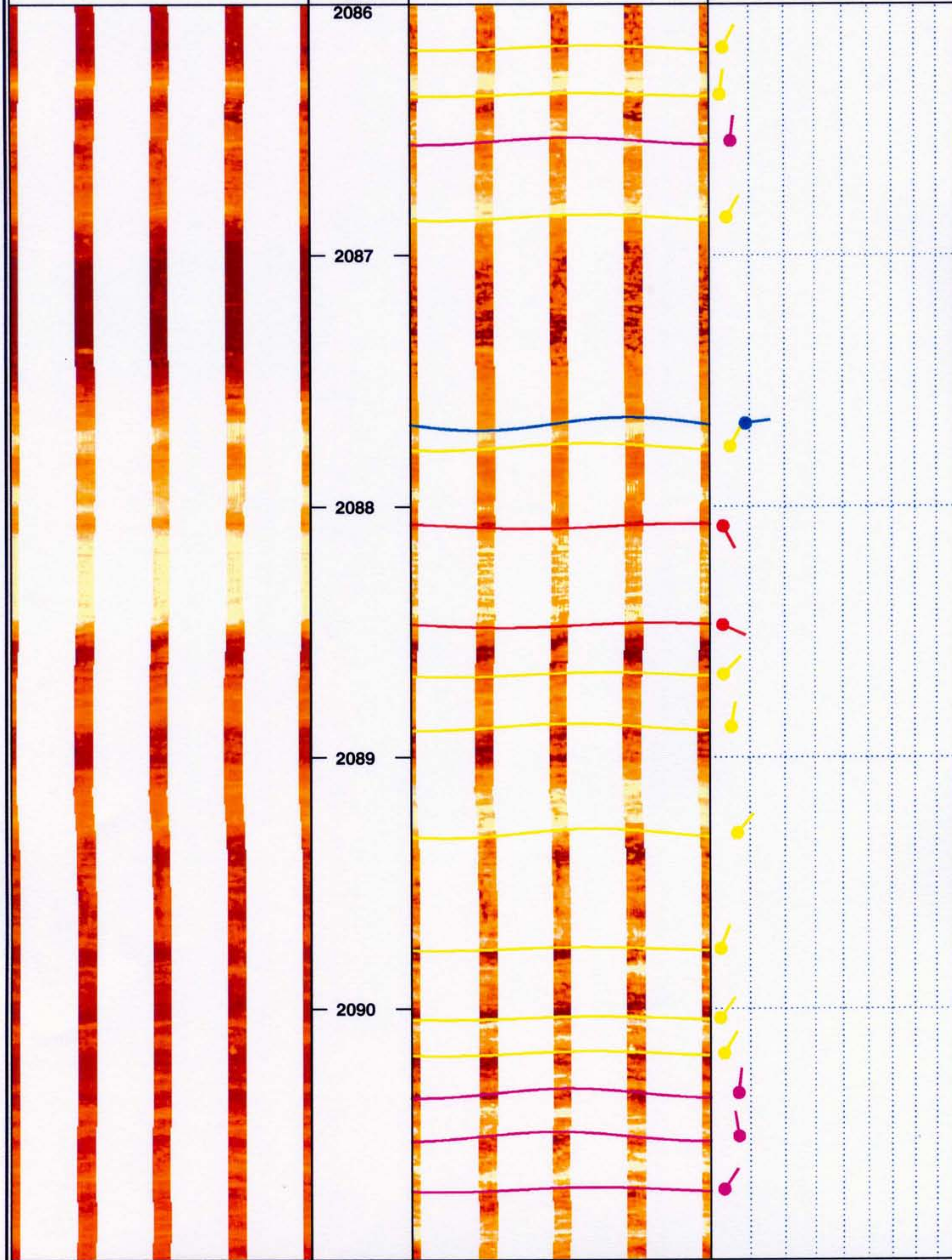
STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	



Z&S (Asia) Limited

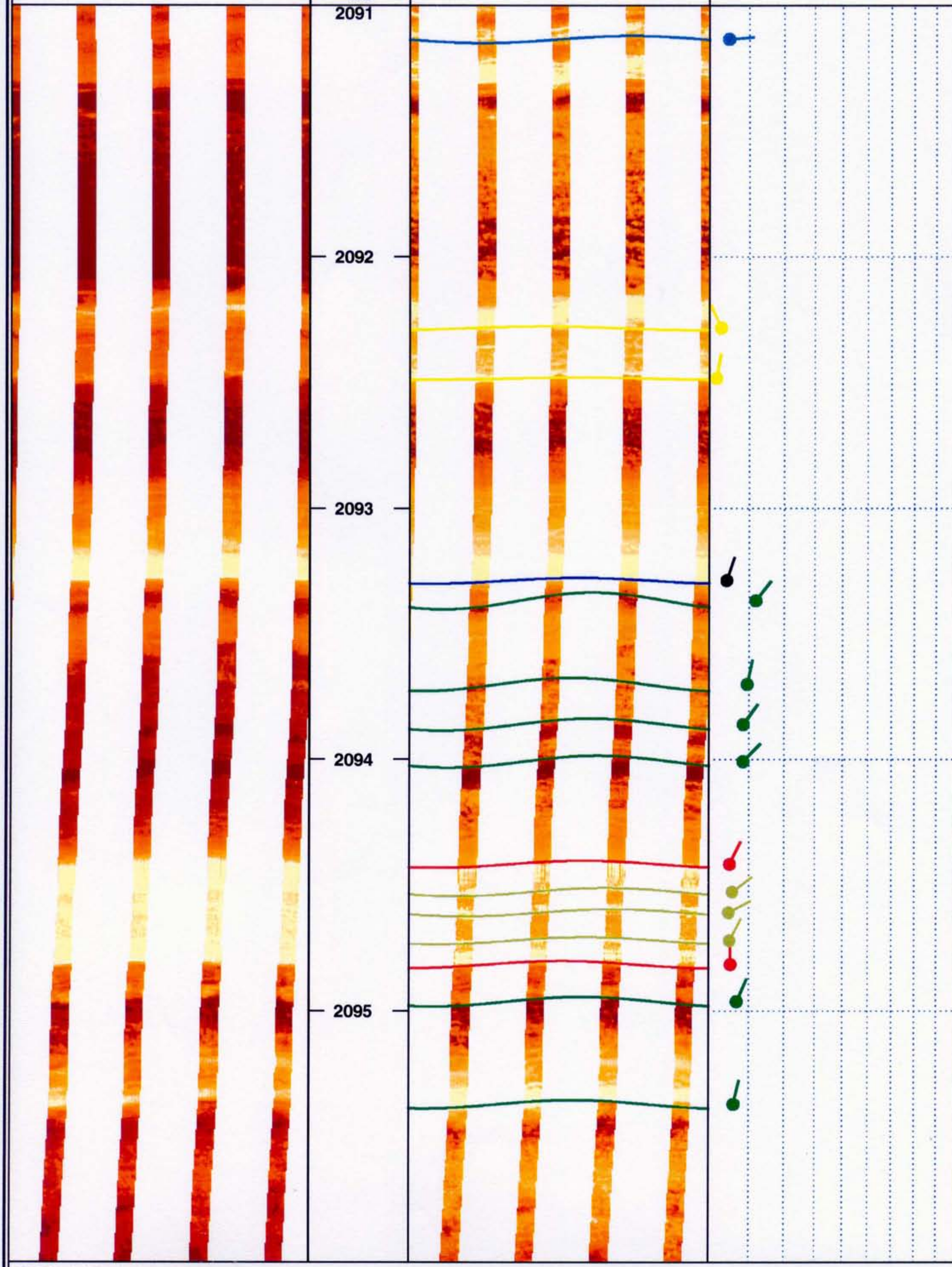
ZSA-98-050

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	



Premier Oil Australia | White Ibis 1

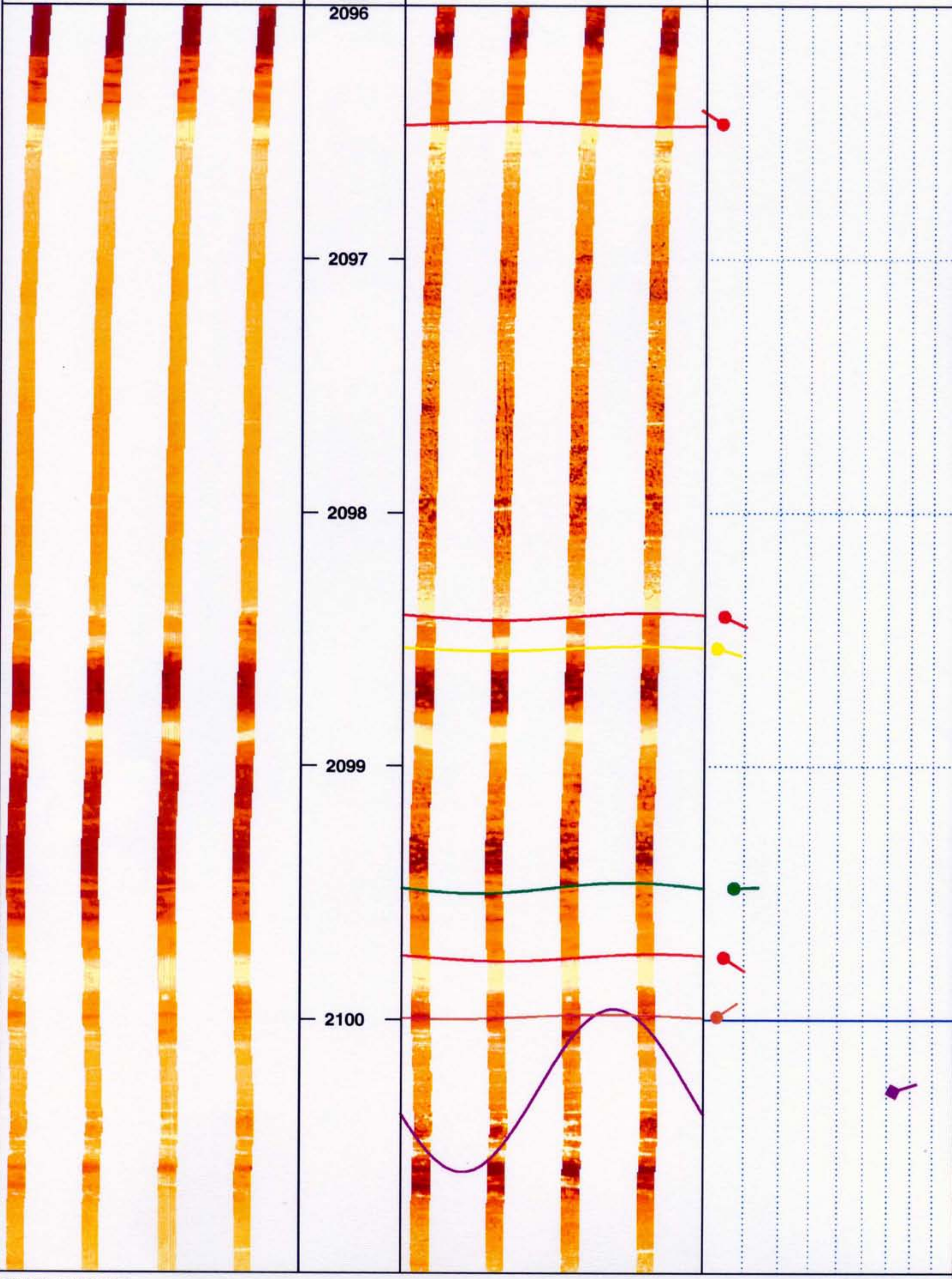
STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	



Premier Oil Australia

White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	



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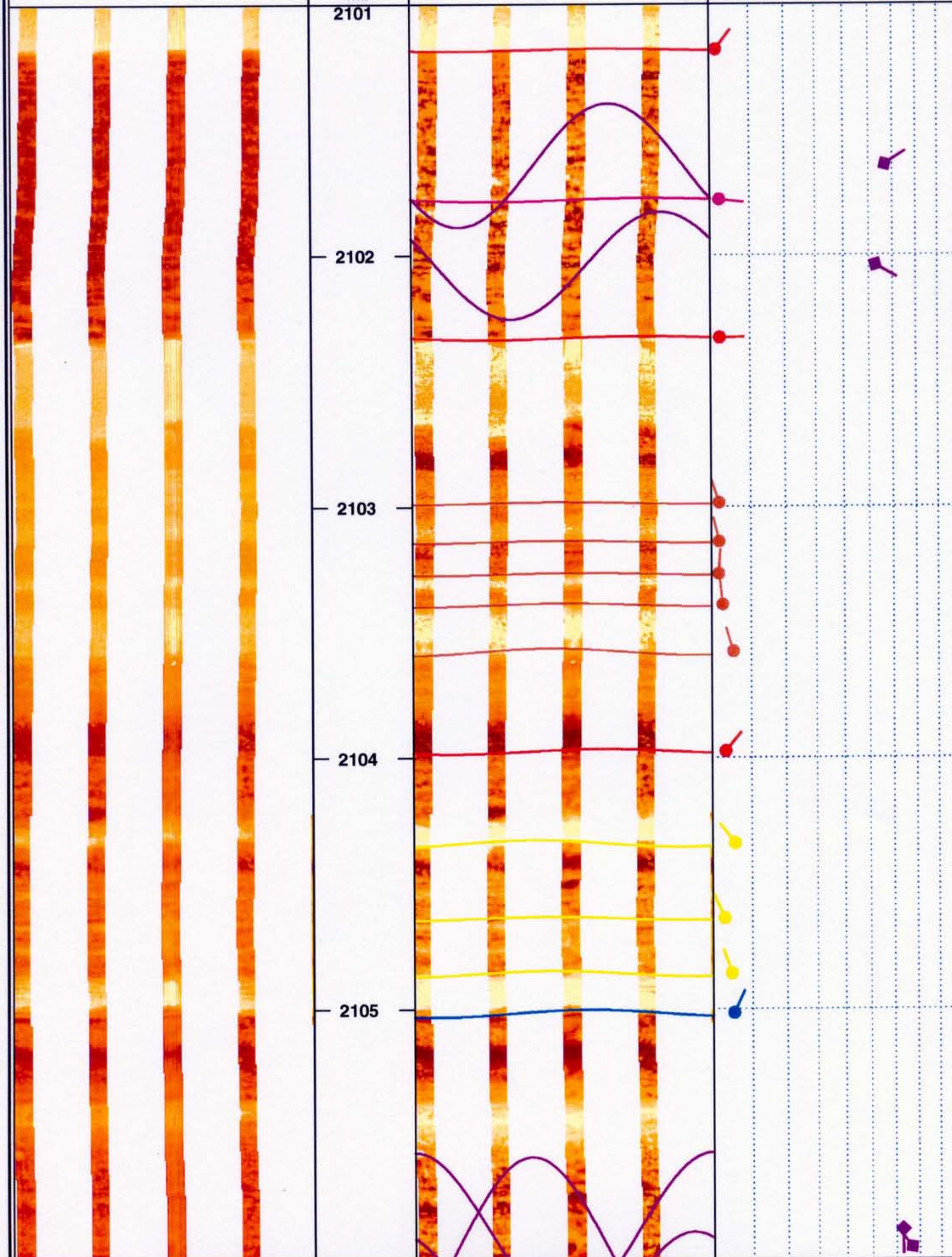
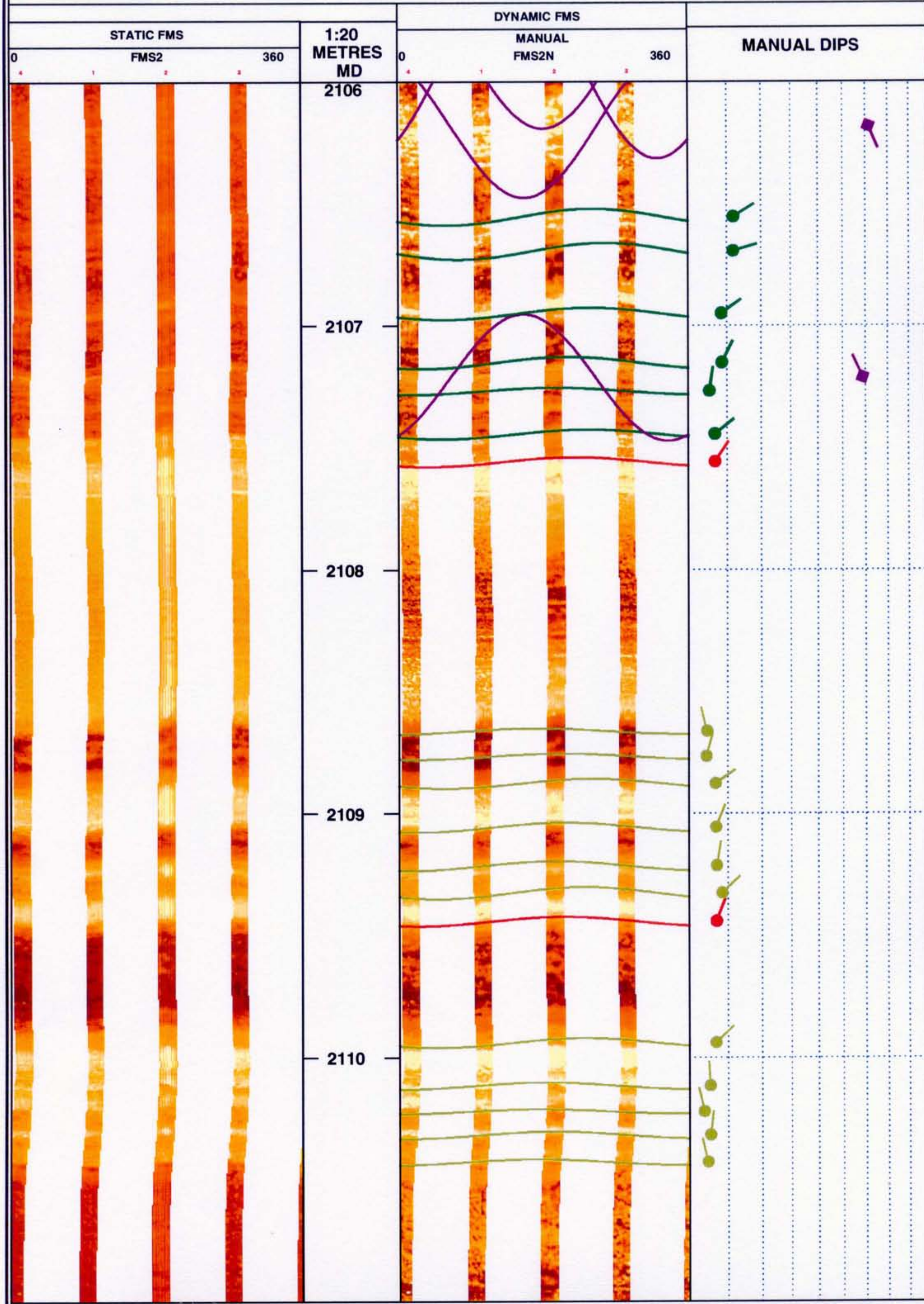
ZSA-98-050

STATIC FMS	1:20 METRES MD	DYNAMIC FMS	MANUAL DIPS
0 FMS2 360		MANUAL 0 FMS2N 360	



Premier Oil Australia

White Ibis 1



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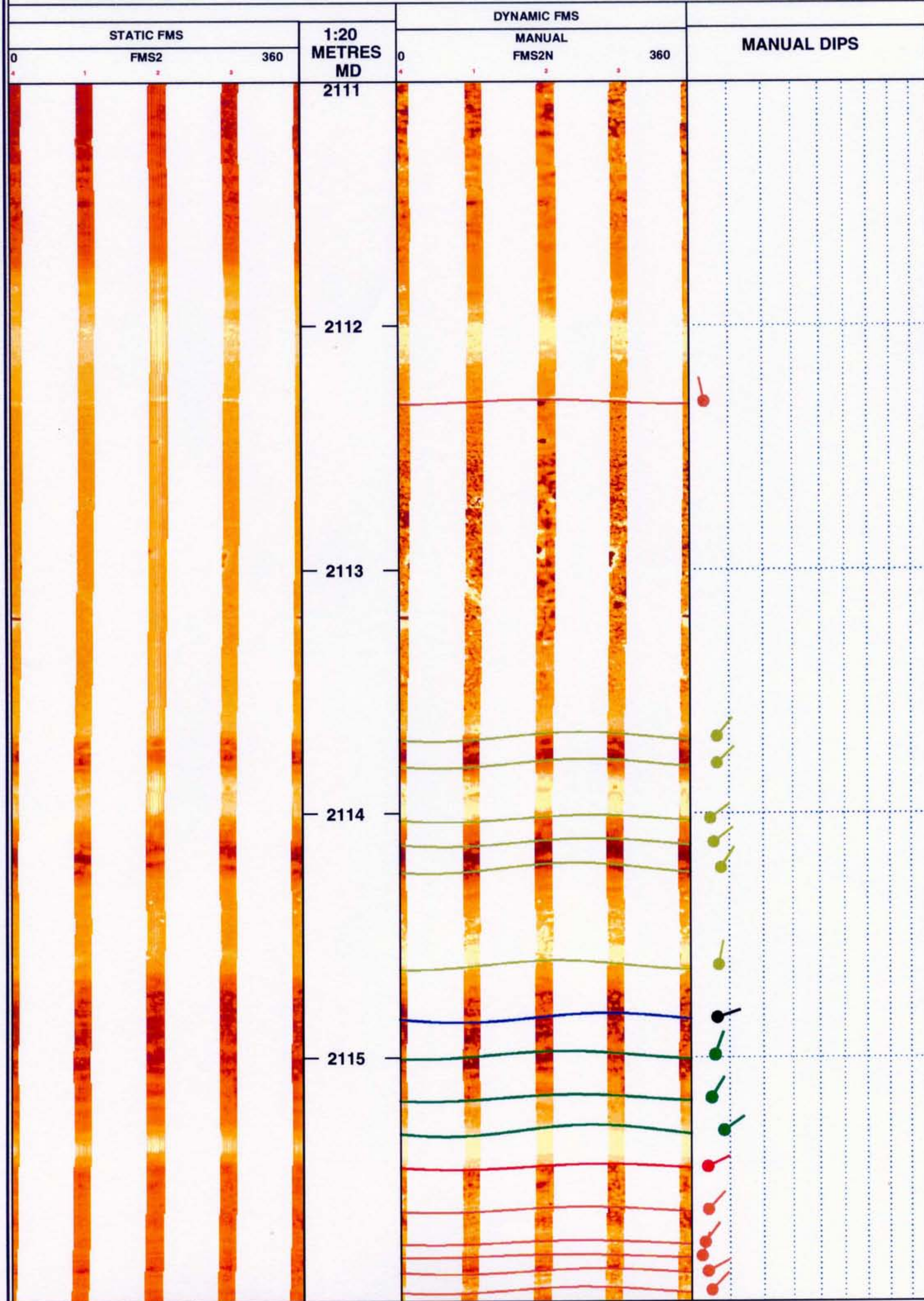
Premier Oil Australia

White Ibis 1



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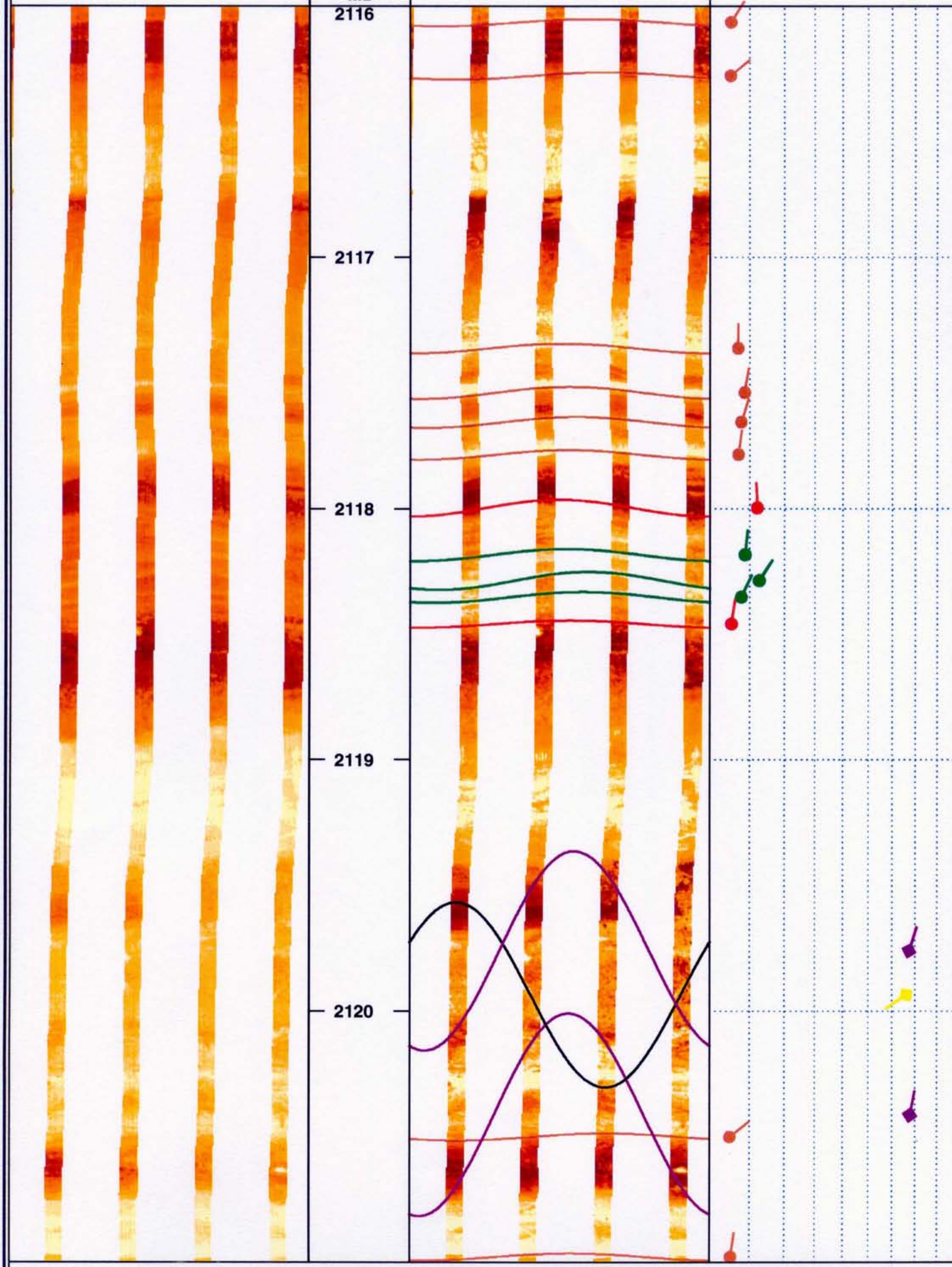
Premier Oil Australia | White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	



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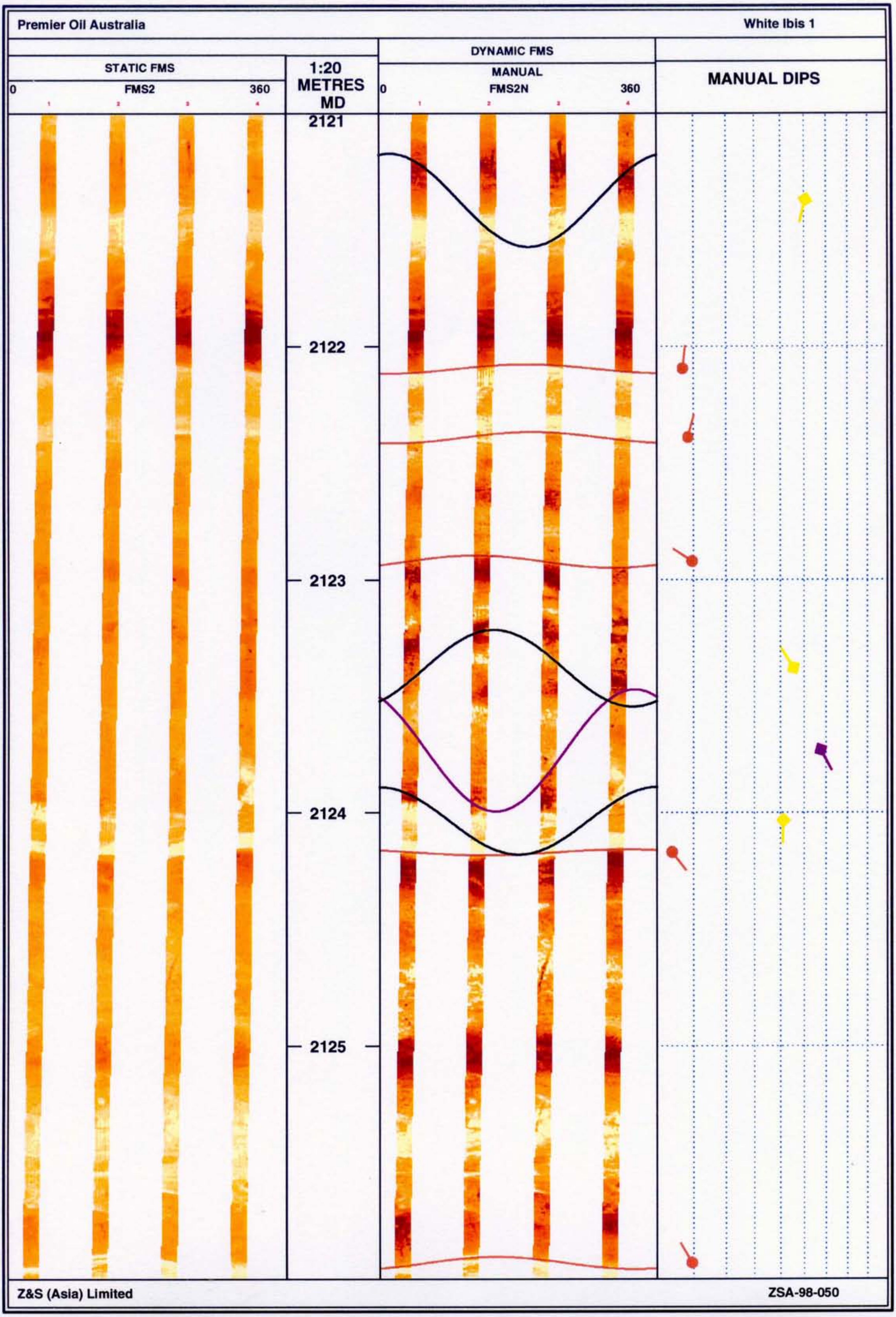
Premier Oil Australia
White Ibis 1
STATIC FMS
0
FMS2
360
1
2
3
4
1:20
METRES
MD
DYNAMIC FMS
MANUAL
0
FMS2N
360
1
2
3
4
MANUAL DIPS
2121
2122
2123
2124
2125
Z&S (Asia) Limited
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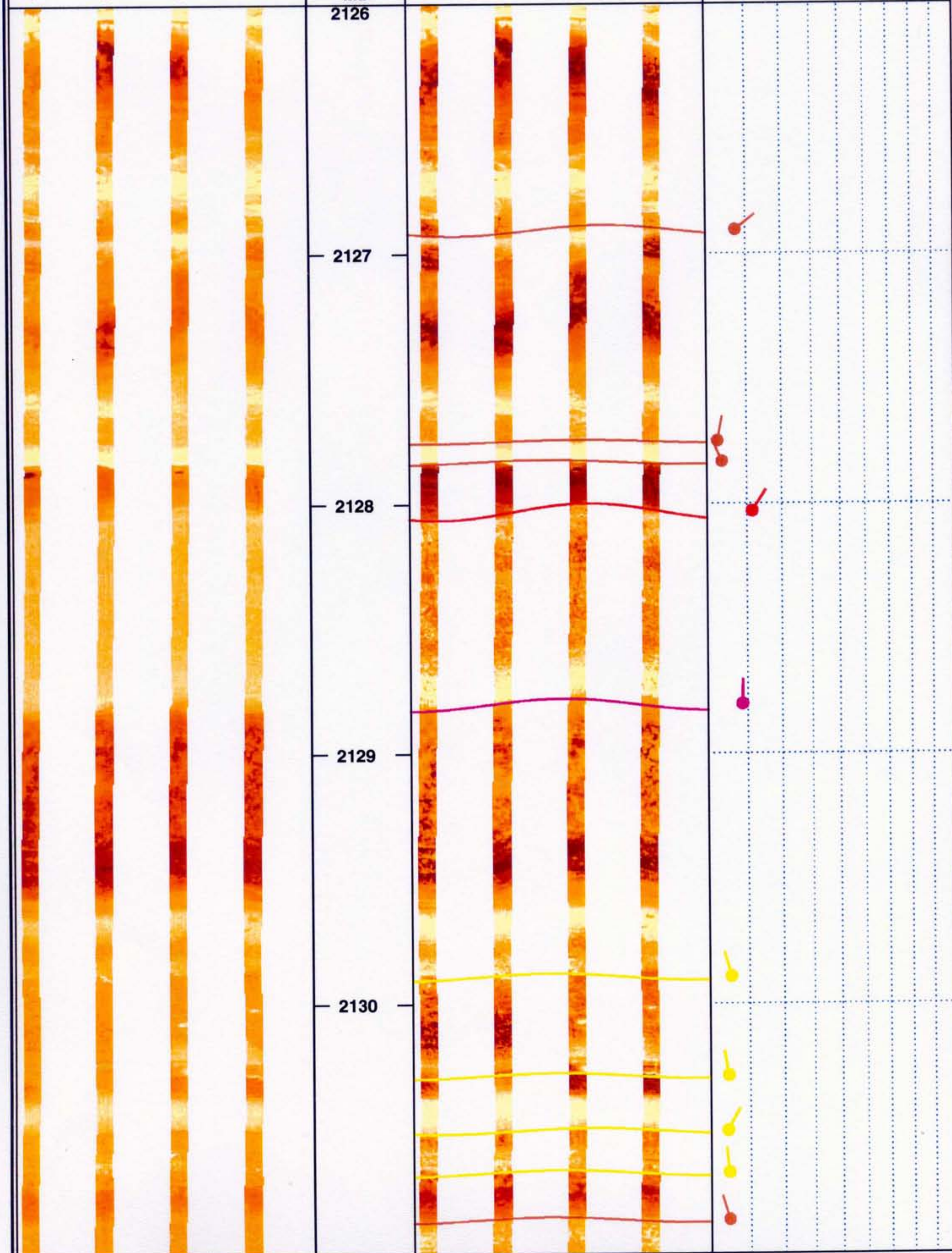
Premier Oil Australia

White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	
1 2 3 4		1 2 3 4	



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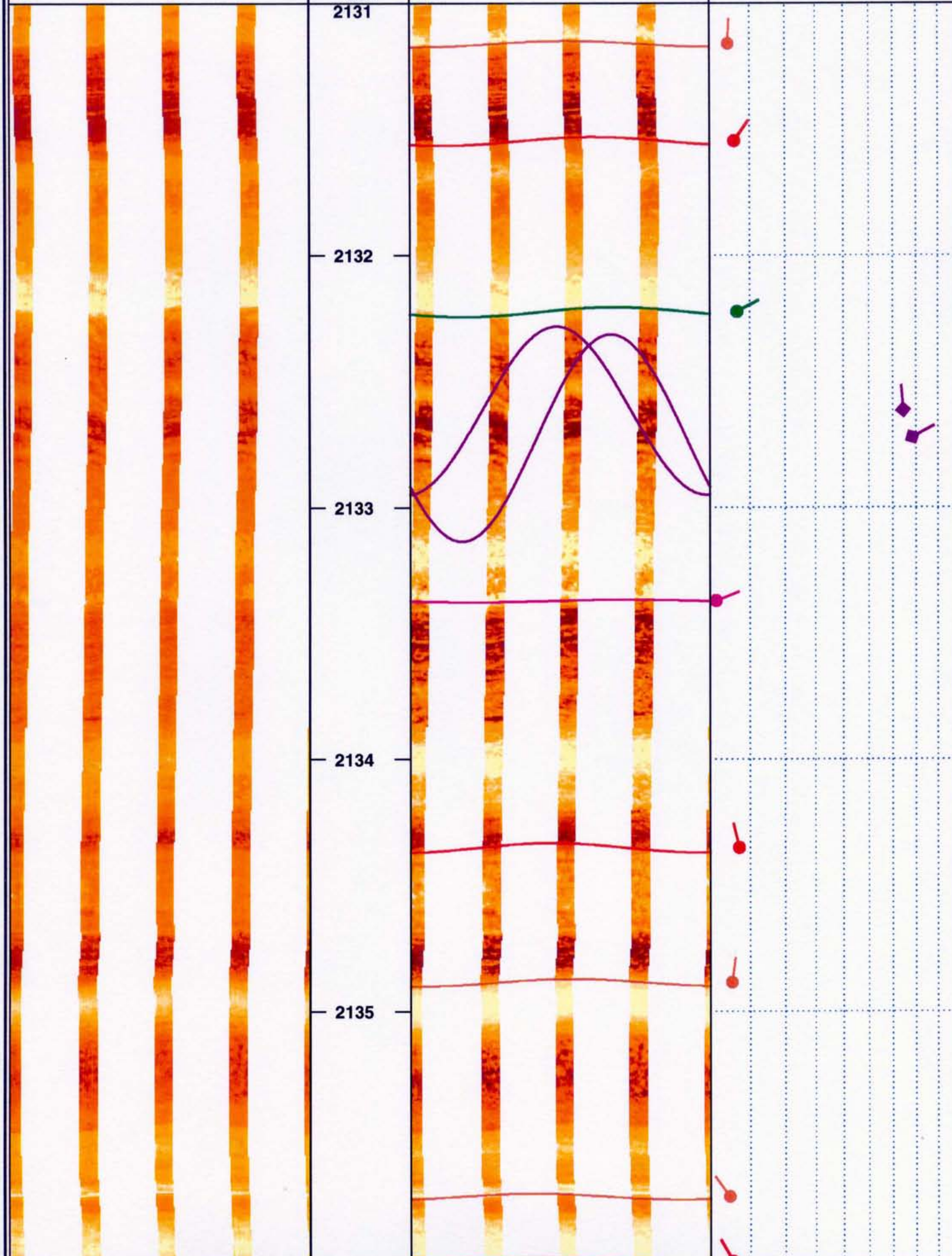
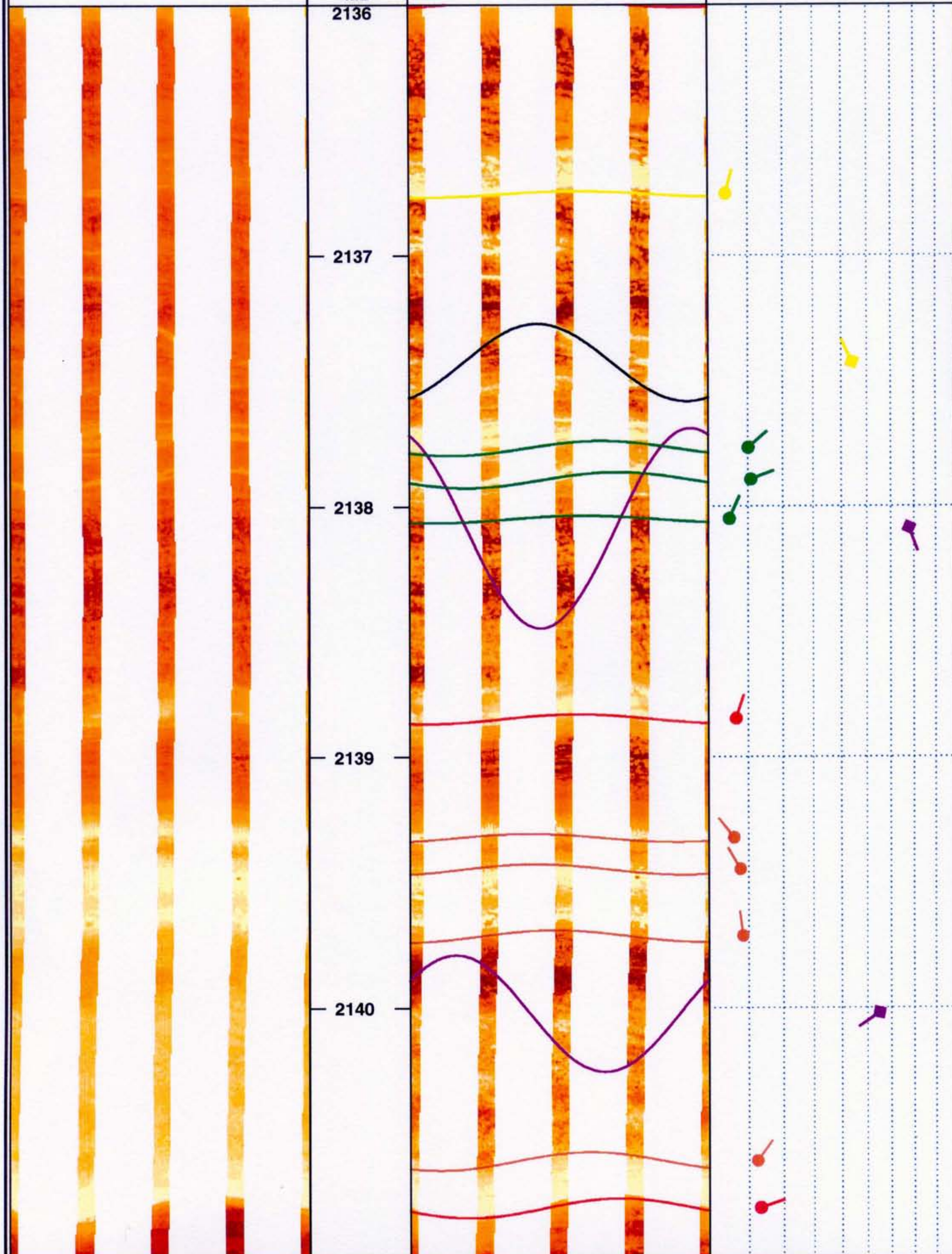
STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	
1 2 3 4		1 2 3 4	



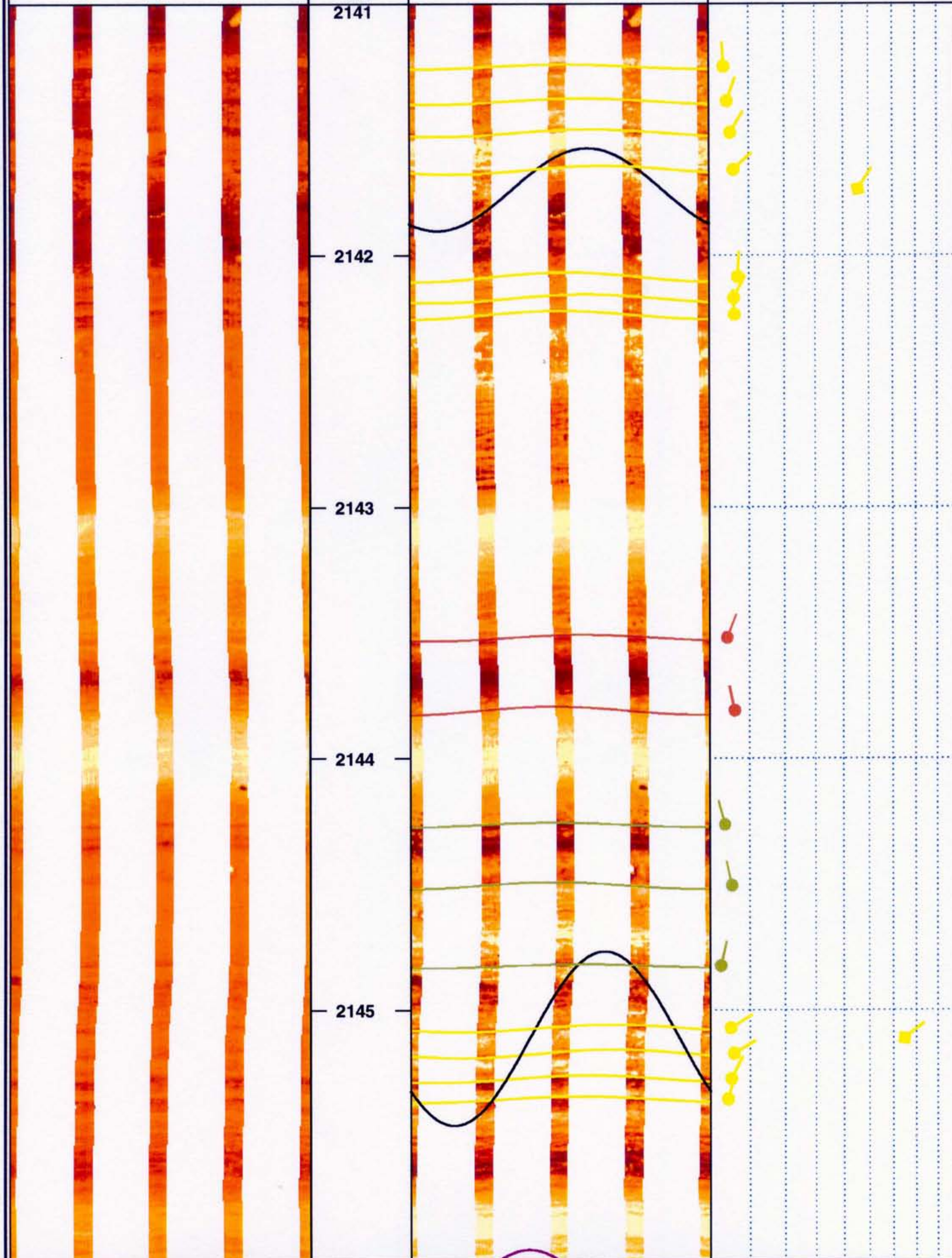
Premier Oil Australia | White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	



Premier Oil Australia | **White Ibis 1**

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	

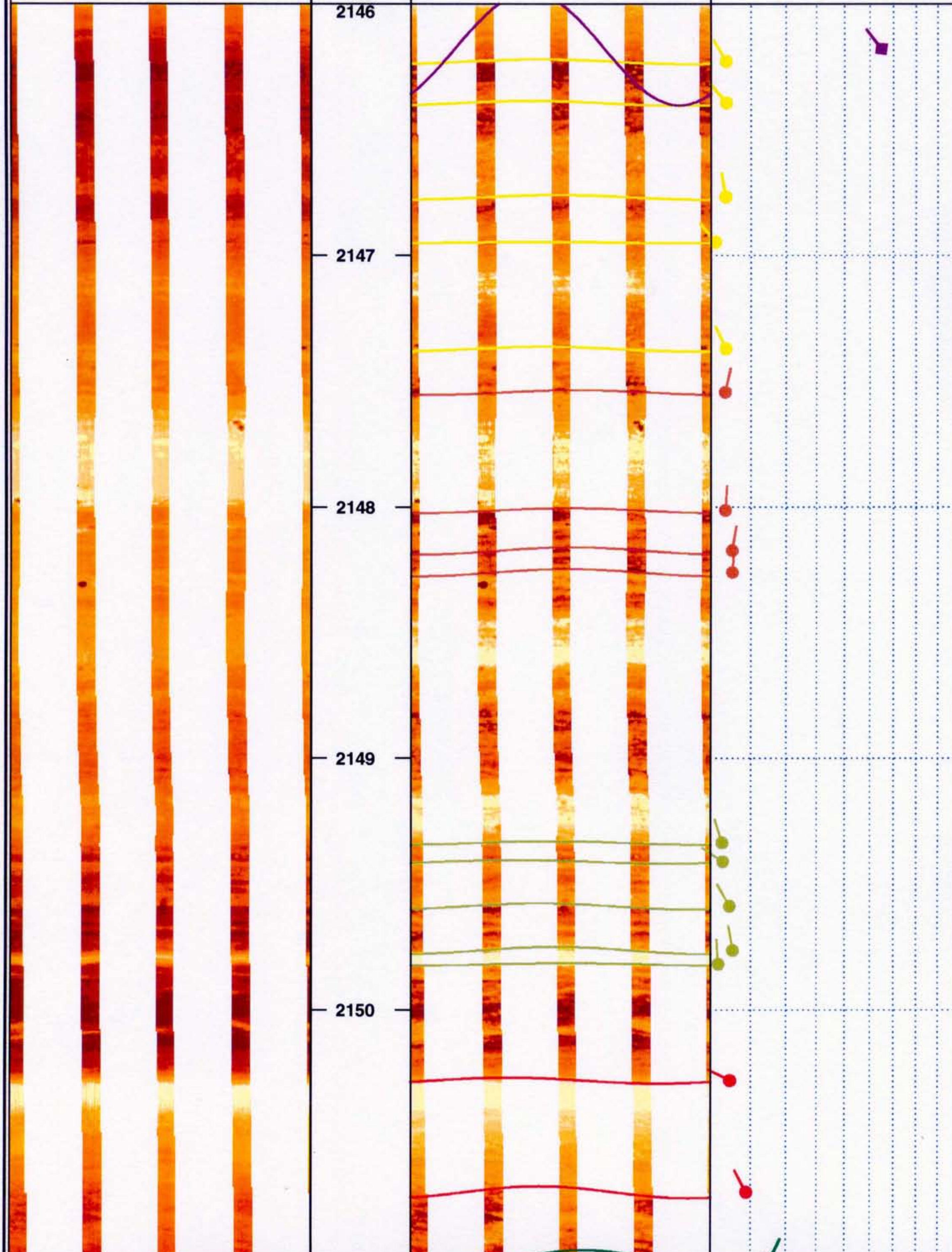


Z&S (Asia) Limited | ZSA-98-050

Premier Oil Australia

White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS	MANUAL DIPS
0 FMS2 360		MANUAL FMS2N 0 360	

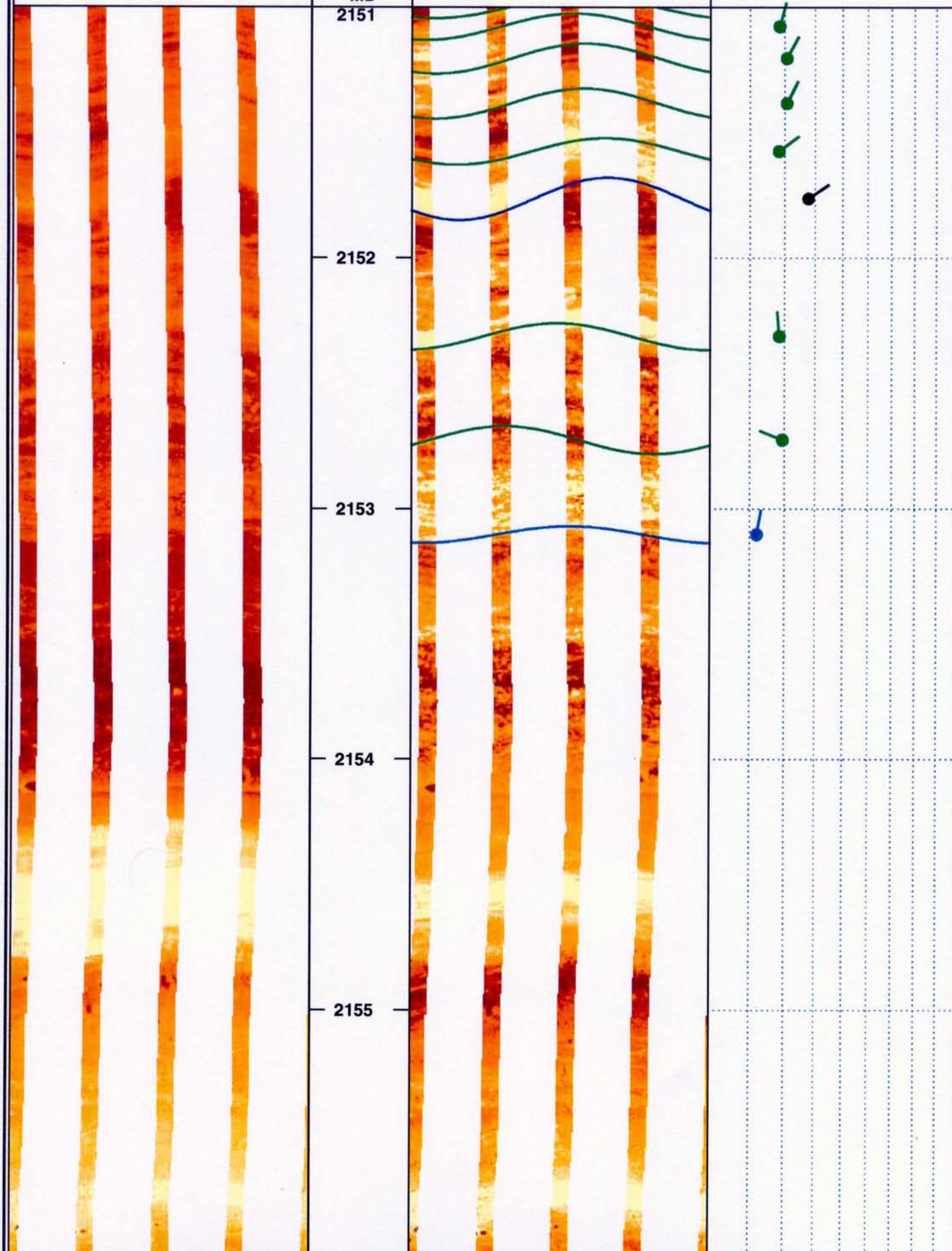


Z&S (Asia) Limited

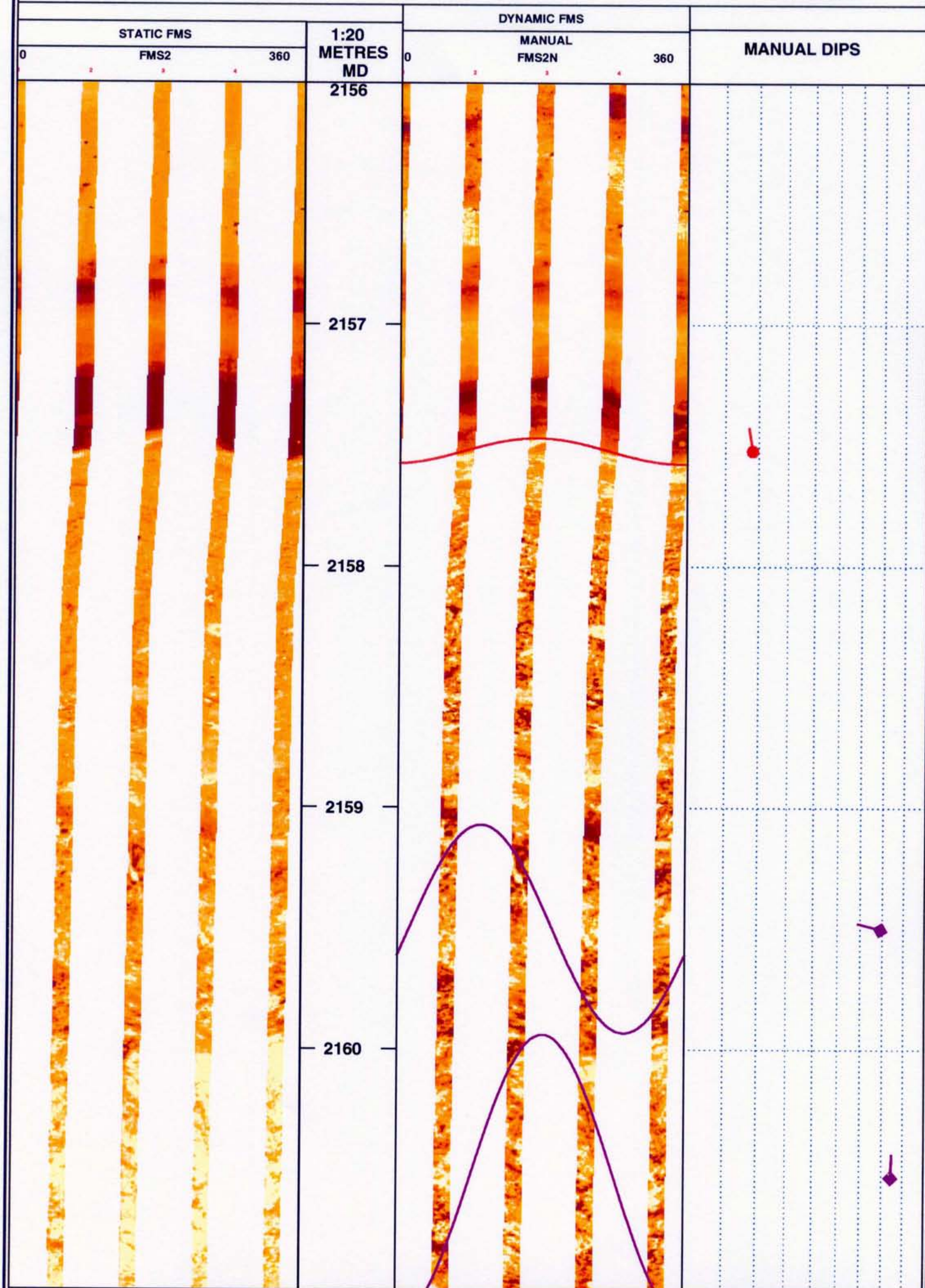
ZSA-98-050

Premier Oil Australia | White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS	
FMS2 (0 – 360)		MANUAL FMS2N (0 – 360)	MANUAL DIPS

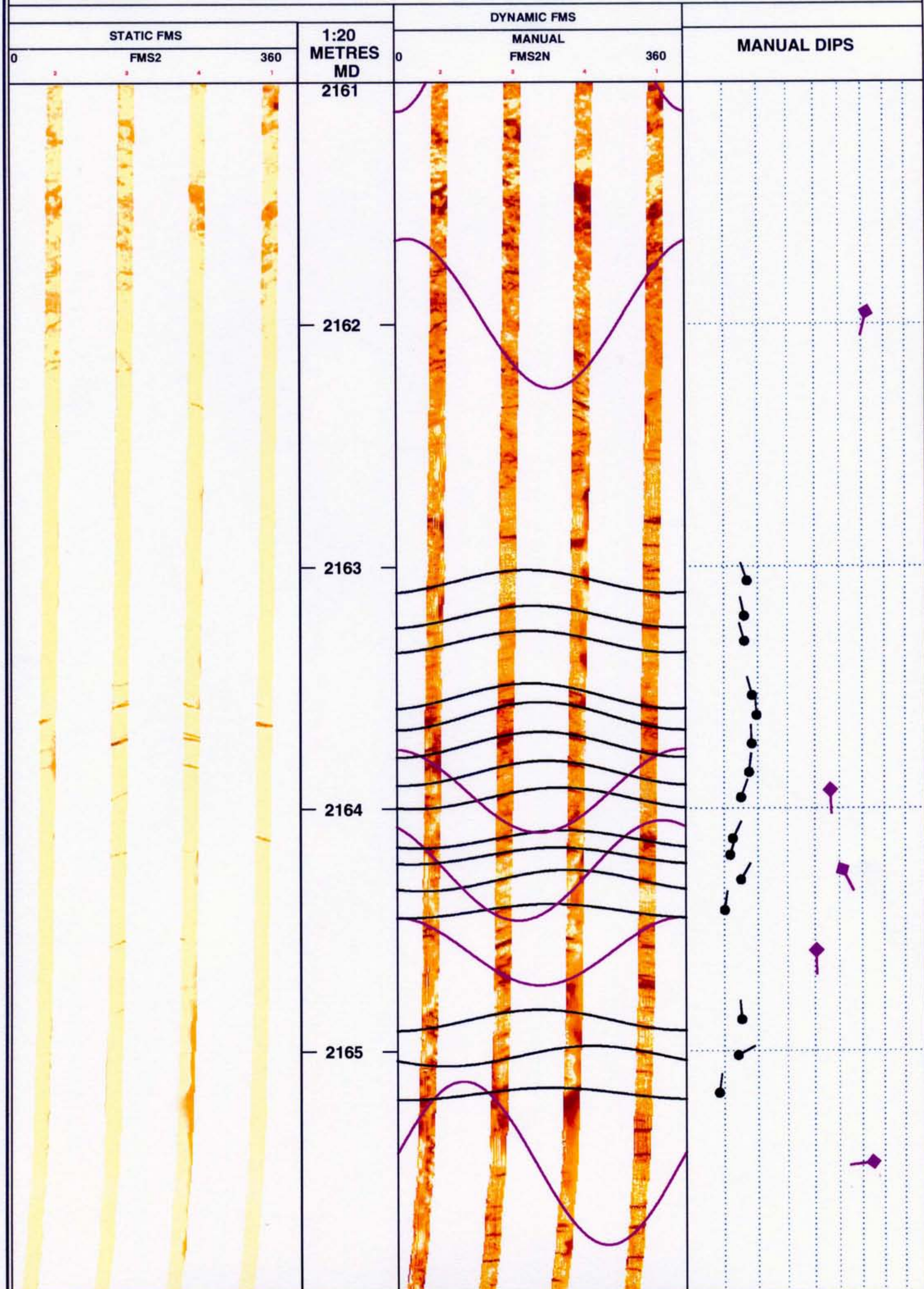


Z&S (Asia) Limited | ZSA-98-050


STATIC FMS
0 FMS2 360
1:20
METRES
MD
DYNAMIC FMS
MANUAL
0 FMS2N 360
MANUAL DIPS
2156
2157
2158
2159
2160

Premier Oil Australia

White Ibis 1



Z&S (Asia) Limited

ZSA-98-050

Premier Oil Australia | White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
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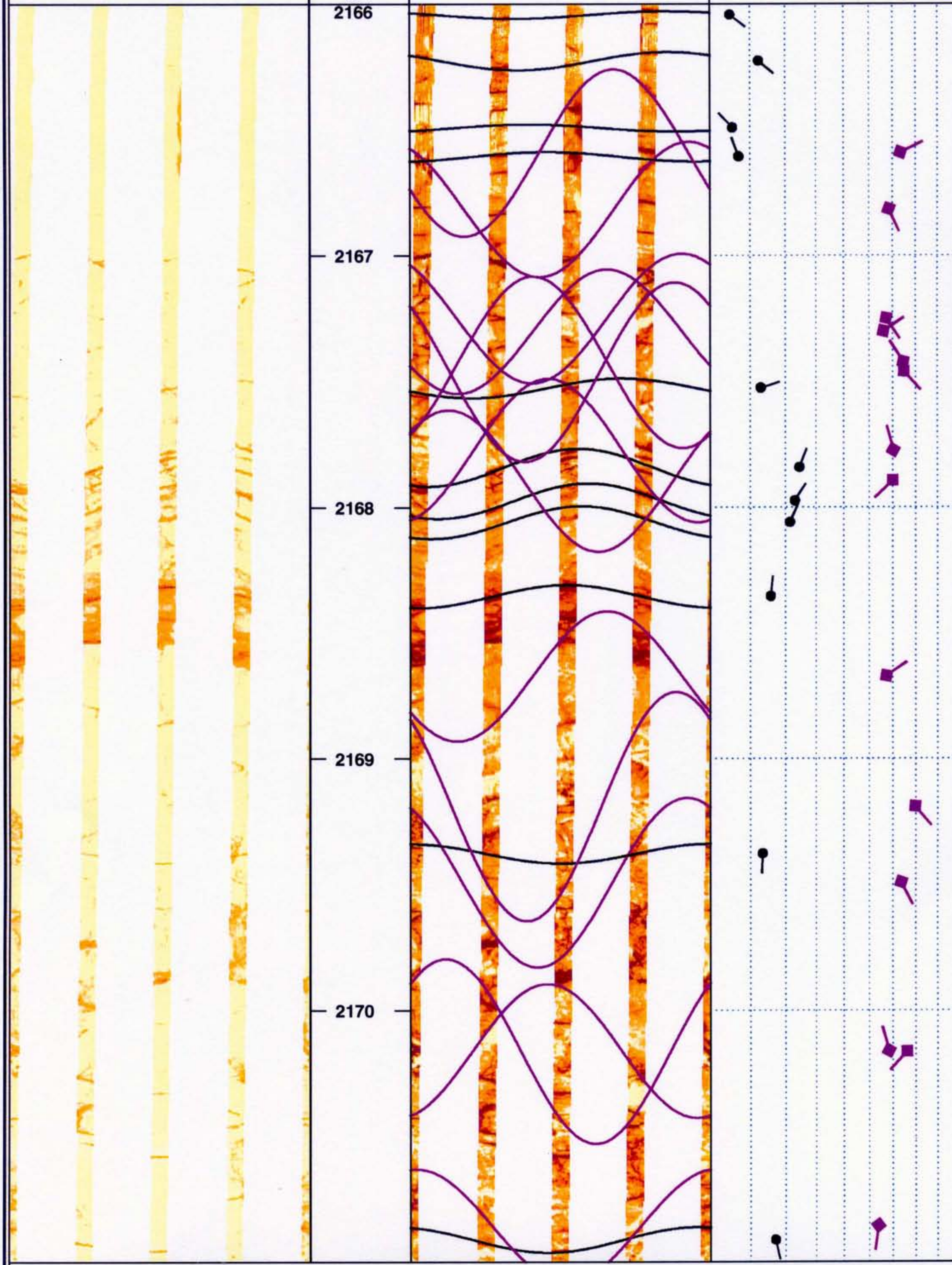

Premier Oil Australia

White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
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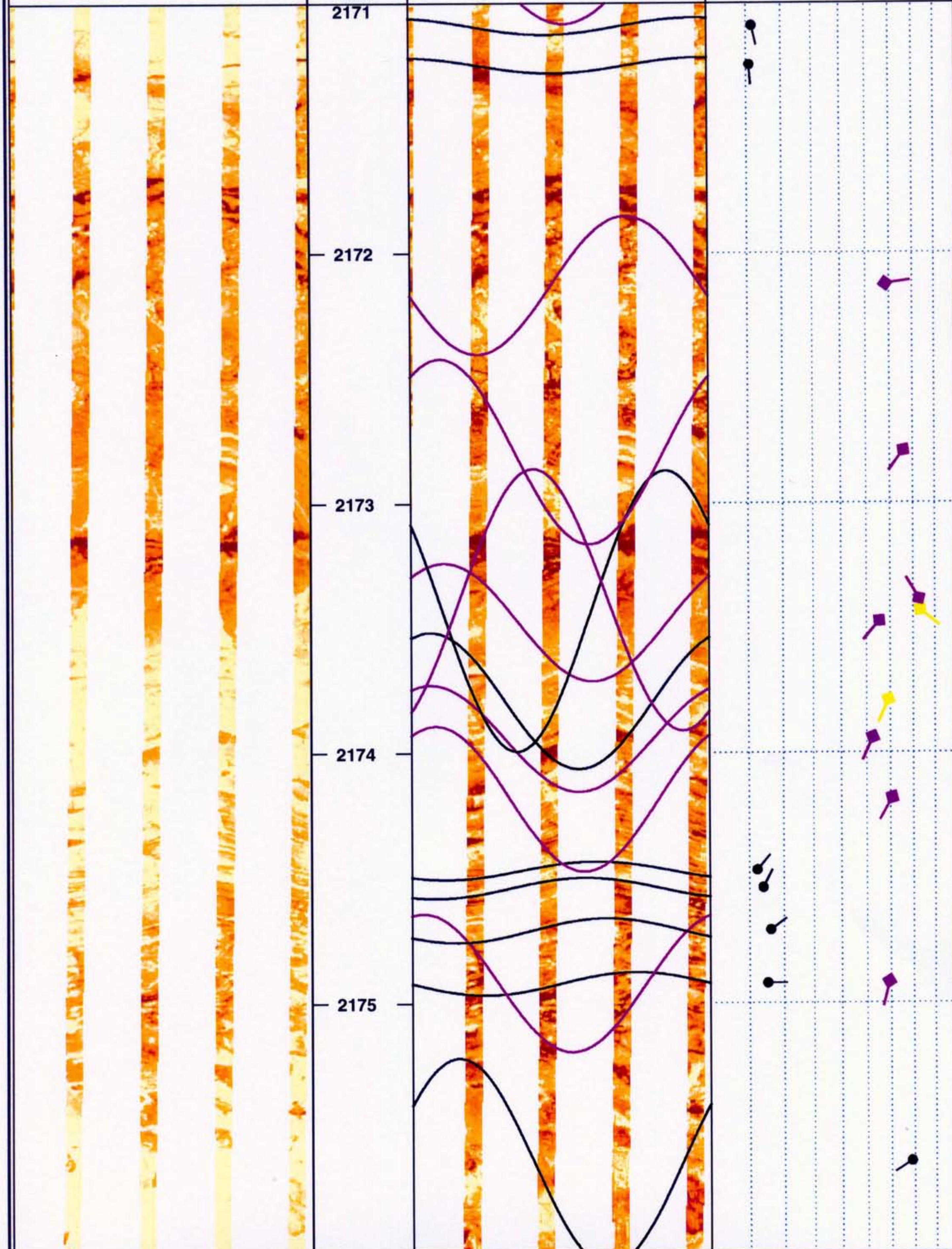
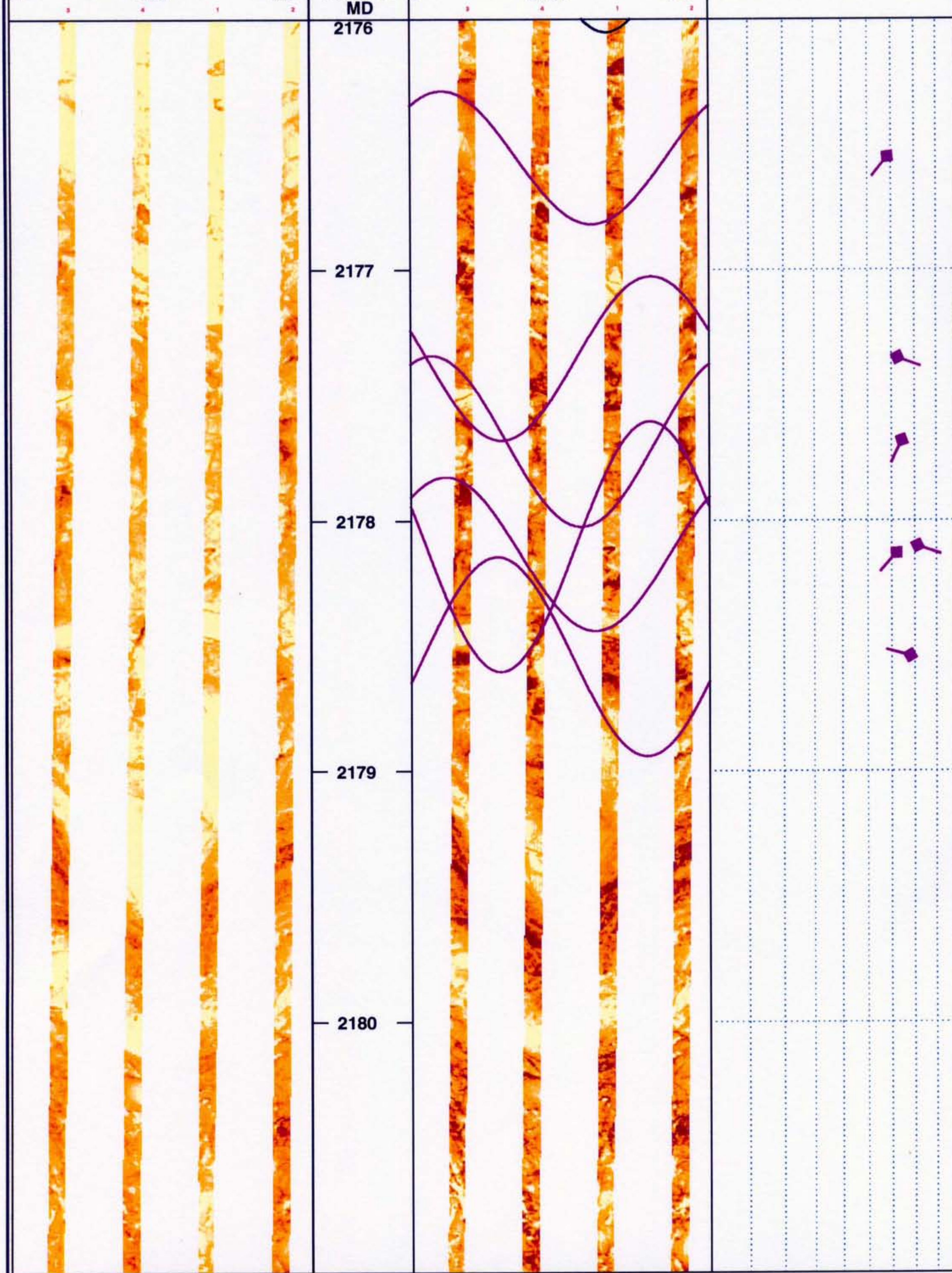


Z&S (Asia) Limited

ZSA-98-050

Premier Oil Australia | White Ibis 1

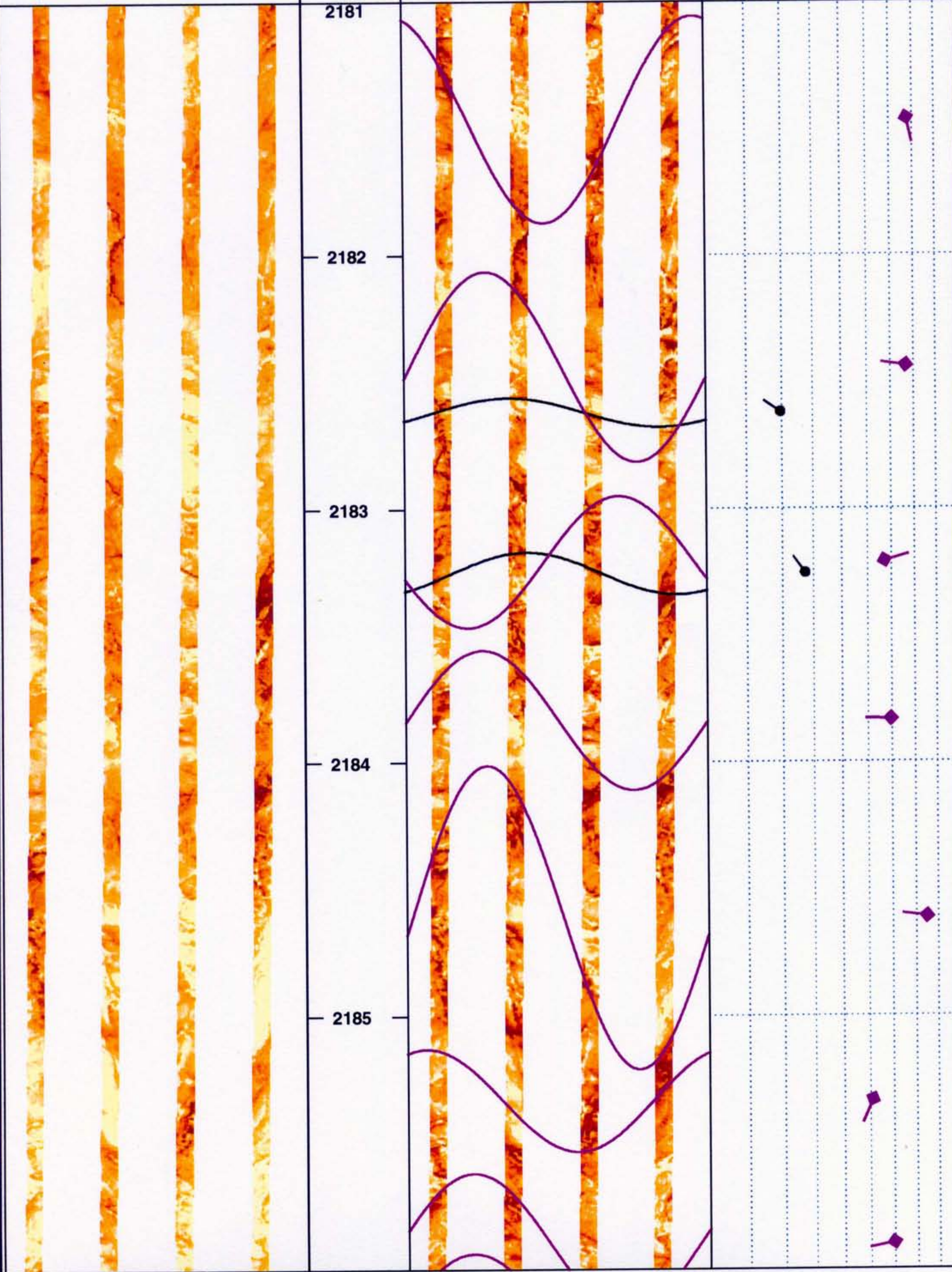
STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	



Z&S (Asia) Limited | ZSA-98-050

Premier Oil Australia | White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS MANUAL	MANUAL DIPS
0 FMS2 360		0 FMS2N 360	



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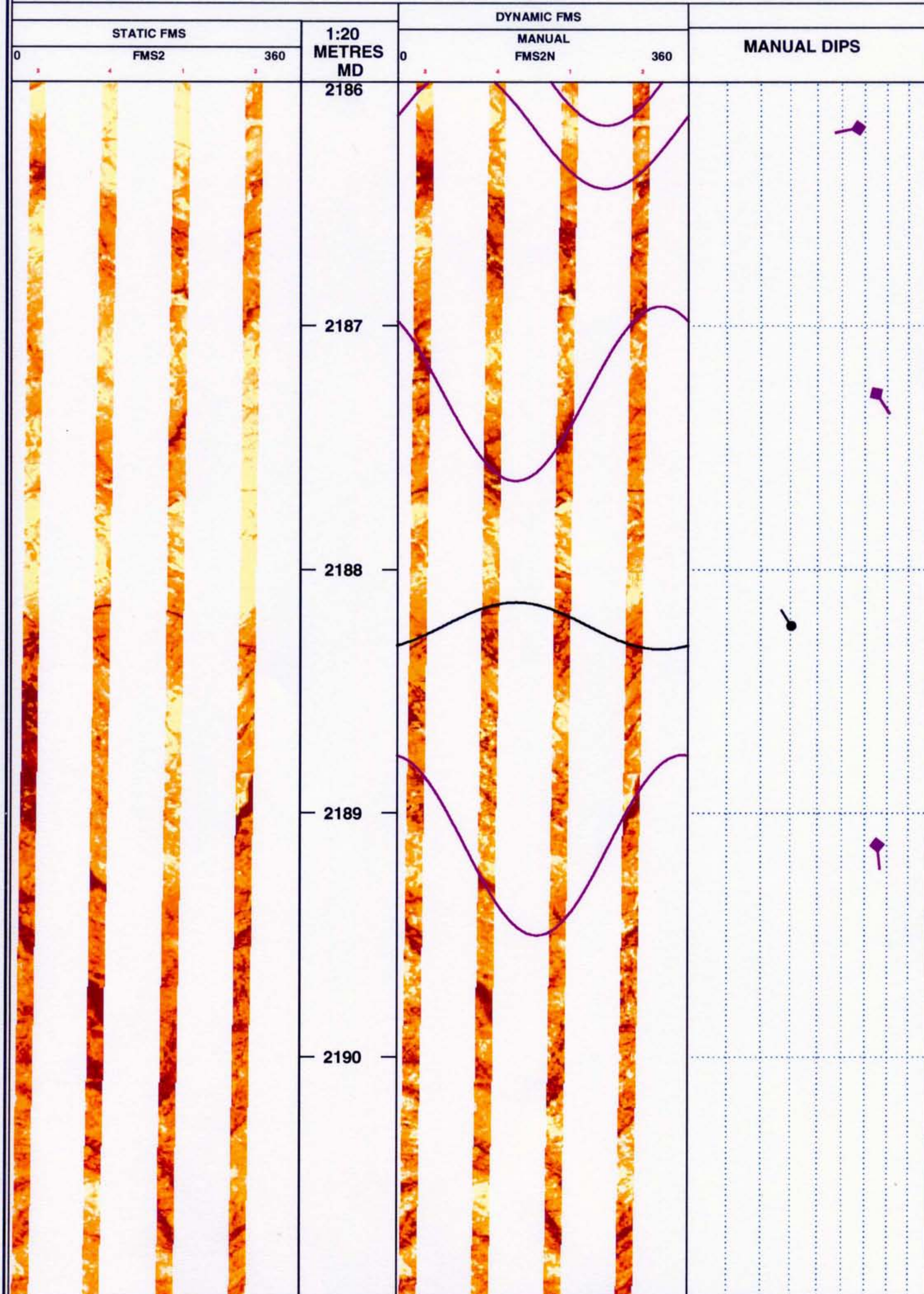
Premier Oil Australia

White Ibis 1



Z&S (Asia) Limited

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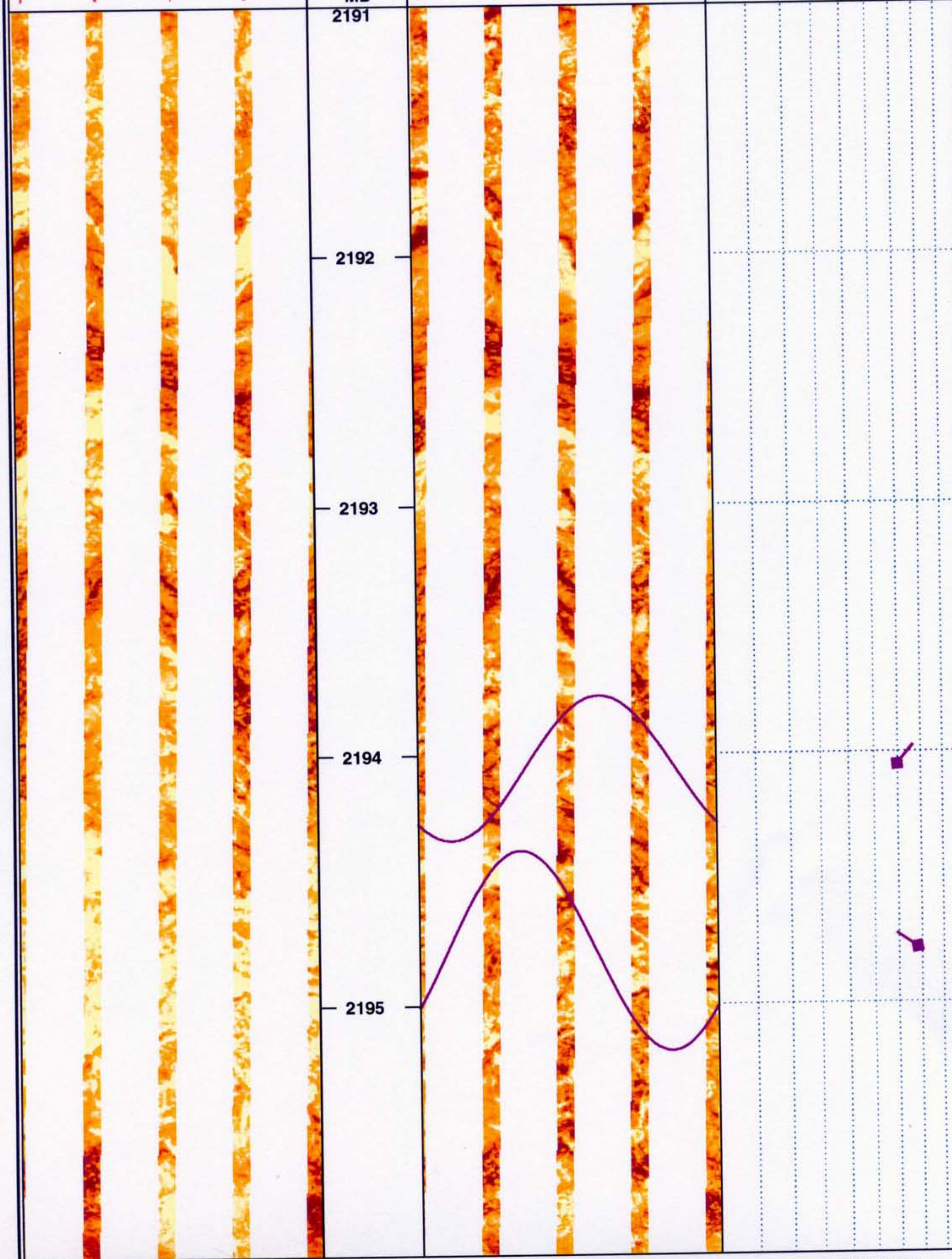
Premier Oil Australia

White Ibis 1

STATIC FMS	1:20 METRES MD	DYNAMIC FMS	
0 FMS2 360		MANUAL	MANUAL DIPS
		0 FMS2N 360	



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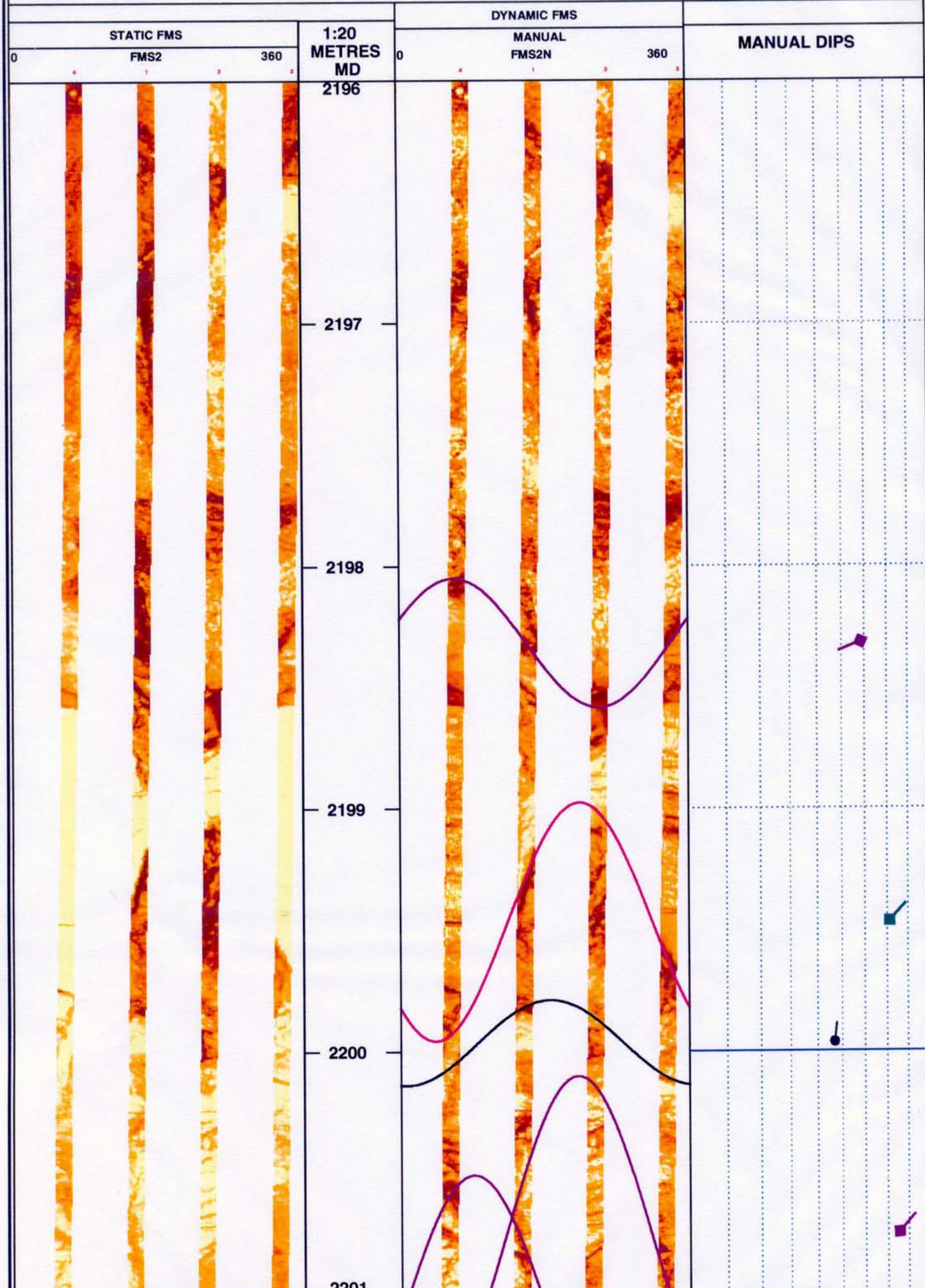
Premier Oil Australia

White Ibis 1



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