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ENHANCED ENERGY EFFICIENCY OF WIRELESS SENSOR NETWORKS USING PROTOCOL BASED RESPONSE ROUTING (PBRR) IN OIL RIG

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Abstract— **A system called system-Based Response Routing (PBRR) was created to increase energy efficiency in wireless sensor networks (WSNs) installed on oil rigs. By optimizing routing choices in response to sensor responses, PBRR reduces energy usage and increases network lifetime. It ensures that vital information is transmitted on time while sparing less urgent data from energy use by prioritizing data transmission according to urgency. By using multi-hop routing techniques, PBRR saves energy costs and guarantees dependable monitoring under difficult circumstances. This method makes WSNs more practical for long-term deployment in difficult situations like oil rigs.**

Keywords— **WSN PBRR**

I. INTRODUCTION

A wireless sensor network is made up of a number of wireless sensor nodes, or devices, that are typically used to record data on local occurrences according to Santhameena S. et al (2022). The computing and communication power of sensor nodes is restricted in accordance with Havashemi K. et al (2022). Sending data from scanning (sense) phenomena to the base station or several nodes designated as data collectors is the standard communication pattern in wireless sensor networks (WSNs) according to Xiong, C.W. et al (2022). The sensor node receives a request from the data collector or base station that includes information about the phenomena to be recorded, the sampling interval, and the overall sampling time as stated by Frey H. et al (2005). Delay is one of the many reasons why wireless sensor networks operate poorly. Data loss, which occurs when data is lost during data exchange operations in WSN as a result of high traffic on the WSN, is another factor contributing to WSN's poor performance based on Rehan W. et al (2017).

The heavy traffic on the protocol line on the WSN is the cause of the high delay rate, which will lower the WSN's performance. The high rate of delay causes more data loss, which can lower the WSN's quality and performance. In order to minimize latency and data loss, we therefore require a solution to these issues according to Hamid M.A. et al (2011). Wireless Sensor Network technology is essential to the intelligent irrigation system's ability to communicate with one another in accordance with Singhal C. et al (2021). The effectiveness of intelligent irrigation can be enhanced by a variety of sensors. For example, a fuzzy logic method can be used to define the temperature and humidity variables in the system, allowing for more optimum watering stated by Lavanya G. et al (2019). The issue is that there are a lot of data collisions according to Mahesh N. et al (2022).

Data packets may collide with one another on a common channel in a collision, which is a physical network segment as stated by Cinar H. et al (2019). Data collision may occur when there are too many sensors since only the temperature and humidity sensors' data will be forwarded to the server. The tool will not function as well when the data collides as described by Yigit M. et al (2016), even blanking out the data and shutting off immediately.

II. PROPOSED ALGORITHM

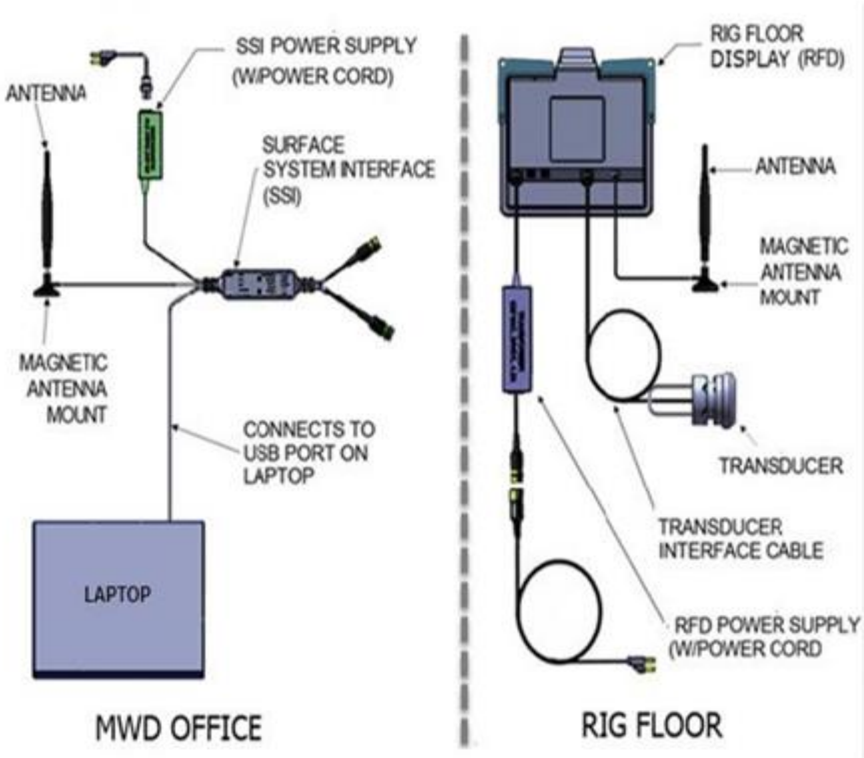
Materials used for the field experiment

The following equipment was used for carrying out the field experimentation in order to show the implementation of the proposed routing protocol. The specifications are also stated.

Acceleration Sensor:

Manufacturer	**DFROBOT**
Type of sensor	**accelerometer**
Integrated circuit	**LIS331HH**
Accelerometer measuring range	**±6g, ±12g, ±24g**
Kind of output	**Digital**
Operating current	**140µA**
Processor Series:	PIC18
Product:	MCUs
Product Type:	8-bit Microcontrollers – MCU
Program Memory Type:	Flash
Factory Pack Quantity:	15
Subcategory:	Microcontrollers – MCU
Trade name:	PIC
Width:	7.24 mm
Unit Weight:	0.075839 oz

SENSOR PLACEMENT



Pump stroke counter

MWD (MEASUREMENT WHILE DRILLING) TOOL

MWD is a system of **taking measurements while drilling a wellbore.** This allows measurements to be sent to the surface continuously while the hole is being drilled.

It is a general term for electronics that use sensors to calculate position and orientation. Inclination is the angle of the wellbore with respect to vertical and azimuth is the angle of the wellbore's direction with respect to North.

Once the measurements have been taken, the information needs to be encoded and sent up to the surface, where it can be interpreted by rig operators.

The MWD tool has three magnetic sensors:

i. Magnetometer
ii. Accelerometer
iii. Telemetry sensor

LOGGING WHILE DRILLING (LWD)

Advances in drilling/logging technology have allowed the acquisition of log data via tools placed in the actual drilling assembly. LWD data may be stored downhole in the tools memory and retrieved when the tool is brought to the surface and/or transmitted as pulses in the mud column in real time while drilling.

Factors that might limit the ability to fully use both sets of data are:

1. **Drilling mode:** Data may be pulsed only if mud is pumped through the drill string.
2. **Battery life:** Depending on the tools in the string, tools may work in memory mode only between 40 and 90 hours after activation.
3. **Memory size**: Most LWD tools have a memory size limited to a few megabytes. Once the memory is full, the data will start to be overwritten. Depending on how many parameters are being recorded, the memory may become full within 20–120 hours.
4. **Tool failure:** It is not uncommon for a fault to develop in the tool such that the pulse data and/or memory data are not transmissible/recordable.

SENSORS ON THE DRILLING RIG

1. Surface sensor

i. Draw work Encoder

This is a digital sensor. It is used primarily to track depth on the rig. It is also referred to as an optical encoder sometimes because contains a disk internally that allows the passage of light at a specific intervals. The sensor allows the drawworks direction and speed to be determined. The sensor output is measured in pulses and a calibration must be performed on the rig to determine the amount of movement of the traveling block per revolution of the drawwork drum. The drawwork encoder is usually mounted on the drawwork shaft and temporary removal of the cooling system is often required.

DRAW WORK ENCODER

ii. Hook load sensor: is used to measure the tension on the travelling block which

Hookload sensor

iii. Standpipe pressure transducer

Standpipe Pressure Transducer

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2. DOWNHOLE SENSOR

i. RESISTIVITY SENSOR

Resistivity logging is a method of well logging that works by characterizing the rock or sediment in a borehole by measuring its electrical resistivity. Resistivity is a fundamental material property which represents how strongly a material opposes the flow of electric current. In these logs, resistivity is measured using four electrical probes to eliminate the resistance of the contact leads. The log must run in holes containing electrically conductive mud or water, i.e., with enough ions present in the drilling fluid.

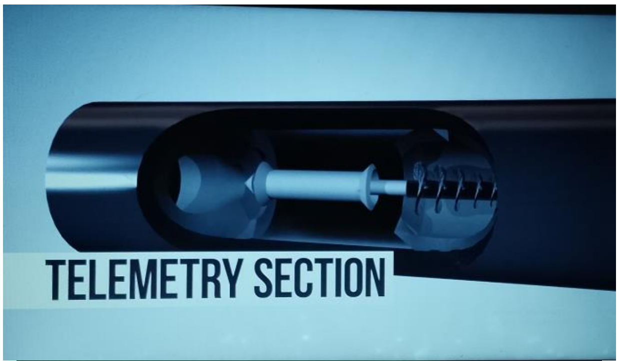
ii. GAMMA RAY SENSOR

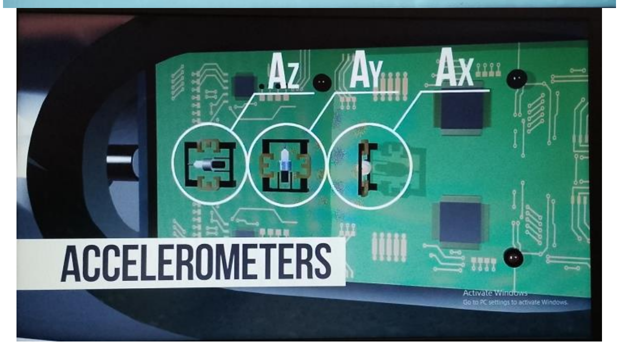
The Gamma Log produced by these Gamma Ray Sensors is most commonly used for Geo-steering, correlation with existing open hole logs, identifying low and high radiation lithologies and depth correlation. Electronics are fully encapsulated for additional shock and vibration protection.

iii. Directional module (DM)

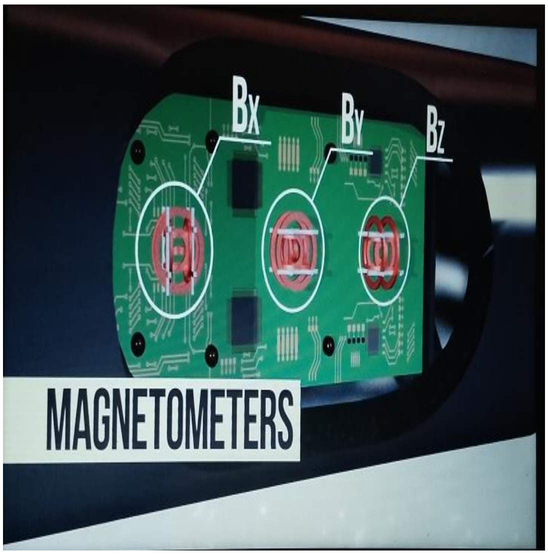
iv. PRESSURE SENSOR

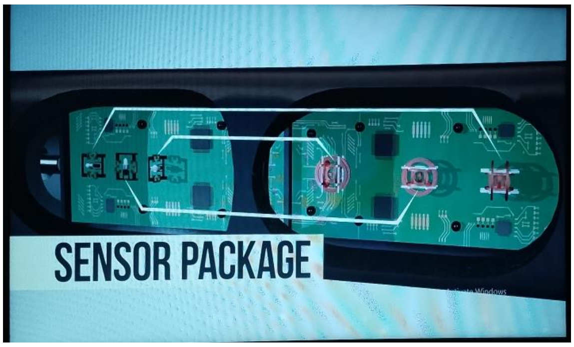
Pressure sensors: are used to measure the force exerted by a fluid or gas on a surface or a container. They are crucial for oil and gas production because they indicate the condition and behaviour of the reservoir, the well, the pipeline, and the processing equipment. Pressure sensors help regulate the flow rate, prevent leaks, detect blockages, and avoid over pressurization or under pressurization.





DIRECTIONAL MODULE



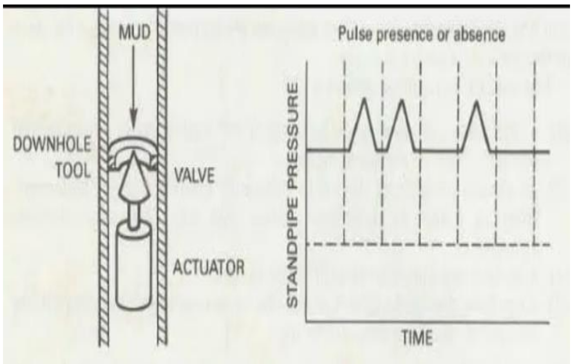


TELEMETRY SENSOR

Mud-Pulse Telemetry. During drilling, a special kind of mud (drilling fluid) is pumped down the drill string and then sent back to the surface. Electronics at the bottom of the hole drive a valve that can constrict and relax the flow of this mud, creating pressure pulses in the fluid that's circulating in and out of the hole. The three common types of signals generated are positive pulse telemetry, negative pulse telemetry and continuous wave telemetry.

POSITIVE MUD PULSE TELEMETRY

This telemetry uses a flow restrictor that closes to increase standpipe pressure when activated. As the mud flows through the pipe, the pressure fluctuates as the flow restrictor opens and closes. The highs and lows of pressure are sensed by the transducer on the standpipe, the transducer then converts the pulses to electrical signals and sends it to the decoder.



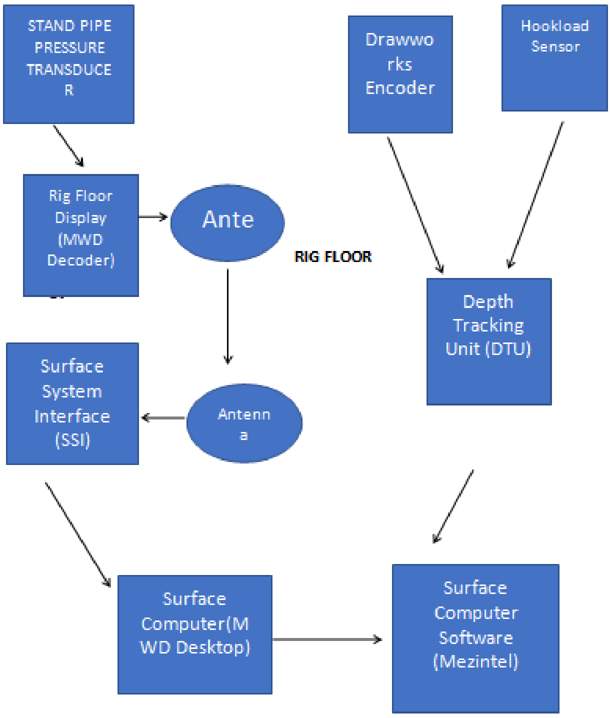
POSITIVE MUD PULSE TELEMETRY

3.1.1 Research Environment

Location: Delta State (Okporhuru Field)
Lat - 5° 53' 47.404N Long - 5° 50' 13. 443E Depth: About 13,500ft
Energy level of battery when activated
Percentage ------ 94.06% Capacity ---------- 27,278.21mAh
Voltage ------------ 28.50V Active time ---------- 16hrs 26mins
Retrieved after operation
Percentage ---------- 34.43% Capacity -------------- 9,986.06mAh
Voltage ------------- 28.60V Active time --------- 78hrs 13mins

THE SYSTEM MODEL

In this section, a detailed explanation of the system model that will be used to implement and test the proposed protocols. Firstly, we present the WSN model, then, we explain the energy consumption model that will be used to test the proposed protocols. Finally, we present the simulator and the WSN simulation settings that will be used to test the proposed protocols.



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III. RESULT AND ANALYSIS

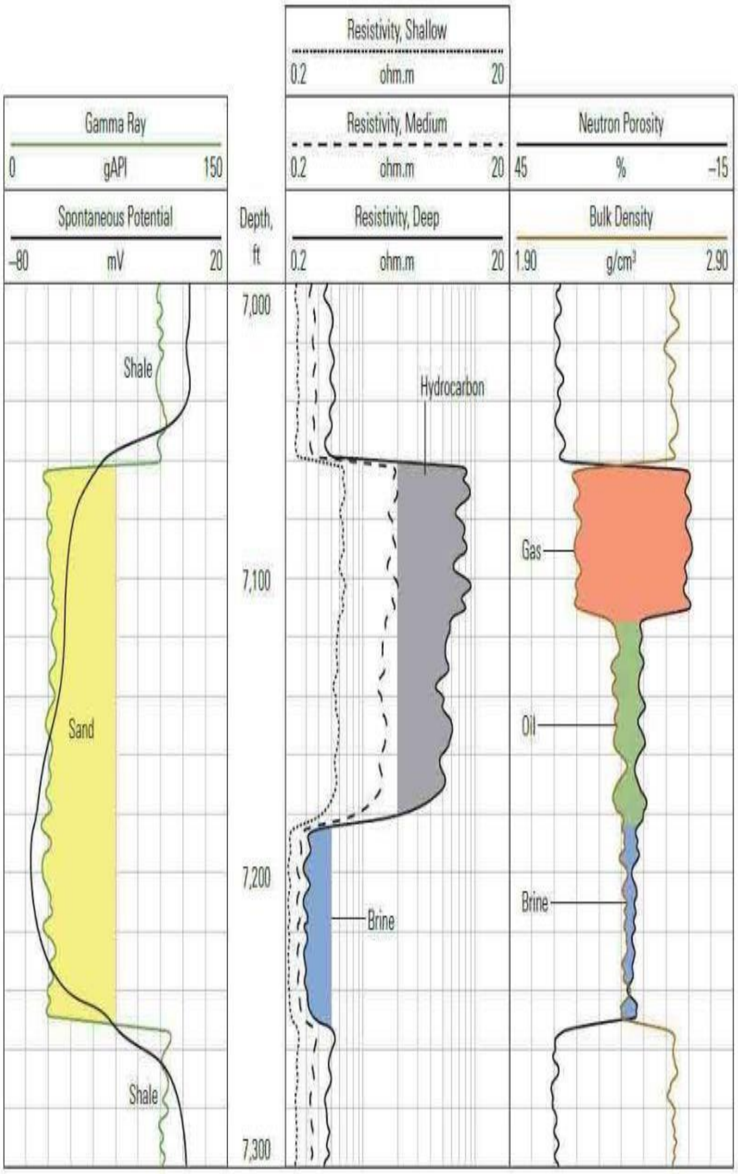
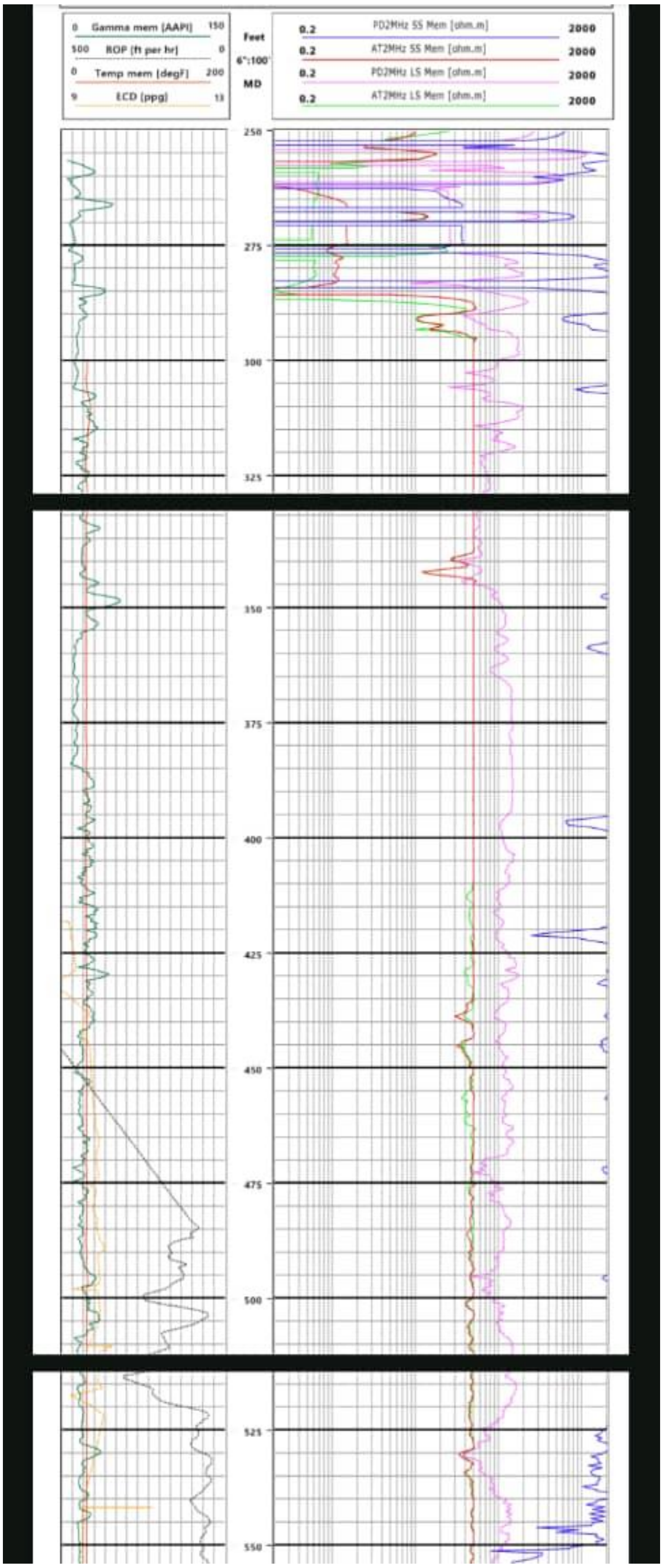


Figure 4.1 Shows the graphical representation of the throughput response.

Fig. 4.1 is a graphical representation of gamma, resistivity, and neutron density logs. The gamma ray log shows the type of formation the drilling tool is passing through, either shale or sand. When the signal increases toward the positive, it indicates shale formation, while a decrease toward the negative indicates a sandy formation.

The resistivity graph identifies the presence of fluid in the formation, whether water or hydrocarbons, while the neutron density log specifies the type of fluid the drilling tool is encountering, such as gas, oil, or fresh water.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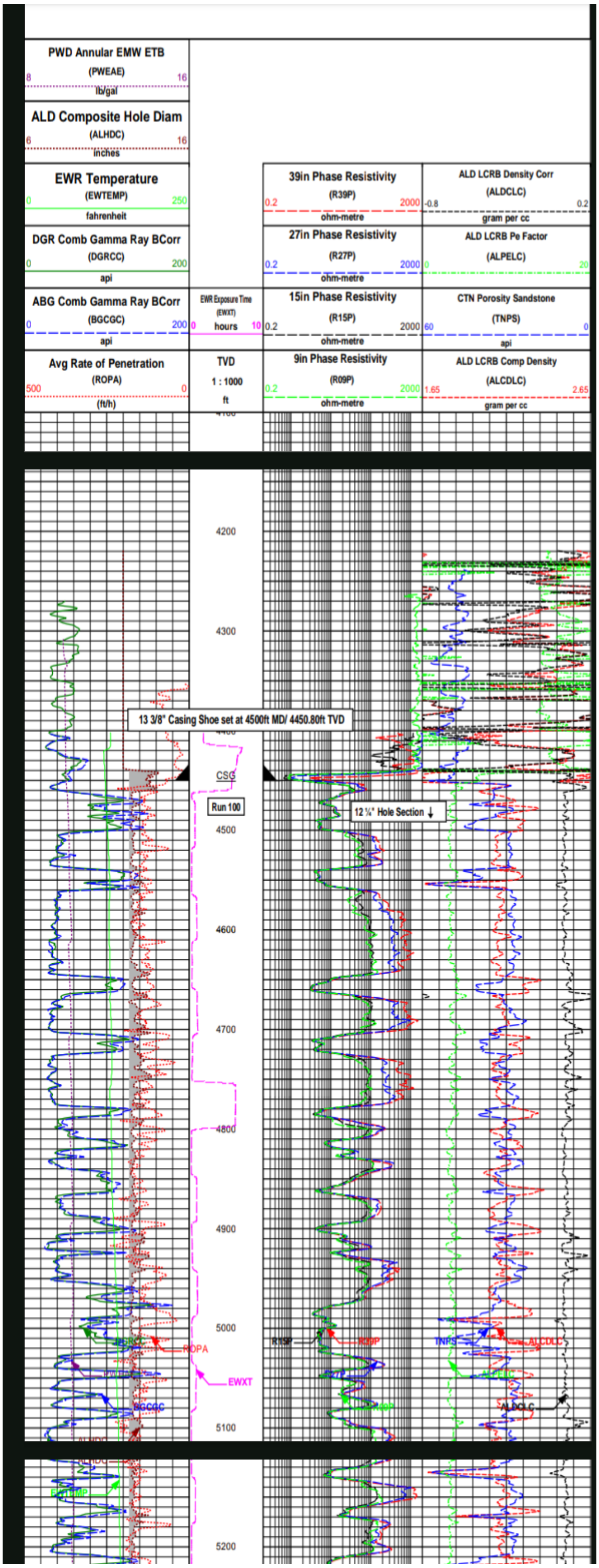
PWD Annular EMW ETB
(PWEAE)
lb/gal
ALD Composite Hole Diam
(ALHDC)
inches
EWR Temperature
(EWTEMP)
fahrenheit
DGR Comb Gamma Ray BCorr
(DGRCC)
api
ABG Comb Gamma Ray BCorr
(BGCGC)
api
Avg Rate of Penetration
(ROPA)
(ft/h)
EWR Exposure Time
(EWXT)
hours
TVD
1 : 1000
ft
39in Phase Resistivity
(R39P)
ohm-metre
27in Phase Resistivity
(R27P)
ohm-metre
15in Phase Resistivity
(R15P)
ohm-metre
9in Phase Resistivity
(R09P)
ohm-metre
ALD LCRB Density Corr
(ALDCLC)
gram per cc
ALD LCRB Pe Factor
(ALPELC)
CTN Porosity Sandstone
(TNPS)
api
ALD LCRB Comp Density
(ALCDLC)
gram per cc
4200
4300
13 3/8" Casing Shoe set at 4500ft MD/ 4450.80ft TVD
CSG
Run 100
12 ¼" Hole Section
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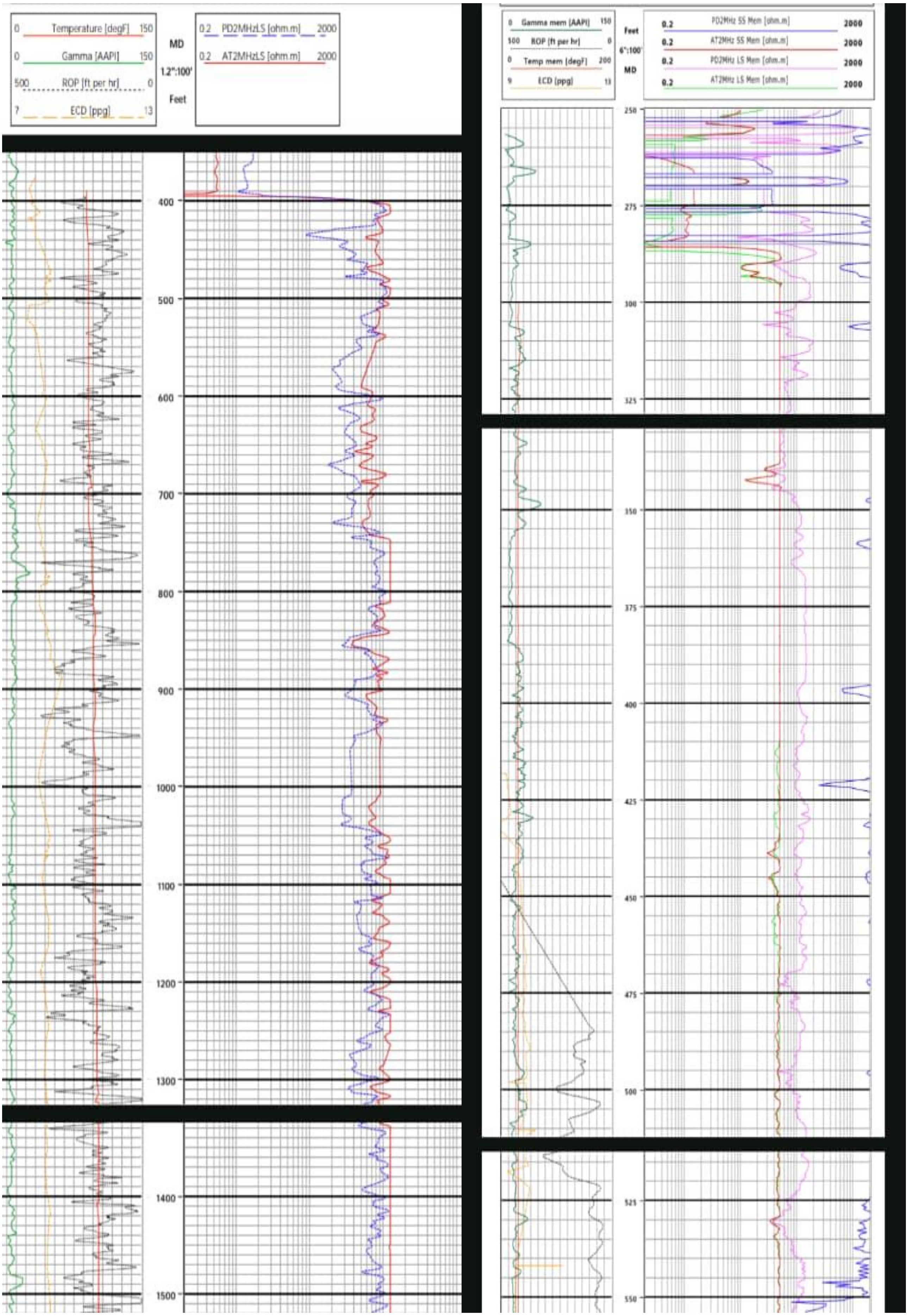
TNPS
ALCDLC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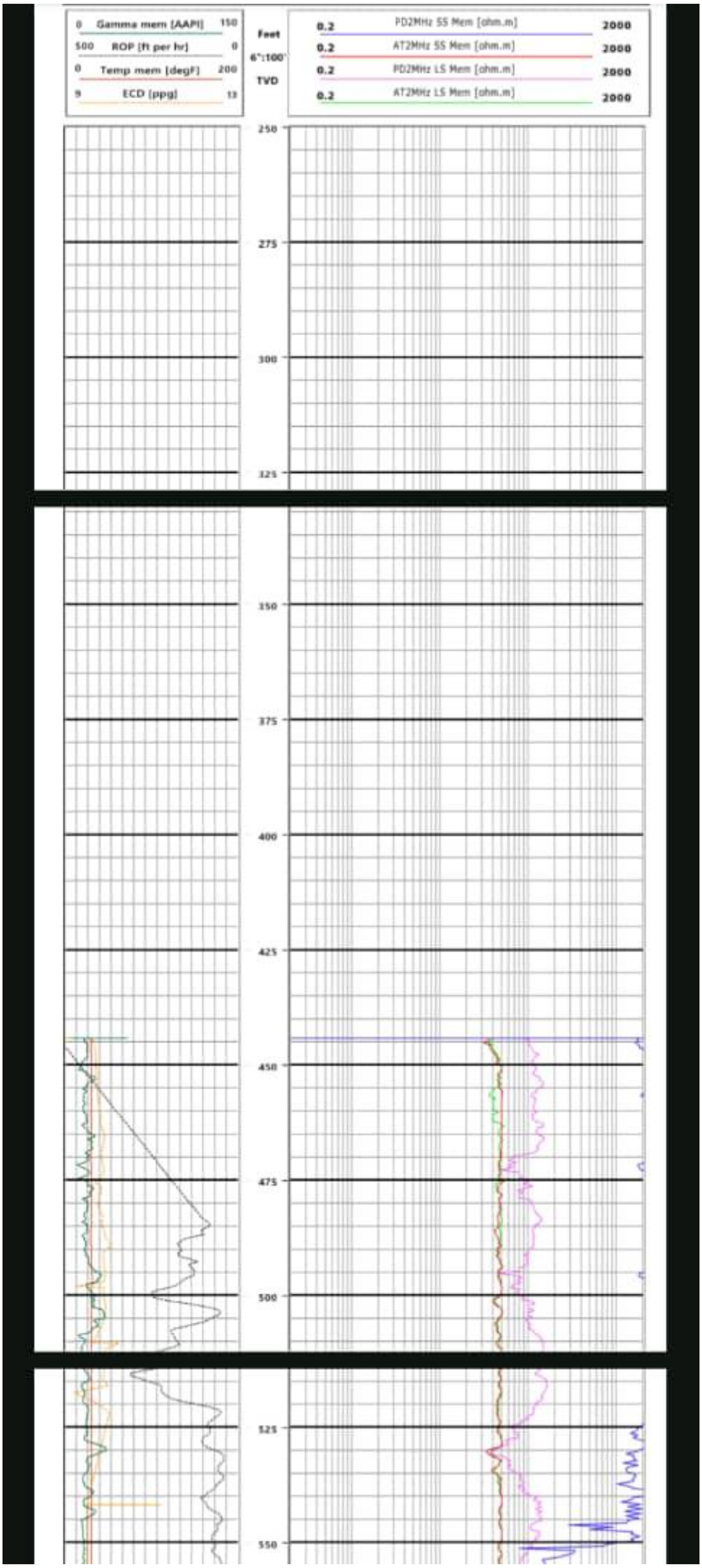
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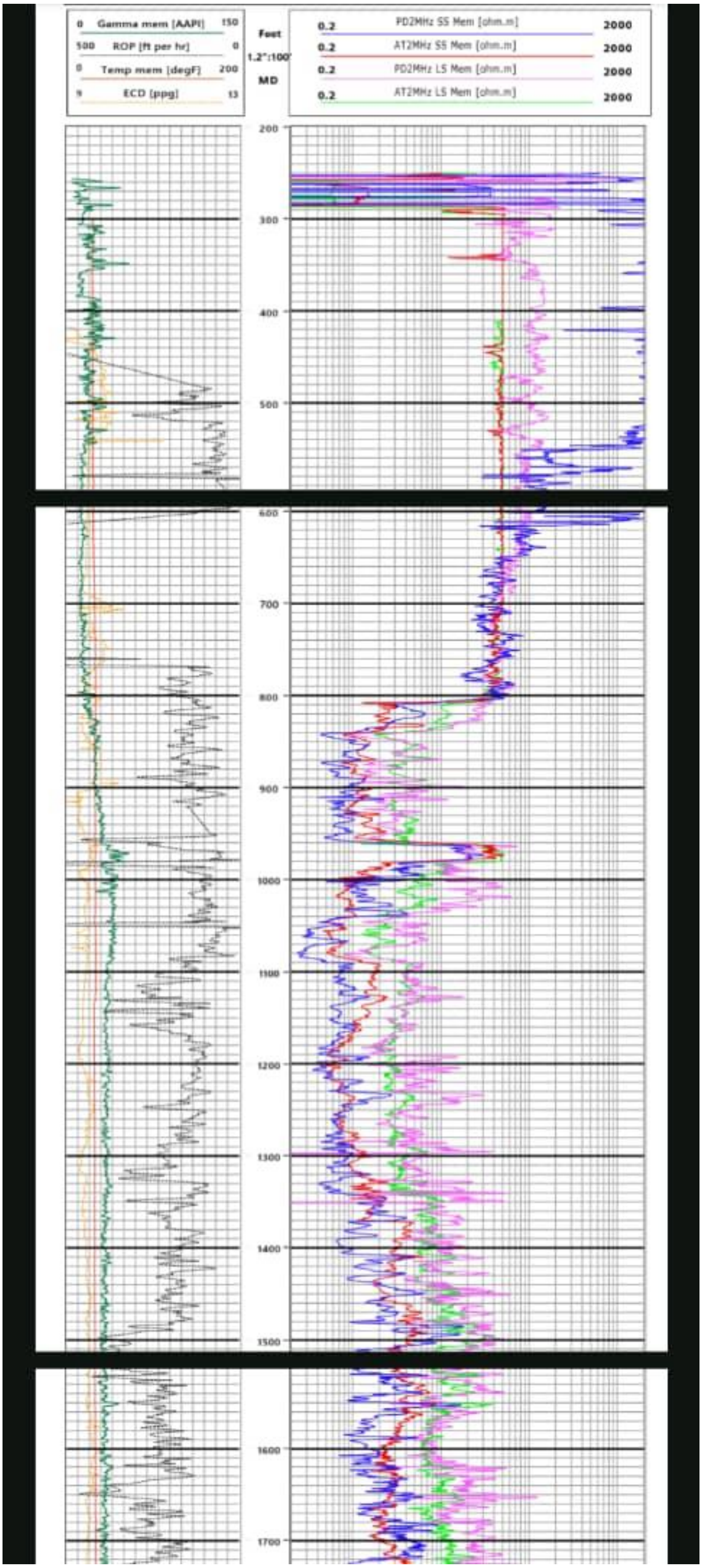
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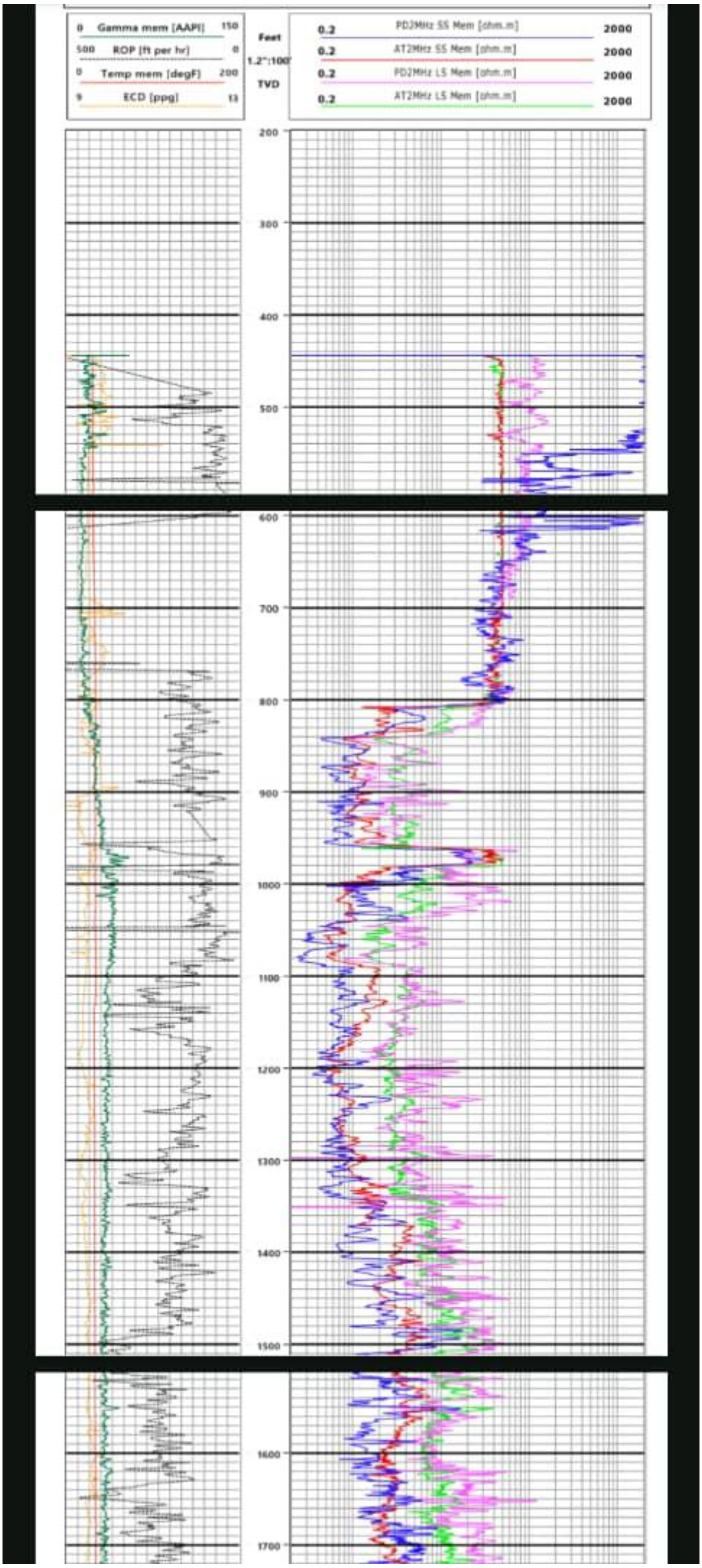
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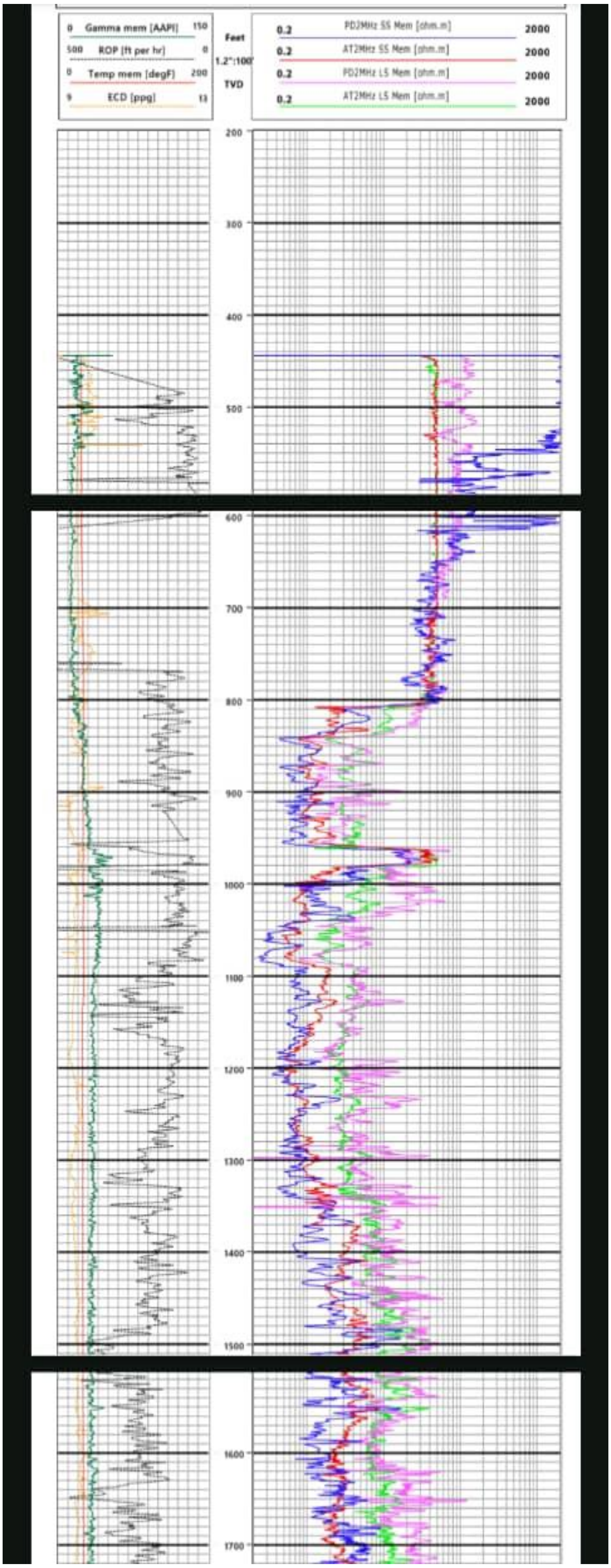

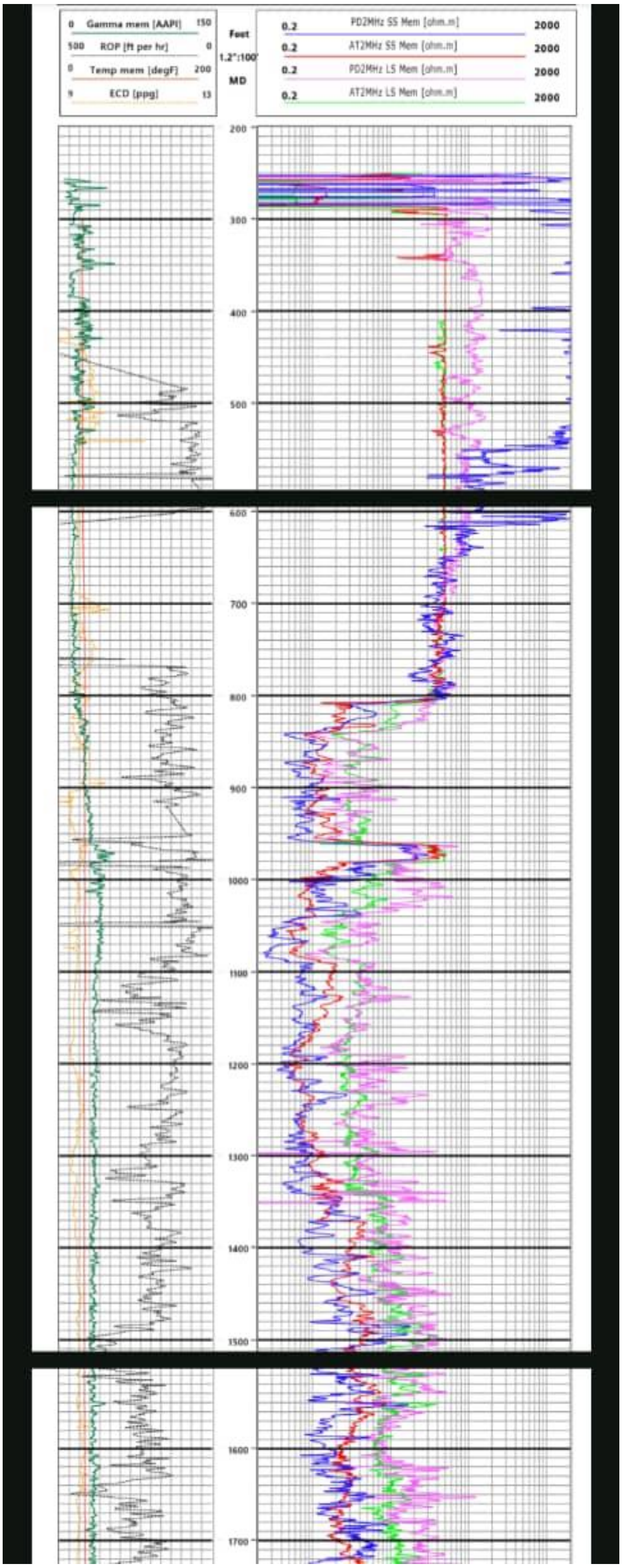
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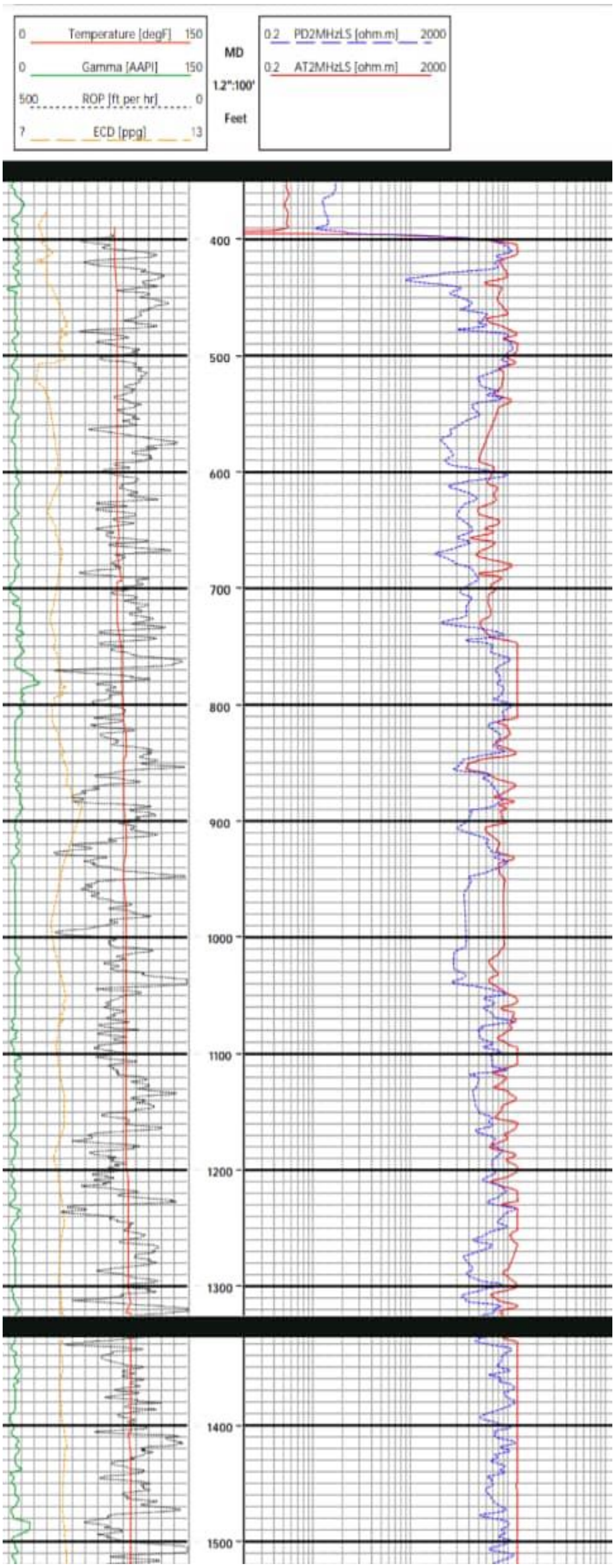

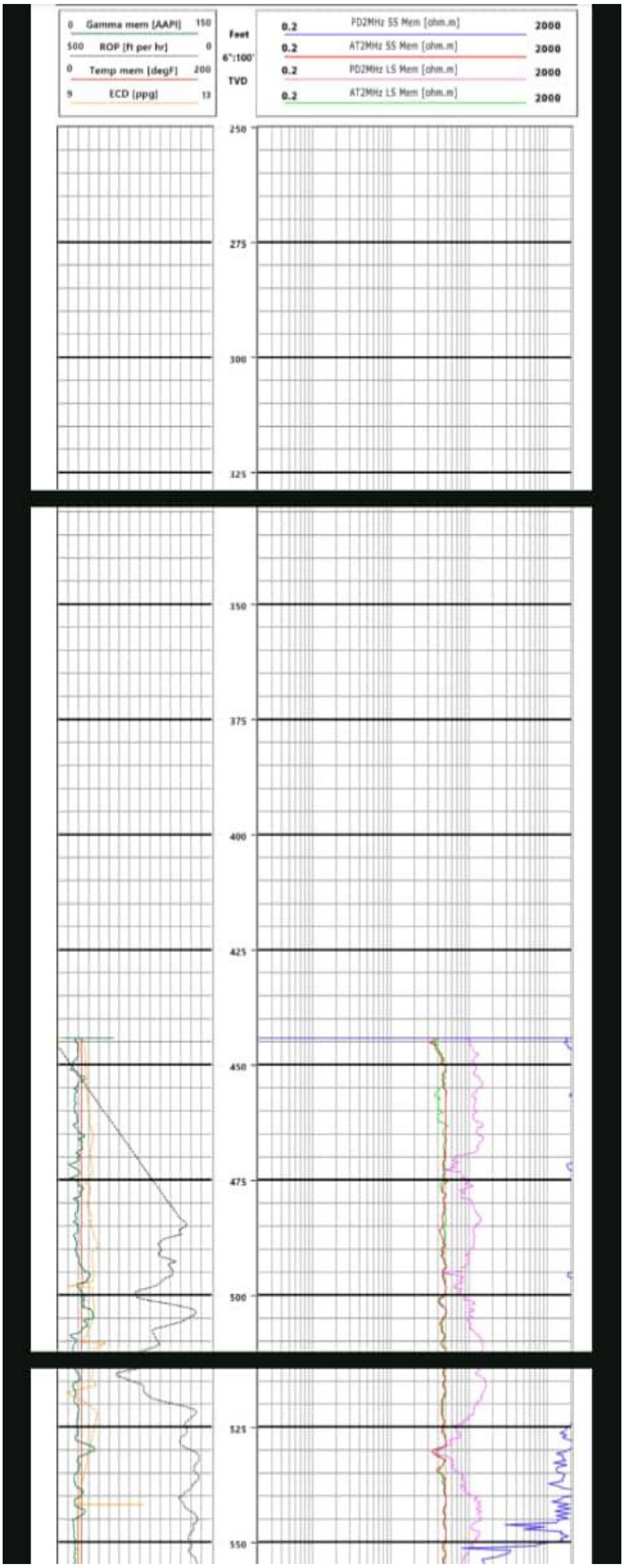
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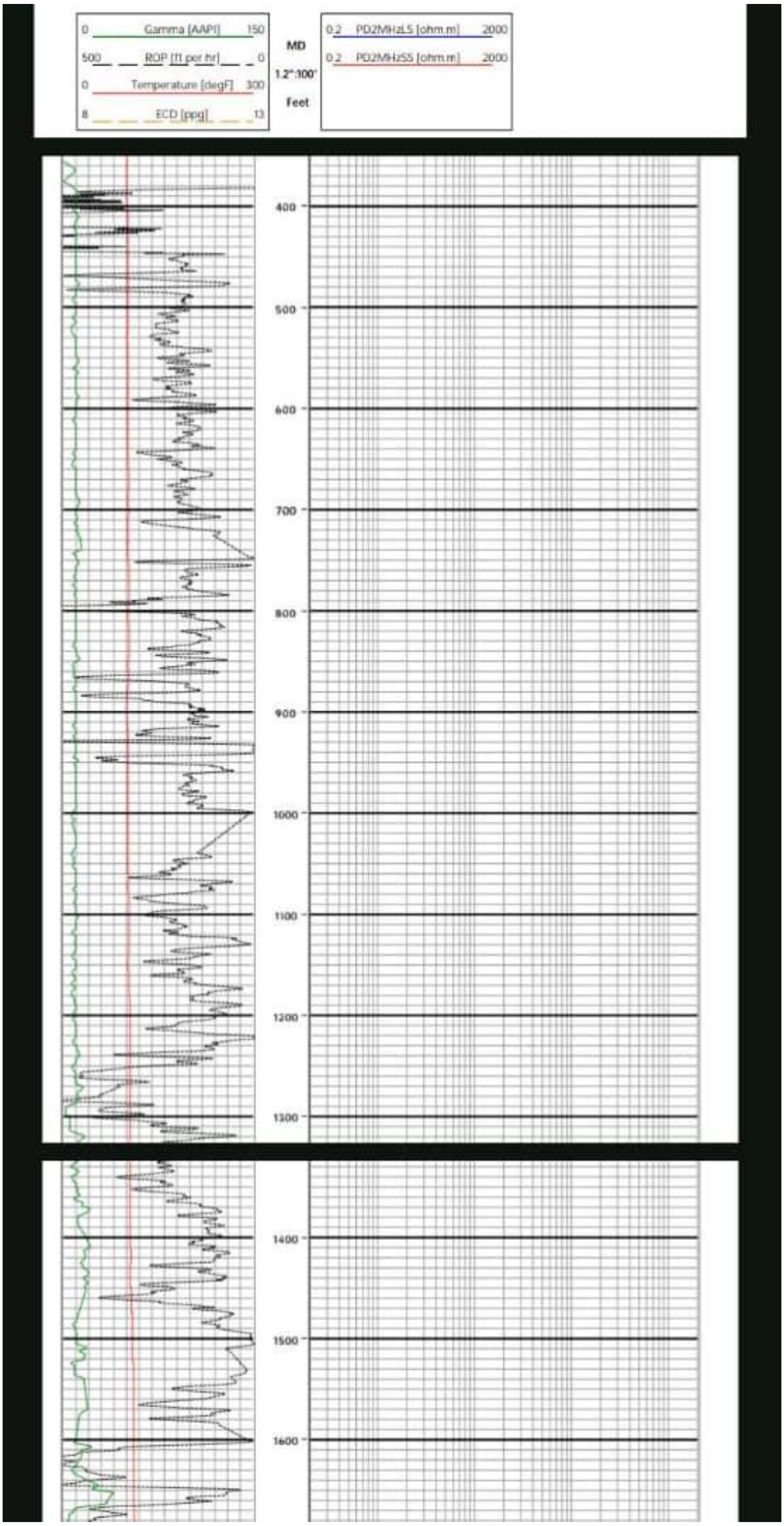
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MEASURED DEPTH(MD)	INCLINATION(INC)	AZIMUTH(AZI)
0.00	0.00	0.00
74.41	0.42	27.22
163.93	0.36	22.51
255.81	0.50	28.01
348.68	1.09	23.78
441.64	1.93	46.05
534.44	1.65	72.11
627.37	3.87	34.83
720.07	4.23	36.19
813.19	3.95	22.30
907.05	3.22	15.76
1002.27	4.18	6.03

IV. CONCLUSION

This thesis conceived and implemented Protocol Based Response Routing (PBRR), an addressing mechanism designed for use in linear networks, in an experimental testbed. We compared the PBRR LEACH and PEGASIS routing protocols. MATLAB Simulink is used to compare the respective performances of the three routing techniques. The simulation findings showed that the recommended routing protocol, PRRP, performs marginally better than LEACH and PEGASIS based on assessment metrics like throughput. The efficacy of PBRR against PEGASIS is 87.9%, and its efficiency against LEACH is 94.4%. The recommended PBRR was 75% effective against LEACH and 65.55% effective against PEGASIS, based on latency data. Plus, as this process is limited to linear or semi-linear networks. In an alternative network architecture, distinct Protocols could operate more efficiently.

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