CHAPTER 7

RESEARCH METHEDOLOGY & ANALYSIS

This chapter is devoted to an empirical study to calculate resource potential for CBM. Here, we apply the well-logging application for our area of study. As per our Area of interest (AOI) we complete the entire Well log analysis for the seven wells. We determine the different reservoir properties like density, area, thickness of the concerned reservoirs as it is a multi-seam environment. Several interesting implications emanate from the analysis and are explored further for determination of resource potential. The results throw up several intriguing issues of relevance of Well log analysis to Drilling Engineers, Geoscientists and Academicians.

7.1 INTRODUCTION

The Indian coal is mainly confined to the Permian Gondwana basins and the tertiary. The Gondwana coal which constitute about 99% of the total coal resources occur along prominent river valleys viz. Damodar, Sone, Koel, Mahanadi, Pench, Kanhan,Wardha, Pranhita, Godavari and Narmada in the states of West Bengal, Jharkhand, Orissa, Andhra Pradesh, Madhya Pradesh and Maharastra.

Bulk of the Gondwana coals are distributed over West Bengal, Jharkhand and Madhya Pradesh with suitable grade and type, having high volatile bituminous to low volatile bituminous ASTM rank (maturity range VRo: 0.8-1.7), as CBM target.

It has been inferred by Biswas (1995), that the range of CBM gas resource of the Gondwana coals in India may be of the order of 1.0 to 2.0 TCM (most likely 1.5 TCM). The maximum density of gas resource is expected in Eastern Coalfields.

Methane emission studies from working mines of India reported most of the degree three gassy mines (> 10 cubic m/ton) , are confined in the four Damodar Valley coal fields, viz. Raniganj, Jharia, Bokaro and North Karanpura in Bihar and West Bengal. In these areas, the thickest bituminous coals are extensively developed in the Barakar measurers and in Raniganj measures of Lower and Upper Permian age, respectively. The Barakar coal seams are superior to Raniganj coal seams as coalbed methane

targets. Based on thickness and burial depth, rank and quality of coal has the greatest coalbed methane potential in India.

7.2 BRIEF DESCRIPTION OF AREA OF INTEREST(AOI)

In the present study, the area of interest has taken as part of Jharia coalfield which is considered as a premier CBM resource basin of India.

The present AOI has been chosen from the perspective of famous and promising Jharia coal field. The Geological map of the area of interest is shown below.

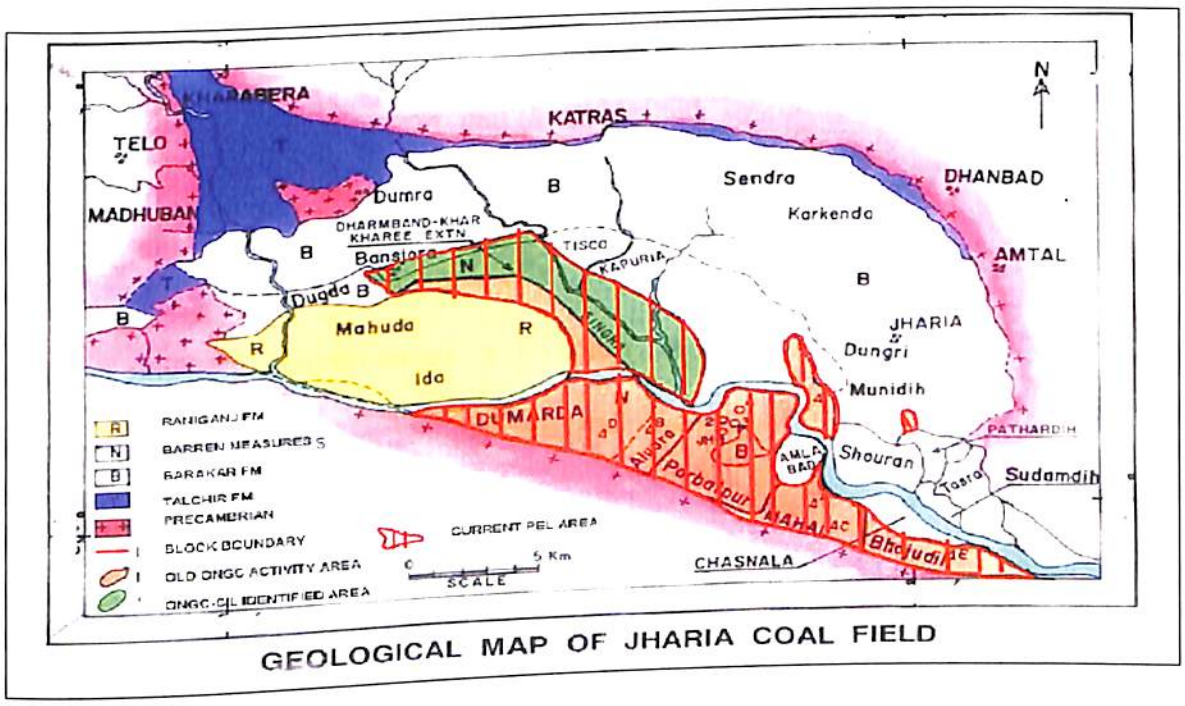


FIGURE 7.1: MAP OF JHARIA BASIN

The Jharia Coalfield is situated about 260km northwest of Kolkata in the heart of the Damodar Valley, mainly along the north of the river. The coalfield lies within the district of Dhanbad, and the town of Dhanbad is in the north-eastern margin. The coalfield is named after the chief mining centre Jharia which is situated in the eastern part of the field. The field is roughly sickle shaped, its longer axis running northwest-

southeast. The coal basin extends for about 38km in an east-west direction and a maximum of 18km in north-south direction and covers an area of about 456 sq km. The basement metamorphic rock are overlain by the Talchir Formation followed by the Barakar Formation, which is major coal bearing horizon. Above it comes the Barren Measures followed by the Raniganj formation which is also coal bearing.

7.3 RESEARCH METHODOLOGY

Major aim of the research will be the application of logging devices to coal evaluator for potential coal bed methane production.

Valuable geologic information can be obtained by utilizing wire-line conveyed measurements. Generally referred to as "logs" derive their name from the general term meaning a "record" of a series of events. It often refers to a measurement of one or more physical properties as a function of well depth. From these physical properties ,the rock properties are inferred. Geophysical Well logs are important information source for CBM prospect evaluation. It defines coal layers without any ambiguity and offers a permanent record which facilitates spatial correlation. It is helpful to work out the geological history of the area. Well logs are one of the most important reliable data source in various map preparation needed for reservoir estimation , forecast production potential, and plan for optimal recovery of methane gas.

Our area of interest(shown in the Figure 7.2) fallen in the range of Barakar Formation around the specific area of Jharia Coalfield.

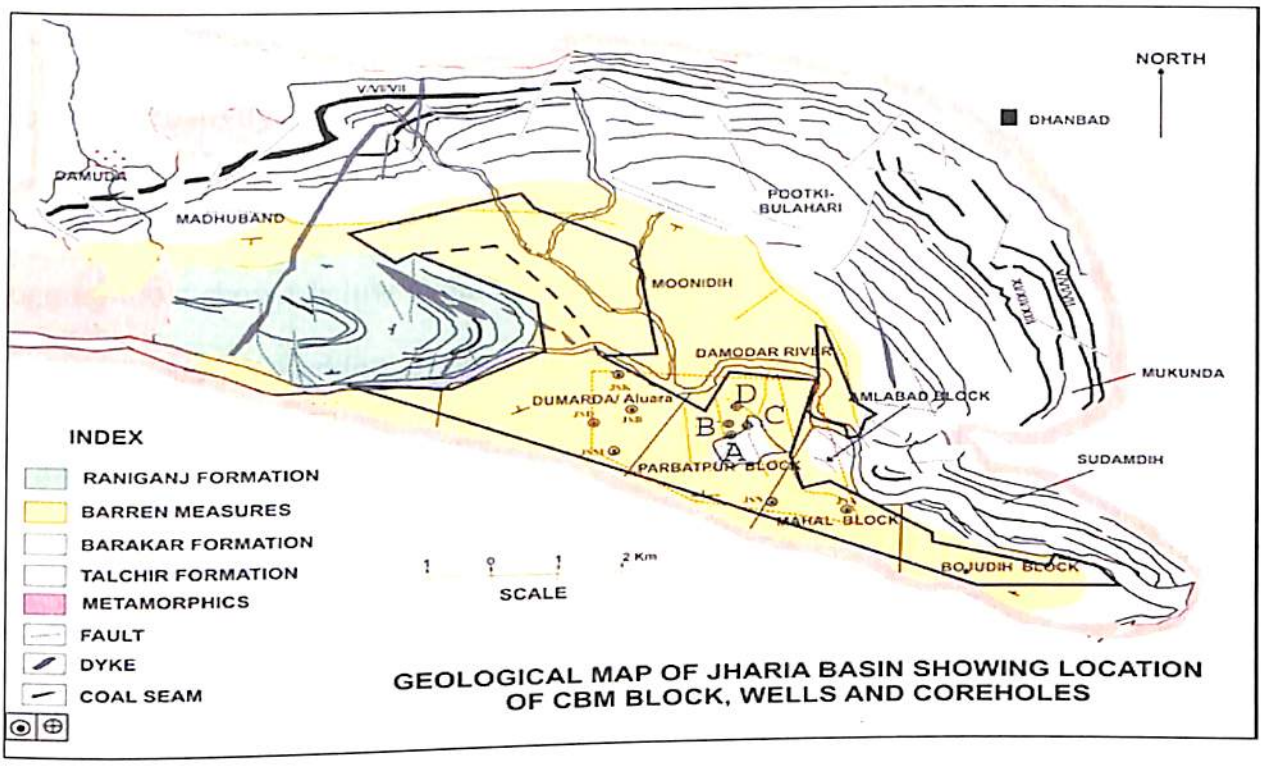


FIGURE 7.2: MAP OF AREA OF INTEREST FOR STUDY

Data has been collected from seven wells(4 wells and 3core hole) from one of our very prestigious National Oil Company i,e Oil & Natural Gas Corporation Ltd.(ONGC). As per the legal confidentiality contract with ONGC, identity of Study area has not been mentioned and described as AOI. Only the analysis part of the data can be included in the thesis. The maximum depth of the well data is approximately 1200+m.

First we have to synthesize the data and input all our raw data to a Landmark Software called **GeoGraphix .** It has different other part like (prizm, Geo-Atlas etc).

With the help of "Prizm" as part of Geographix, log analysis has done for each individual well which has full representation as part of thesis document. While doing

the log analysis for each well, we have the log like Gamma ray, SP(Self Potential), Caliper, Resistivity, Neutron porosity and Density logs.

To discuss the basic principles & their result in our present research, the list of logging tools shown below should be more helpful for CBM exploitation. A list of logging categories used in the present research are as follows:

- Resistivity logging
- Gamma ray logging
- Neutron porosity logging
- Density logging
- Caliper logging
- Self Potential(SP)

This log analysis done is the fundamental piece around which all other parts of this CBM workflow are built. The analysis of the data has been done (well log analysis)- Coal layers have been identified without any ambiguity by correlation of the other log value. Apart from well log data, some key information have been gathered from the laboratory reports of tests run on the key, representative reservoir coal samples. These tests should include canister gas desorption tests, and proximate analysis. We've pick the coal layer. Then correlation of the major Coal seams has been done and Correlation of Coal and Sand beds also been completed.

The final part of the analysis is to calculate the GIP(Gas-in place) for evaluate the resource potential of these coal seams. The objective of this part of research is to demonstrate practical application of fairly high-level CBM scientific theory in practical real world problem setting. The final goal is to generate a lay-out of standard workflow for reservoir characterization and resource estimation.

Ideally, the best estimates of the gas resource available in a CBM play would be obtained by taking closely spaced samples of the coal interval and precisely measuring the gas content of each. Like conventional reservoirs, to be of economic interest, CBM reservoirs are required to have sufficient resources. Coals are dual porosity reservoirs; gas is stored in the coal matrix micro-pore system and in the coal fracture network as free gas. Thus, calculation of CBM reserves involves estimating the volume of the free gas in the fracture network and the volume of the adsorbed gas in the matrix system. The data required for estimating CBM gas reserves are obtained from a variety of sources. This includes well logs and direct measurement of gas content from core samples.

The entire methodology has been summarized below:

1) Chose first Area of Interest(AOI) and Geological detailing has been done.
2) Collection of data(Well logging, proximate Analysis, lab test data) has been completed.
3) Synthesis of the above mentioned data as per our research objective.
4) Loading of these data in Geographix and creation of our Project Model.

5) Analysis of these data as already specified above.

6) Extraction of the key reservoir properties from the analysis of these logs.

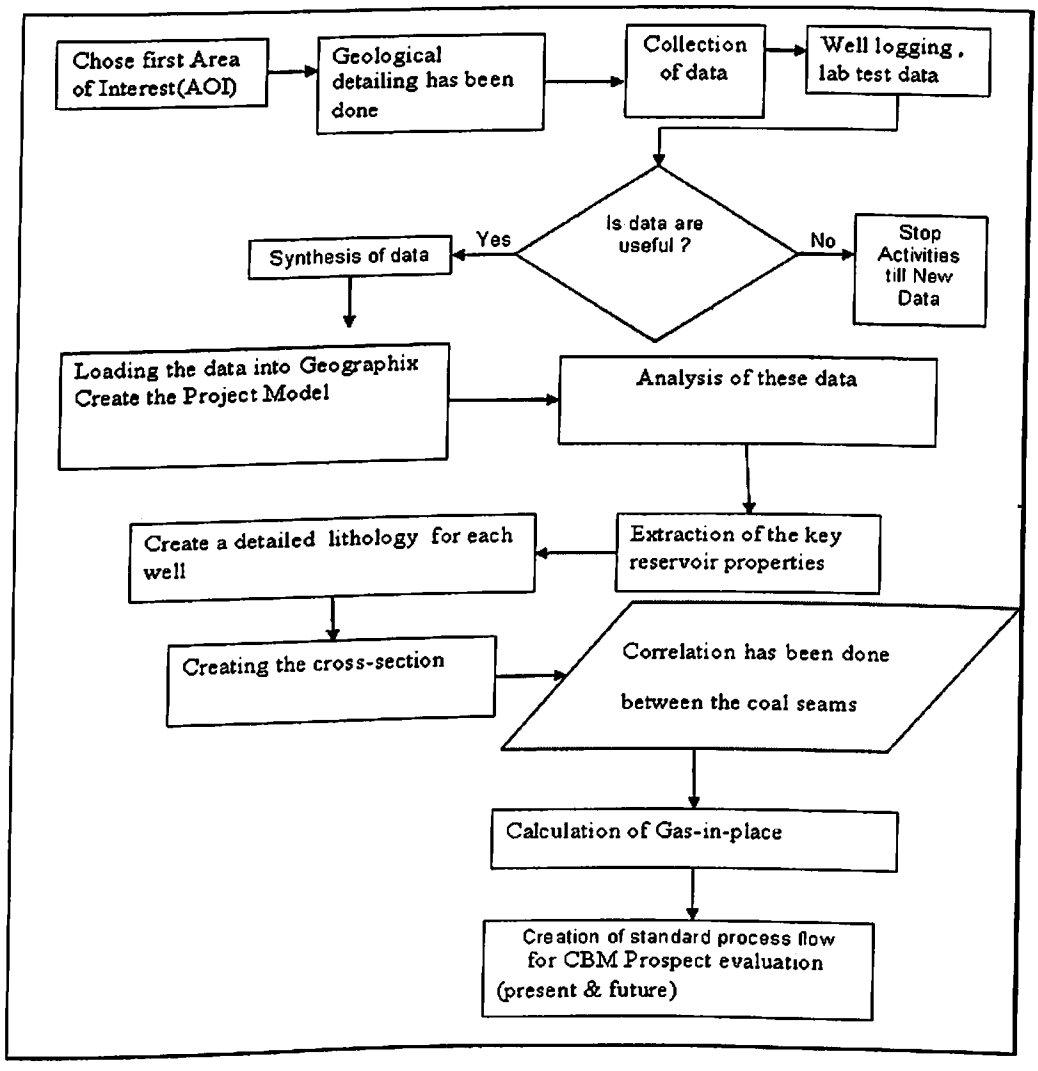
7) Create a detailed lithology for each well with the help of Geographix.

8) Correlation has been done after creating the cross-section between coal seams and with sand layers also.

9) Calculation of Gas-in-place after analyzing well logs, lab data and evaluation has been done.

10) Creation of a standard work-flow model for CBM Prospect evaluation.

The process flow for the methodology has described below:



7.4 ANALYSIS AND FINDINGS FROM WELL-LOGS

From the Well logs, we first identify the coal layers as our AOI has a multi-seam environment. The application of Resistivity logging in this research is for formation correlation. Formation resistivity is a property of the rock that indicates how resistive the rock appears to the flow of electrical current. The traditional use of the resistivity logs are the correlation of formations in one well to the same formation in another well. In pure coals the resistivity logs usually reads high which is also shown by our result.

The principal use of gamma ray logging is to distinguish reservoir rocks from shale. Gamma ray logging is the measurement of the natural gamma radiation emitted by the rock formation. Generally , the higher the radiation the less likely that the rock is a potential reservoir rock. Shale which typically have very less permeability and cannot produce the fluids they contain, will have higher radiation than rocks that may develop effective pore space. That is because the clay minerals that are a large portion of shale composition contain naturally radioactive elements such as potassium and thorium. Referring to the gamma ray log, it usually reads low in pure coals i,e reflected in the log analysis in the present research. If certain impurities such as clay minerals are inter-bedded with the coal, the gamma ray log will likely identify this.

The application of density logging is the measurement of traditional formation porosity. In coal evaluation, it is very useful for calculating coal properties such as proximate analysis.(fixed carbon, moisture, volatiles and ash). This log has enormous

value in coal bed methane model generation ,it delineates coal characteristics related to coal bed methane production.

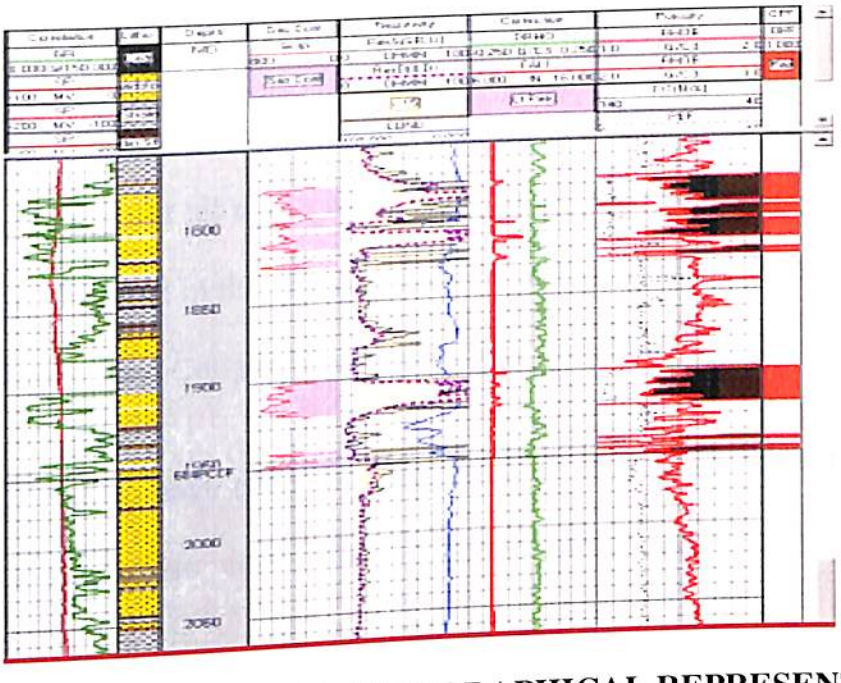


FIGURE 7.3: DIFFERENT WELL LOG GRAPHICAL REPRESENTATION

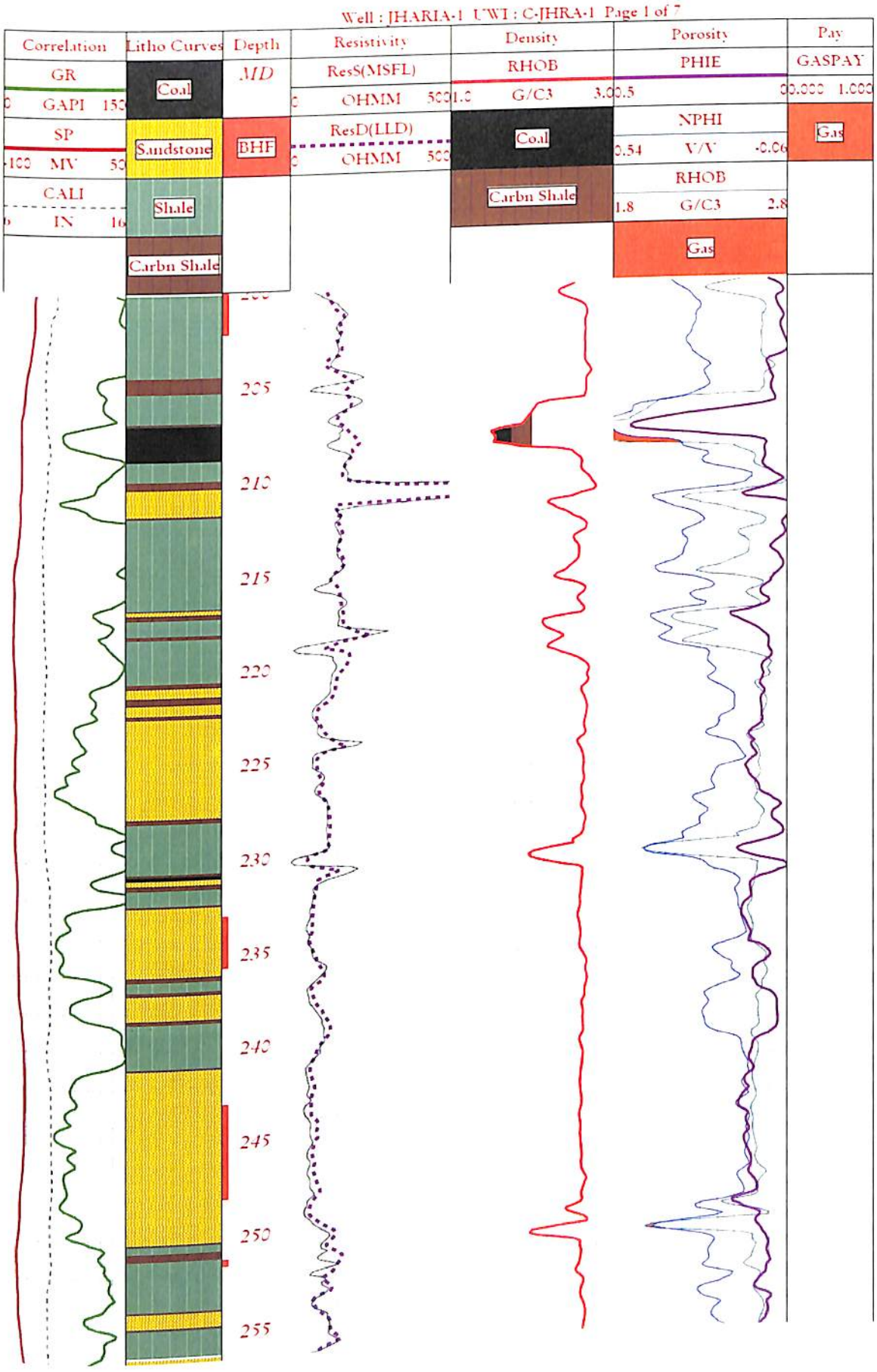
Well logs are important information source for identifying coal layers and infer their characteristics. It provides several important parameters such as net pay thickness, and host of inputs for map preparation necessary for reserve estimation and forecasts spatial extent, gas potential and recovery factor. Well logs have been found useful in all stages of CBM project management –venture exploration, evaluation and exploitation.

The modus operandi for studies on CBM exploitation is first do the log analysis of four major ONGC wells which has shown below (log interpretation) and also included the rest three remaining core wells well log analysis also.

As per the confidentiality contract with data provider company, the nomenclature of the four major wells have been given as A(JHRA-1), B(JHRA-2), C(JHRA-3) & D(JHRA-4) respectively. The data from three core wells(Core-well-1,Core well-2 & Core-well-3 respectively) have also been collected.

The Well-log analysis for all seven wells have been completed, lithology of the each well created and depicted in the analysis curve. The logs used for the analysis are SP, Resistivity, Gamma Ray, Caliper, Neutron porosity and Density.

All seven well location have been shown in the Map of Area of interest(AOI) of the study. Well log analysis curve for all seven wells have shown below and simultaneously lithology curve also been shown.


Well : JHARIA-1 UWI : C-JHRA-1 Page 1 of 7
Correlation
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GAPI
SP
MV
CALI
IN
Litho Curves
Coal
Sandstone
Shale
Carbn Shale
Depth
MD
BHF
Resistivity
ResS(MSFL)
OHMM
ResD(LLD)
OHMM
Density
RHOB
G/C3
Coal
Carbn Shale
Porosity
PHIE
NPHI
V/V
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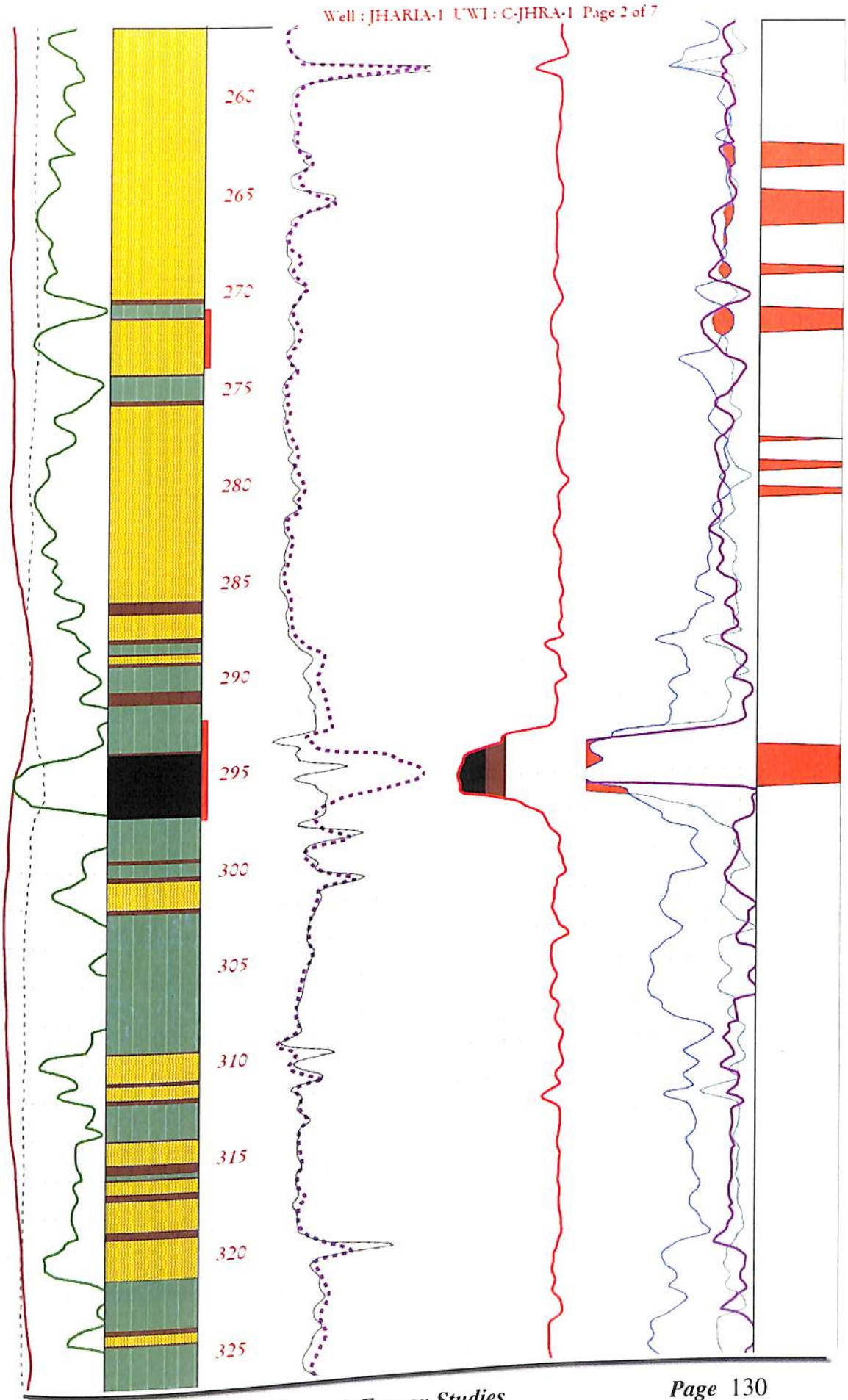
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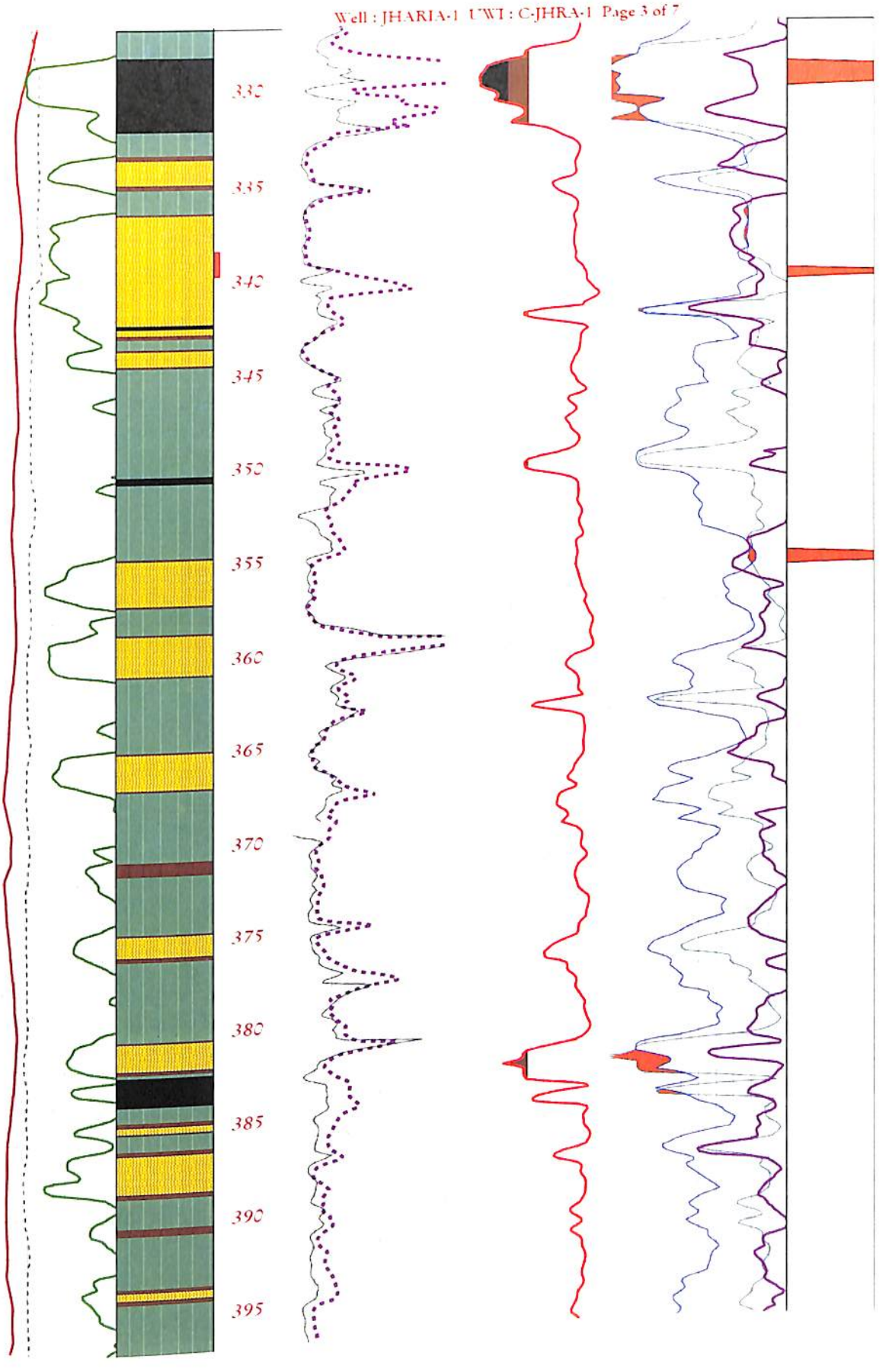
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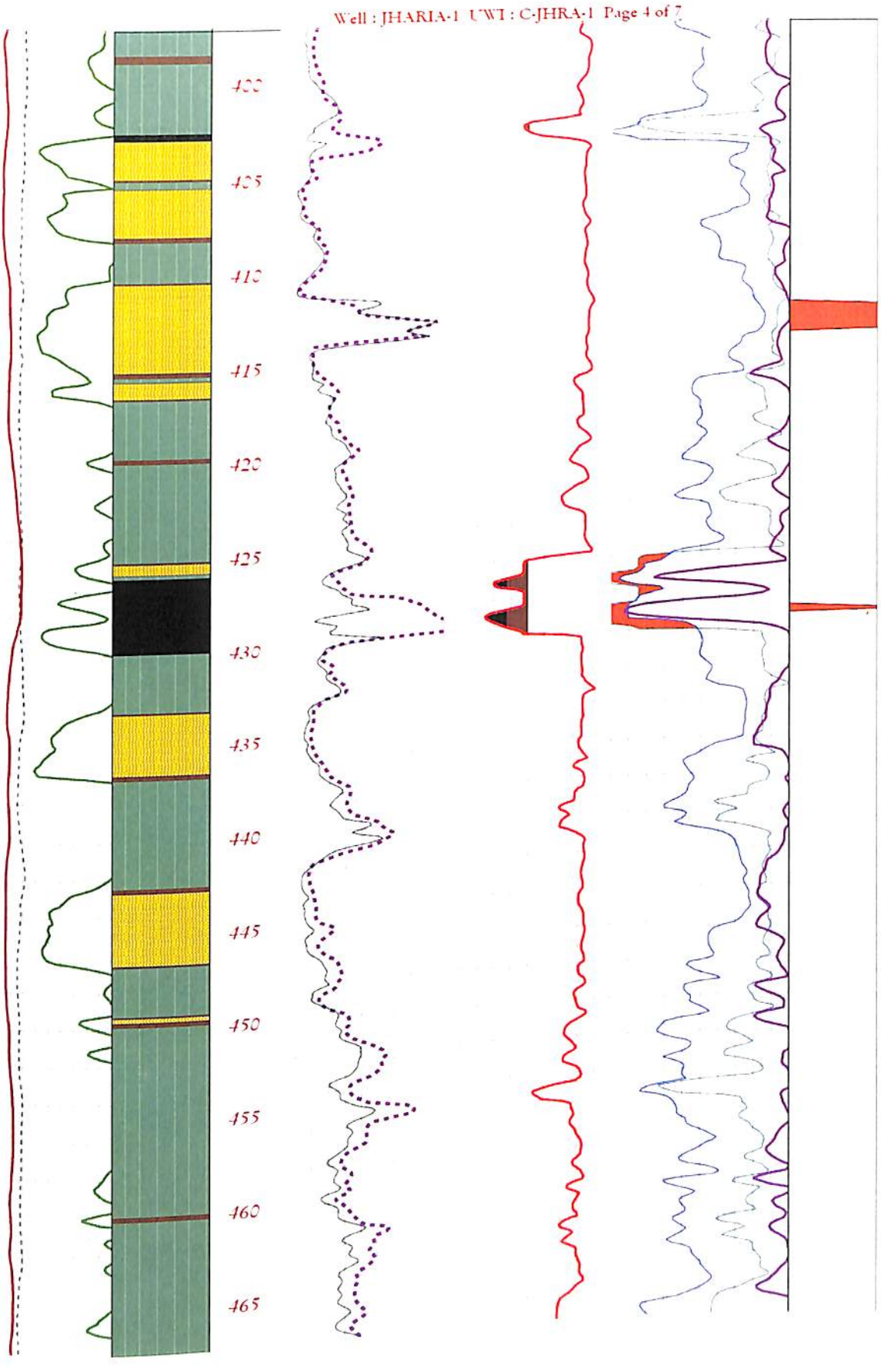
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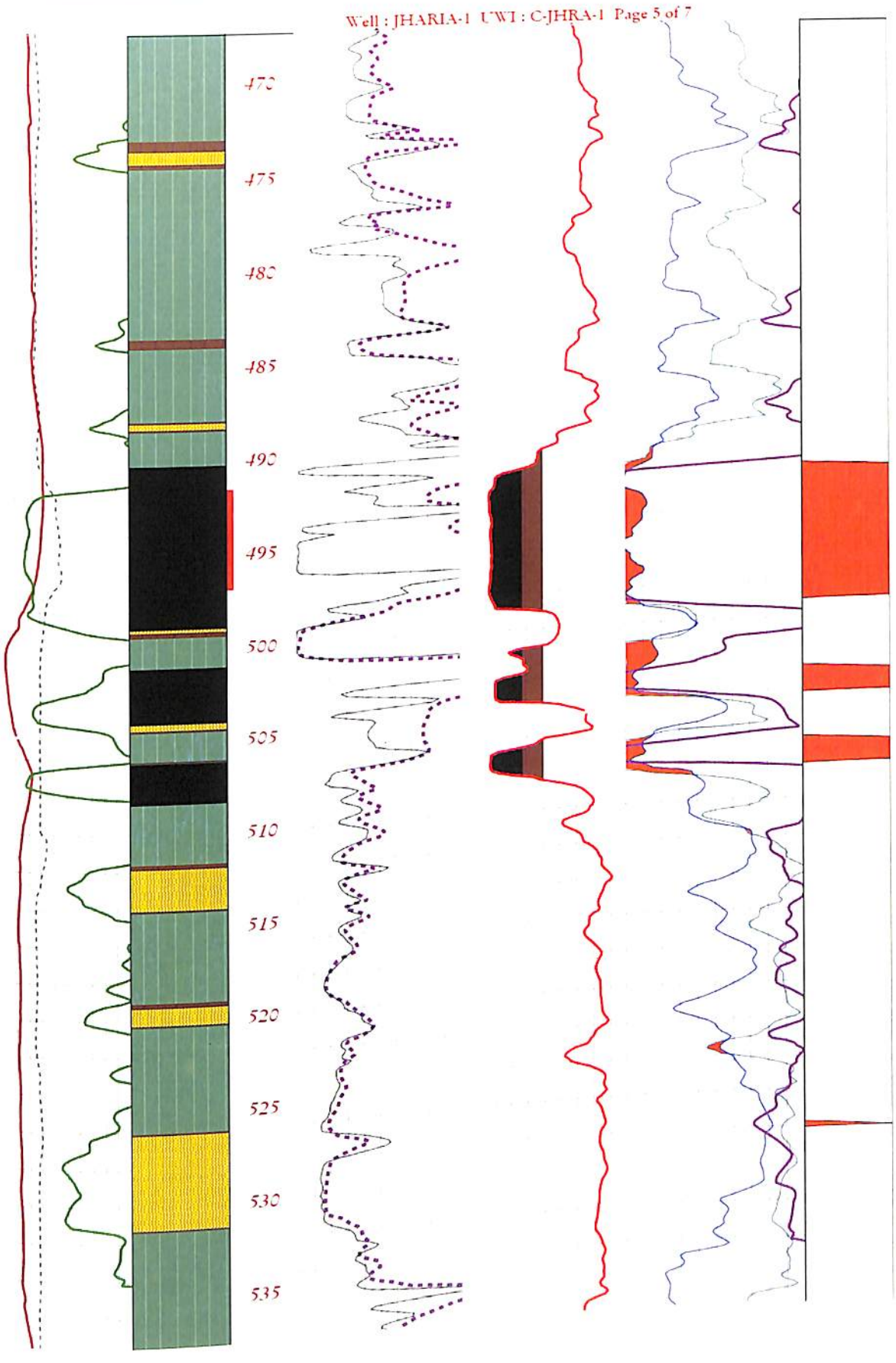
Well : JHARIA-1 UWI : C-JHRA-1 Page 5 of 7
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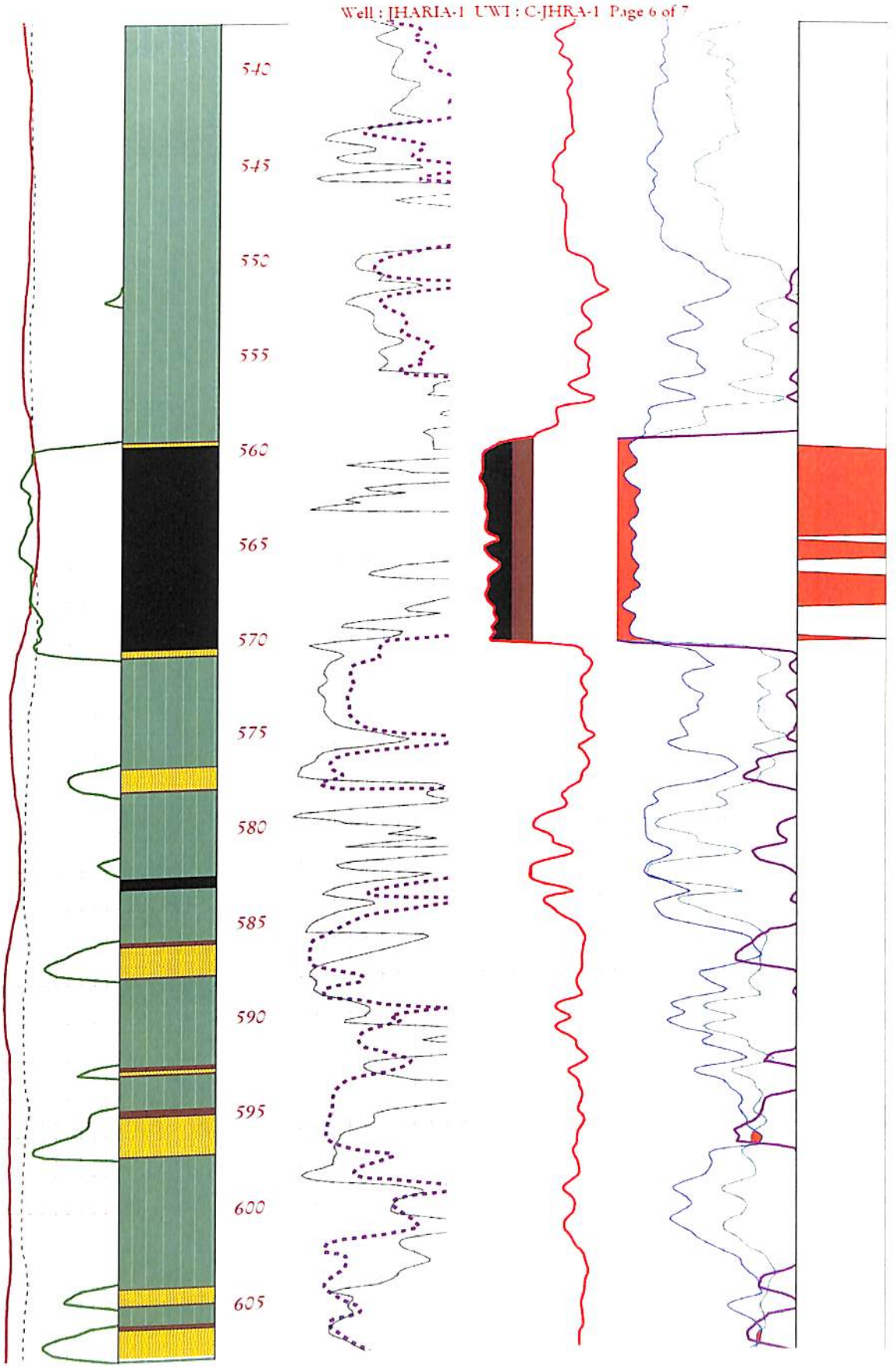
Well : JHARIA-1 UWI : C-JHRA-1 Page 6 of 7
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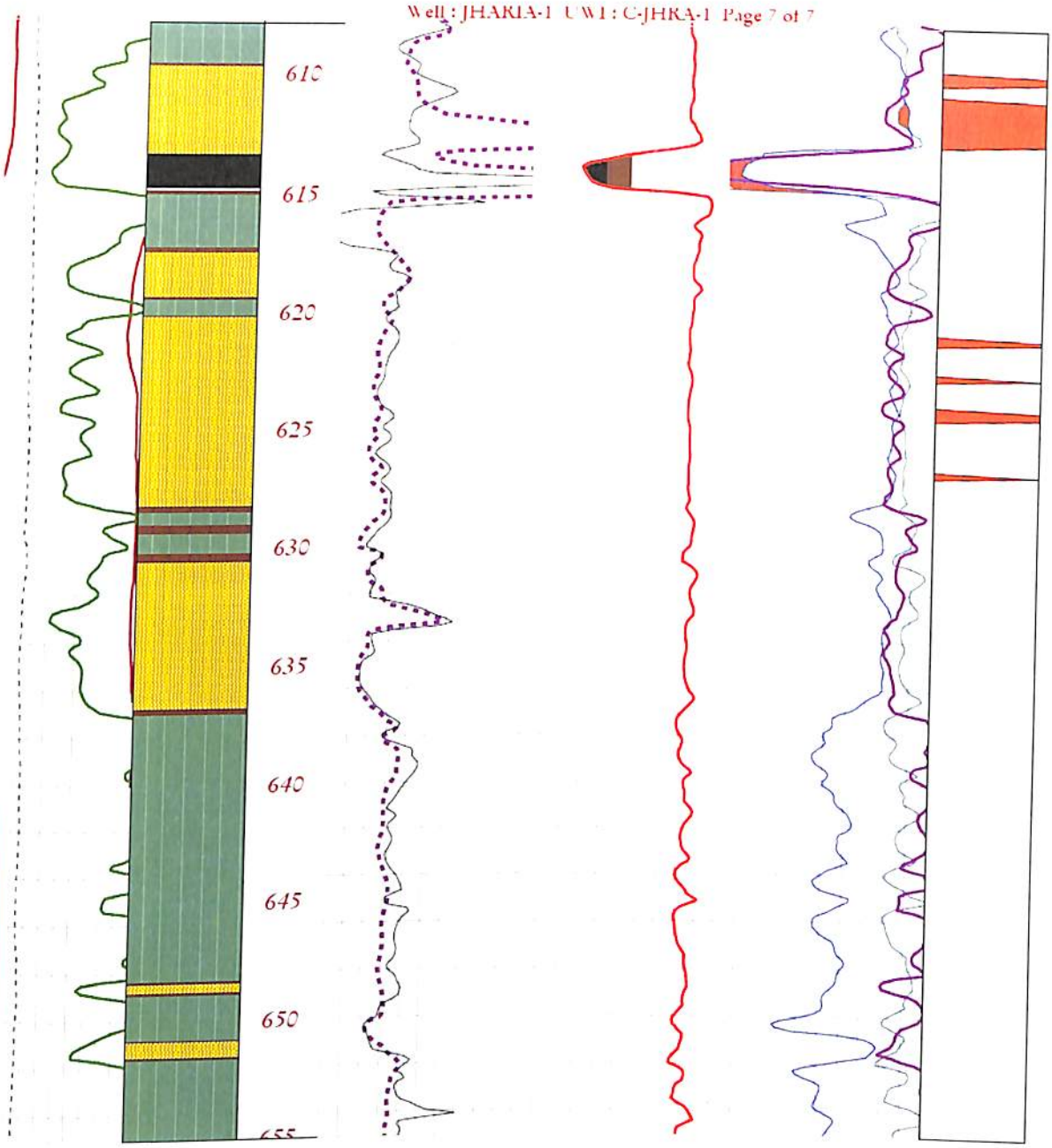
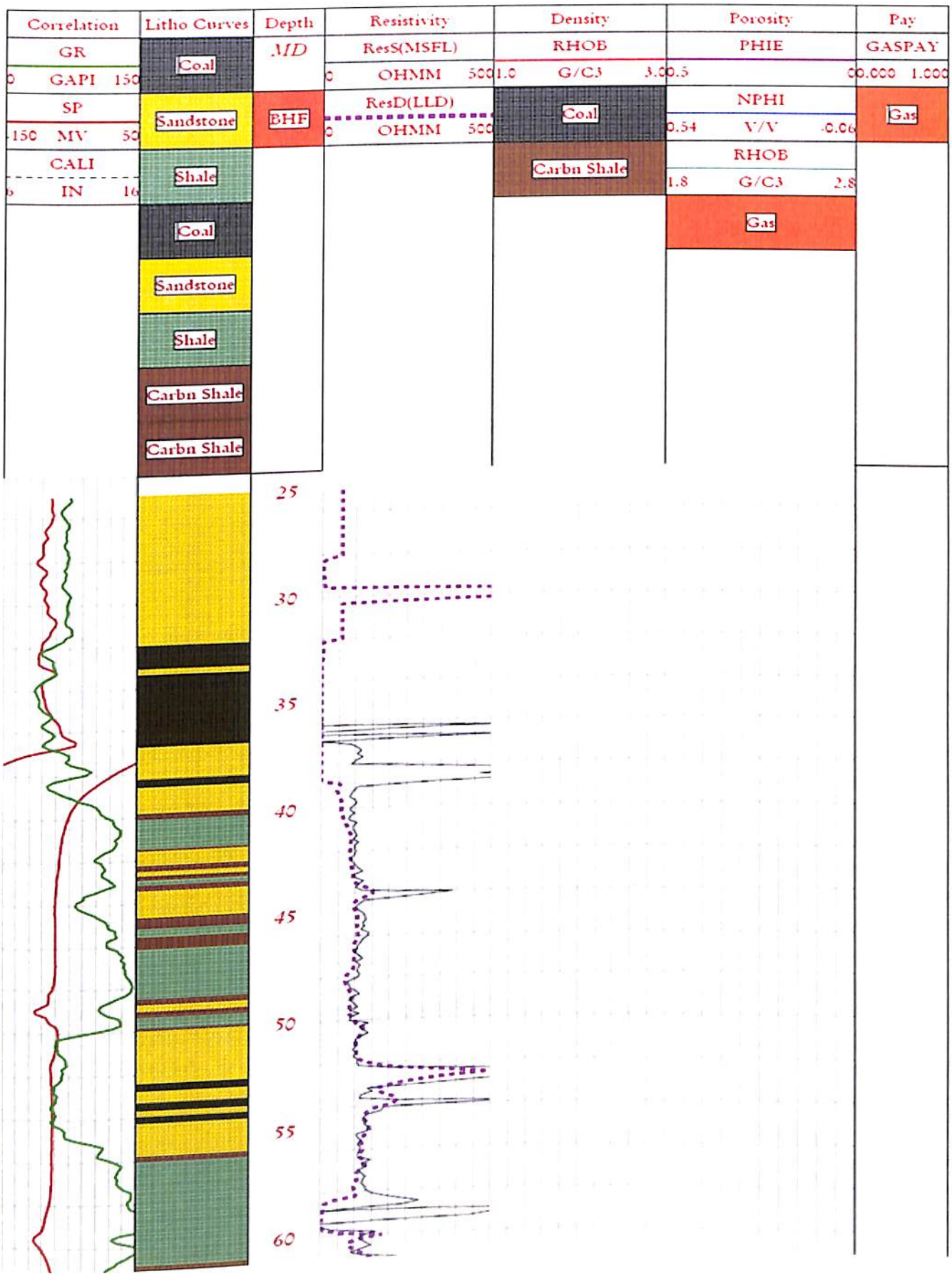


FIGURE:7.4 WELL LOG ANALYSIS OF THE FIRST WELL A(JHRA-1)

The Well log analysis for the well 2(B) which is depicted as JHRA-2 is given below.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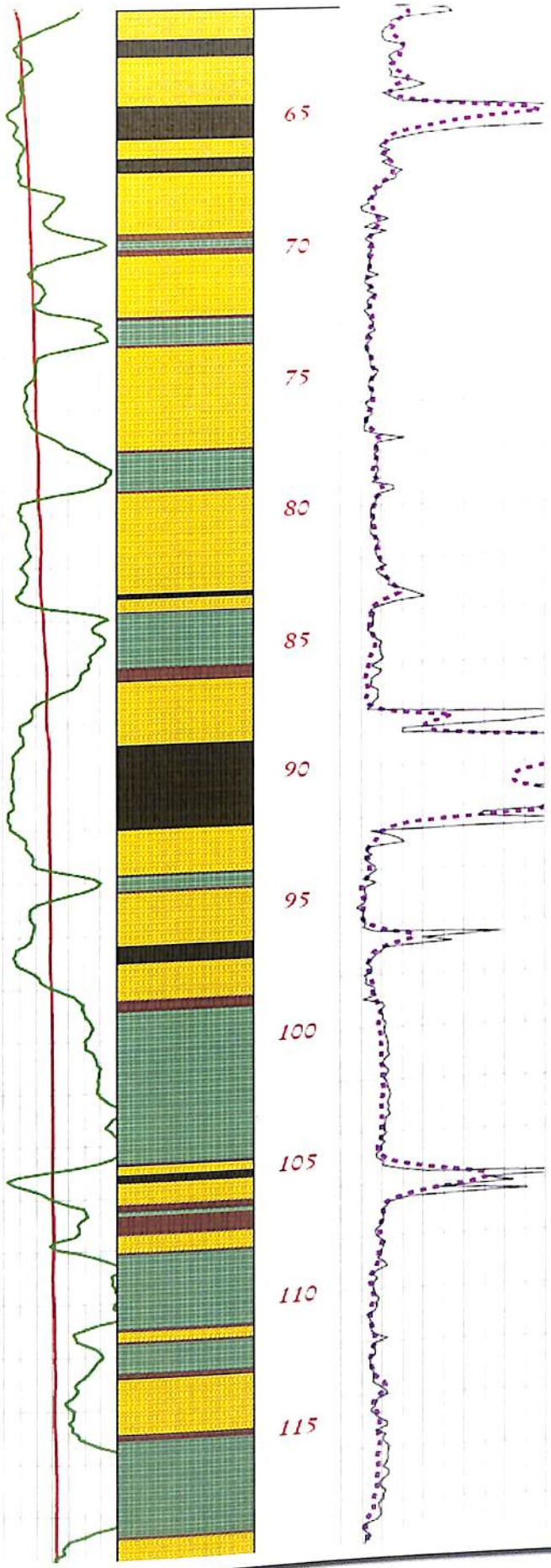
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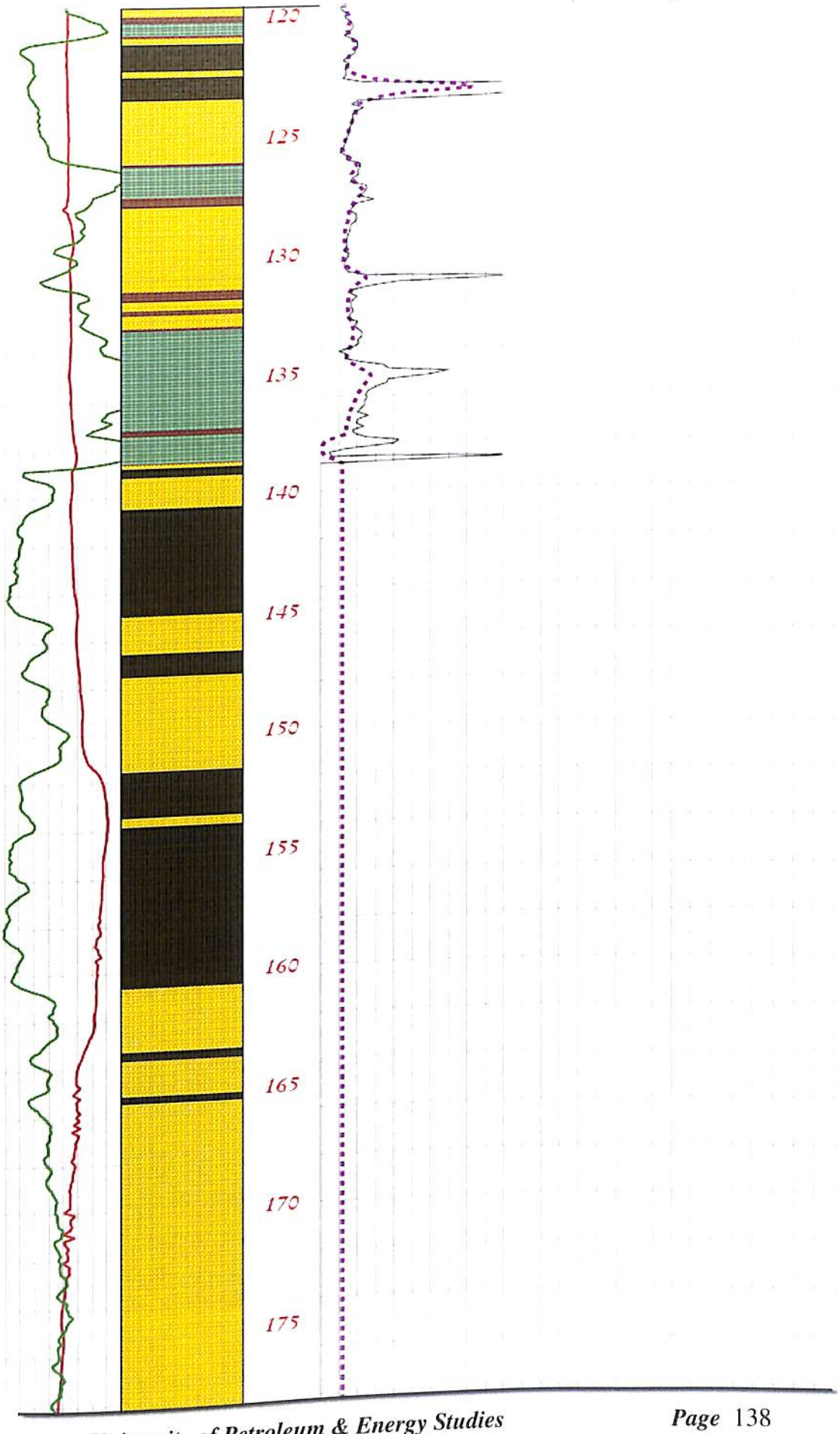
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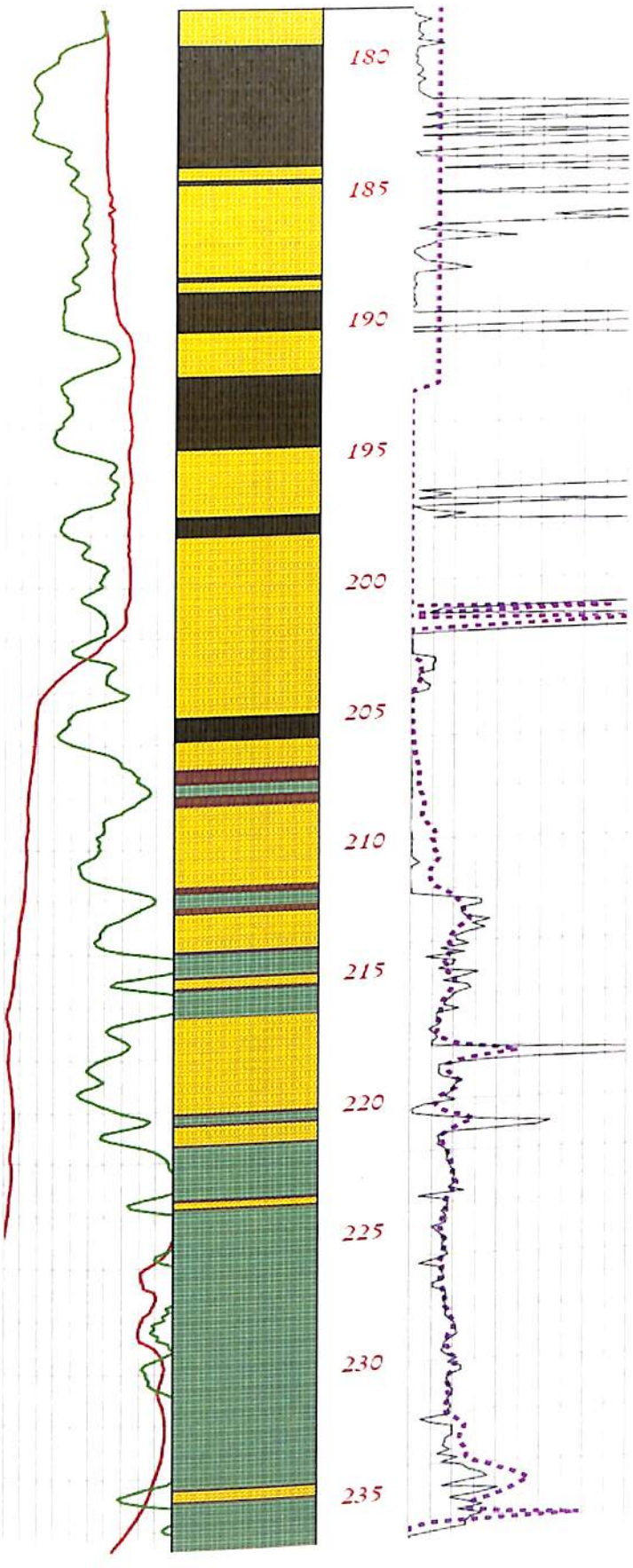
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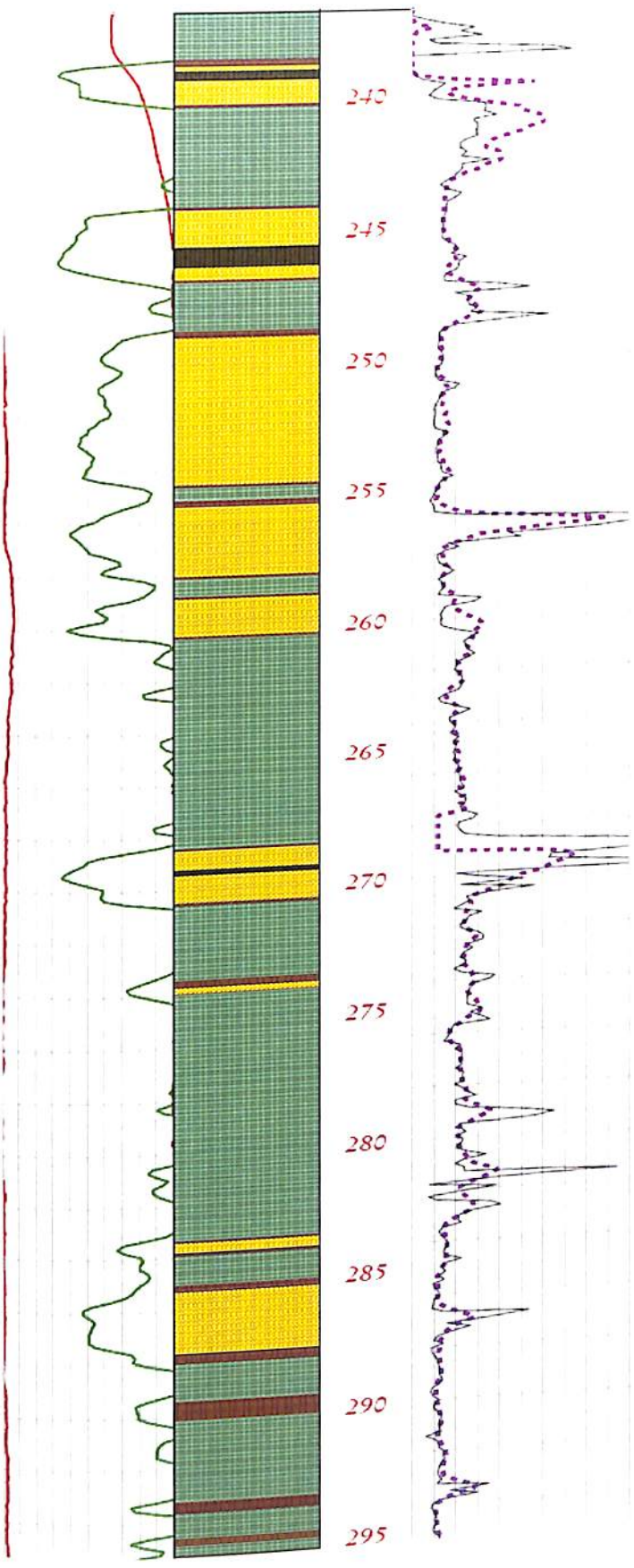
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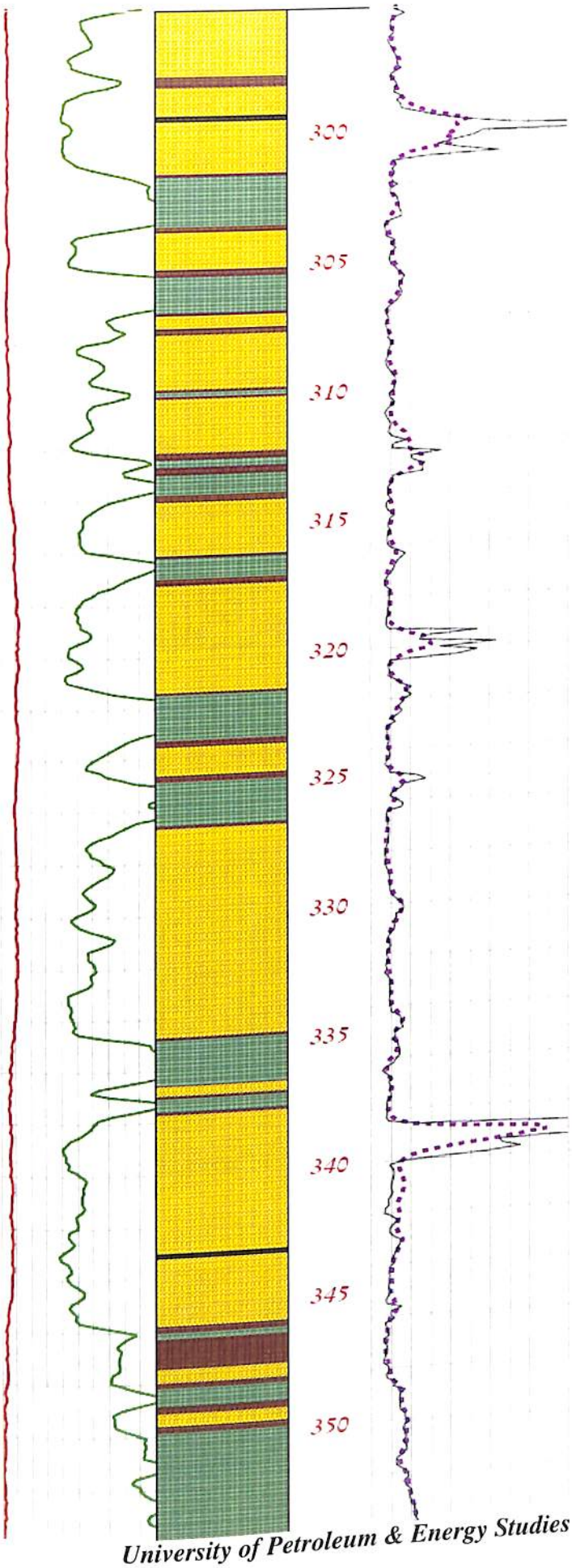
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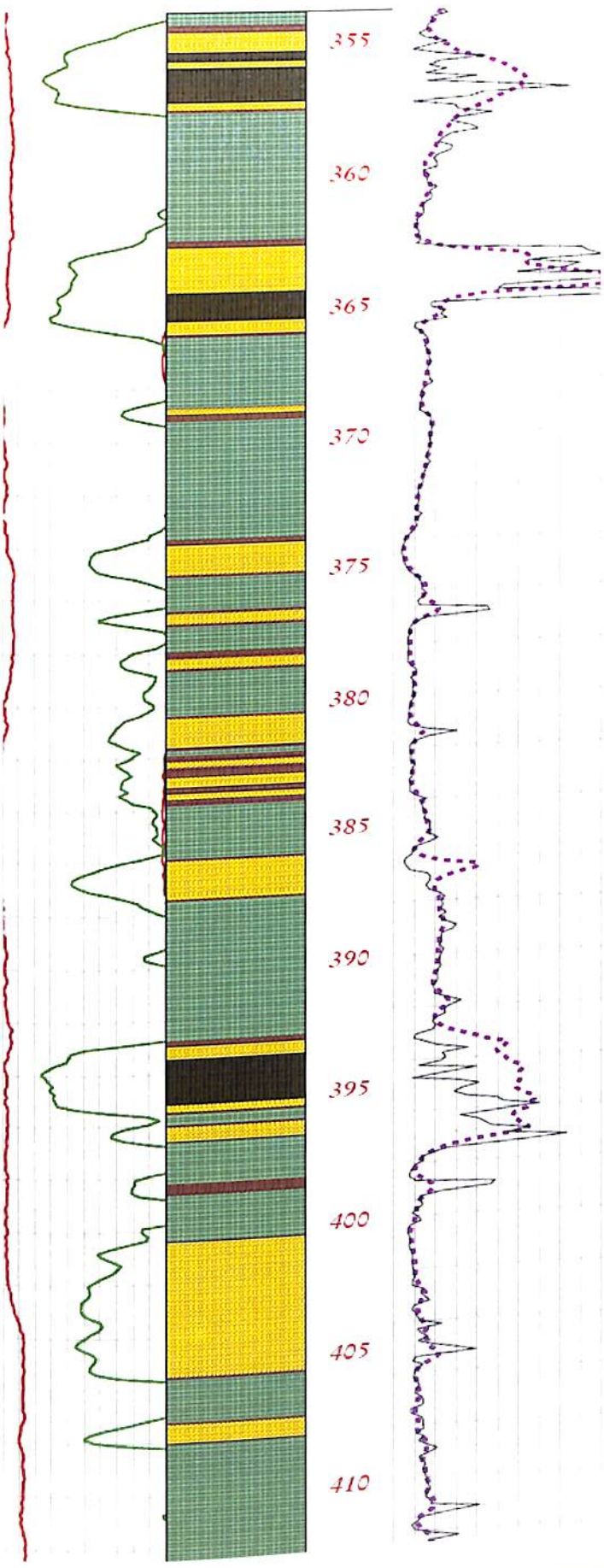
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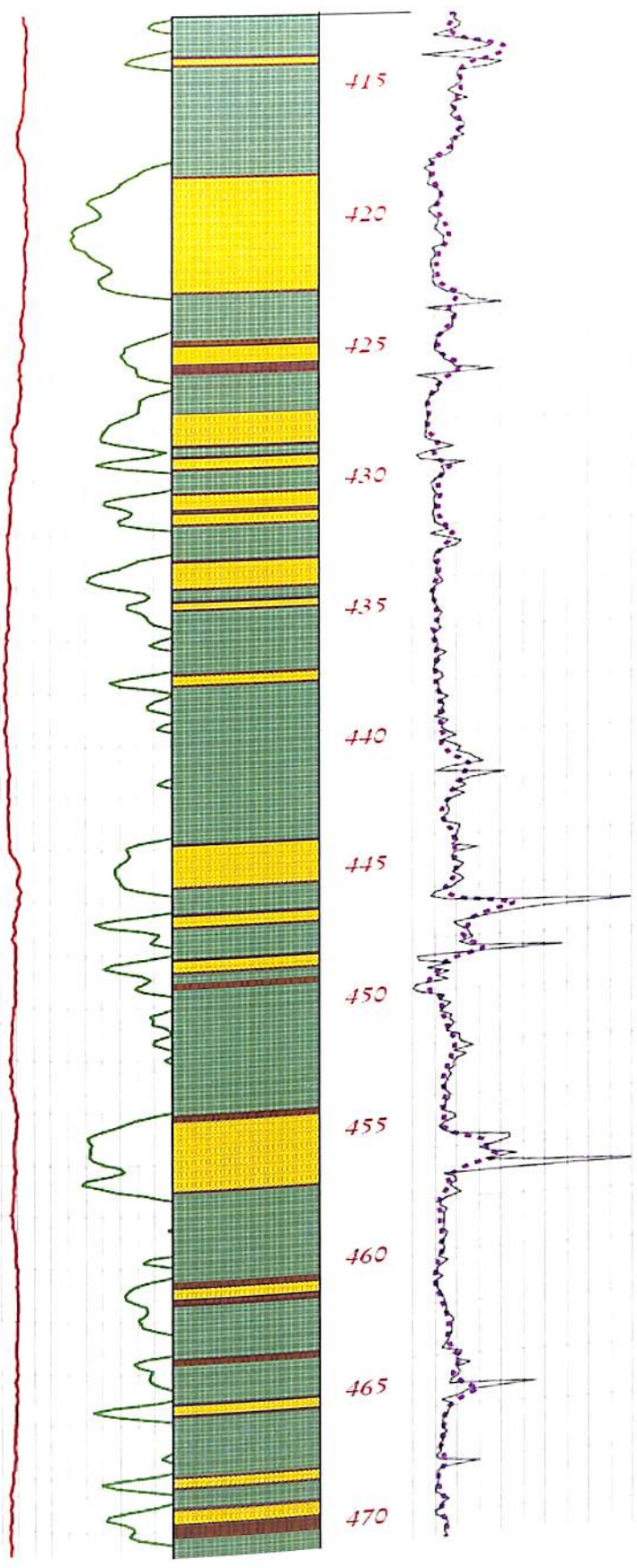
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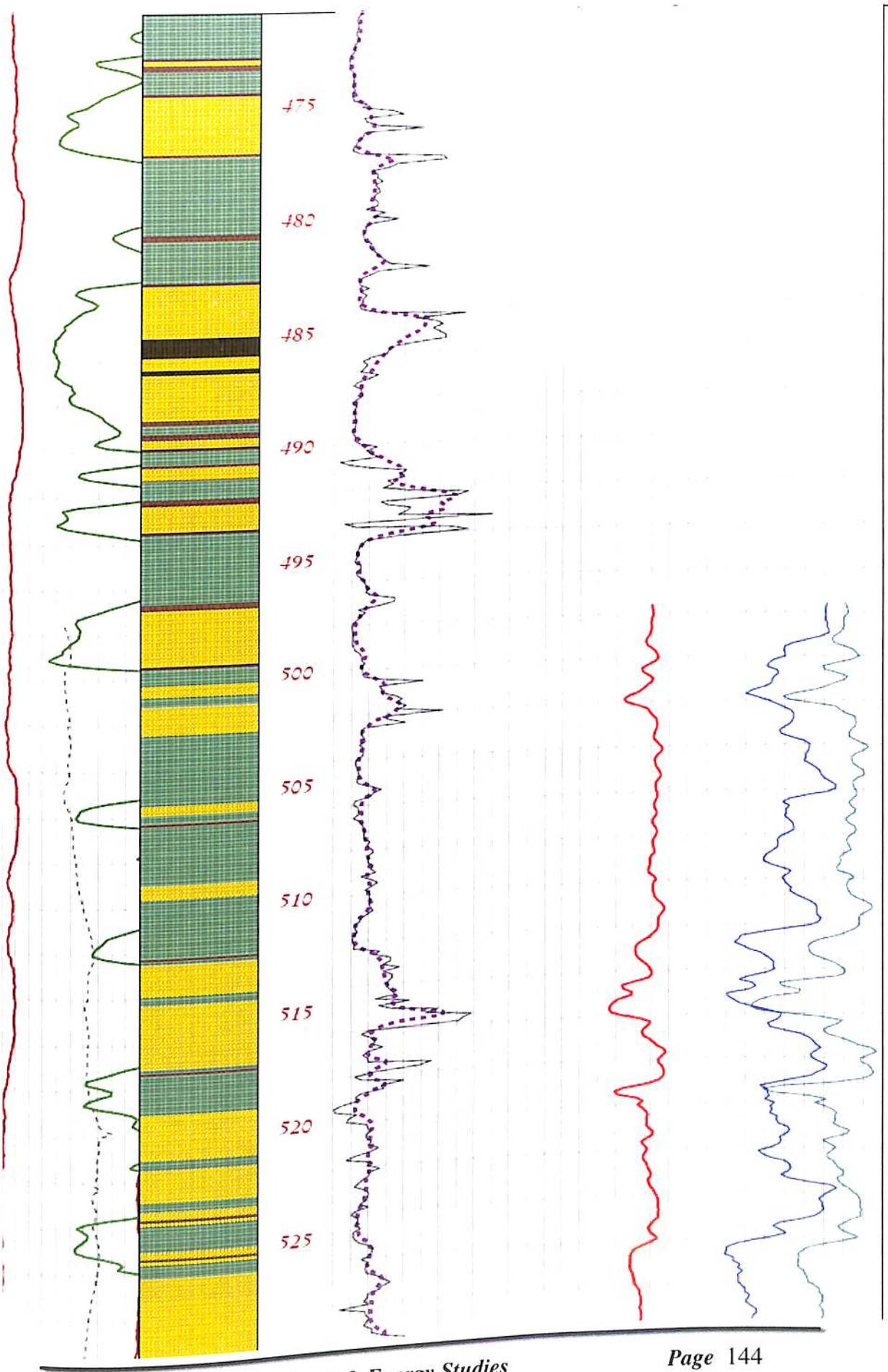
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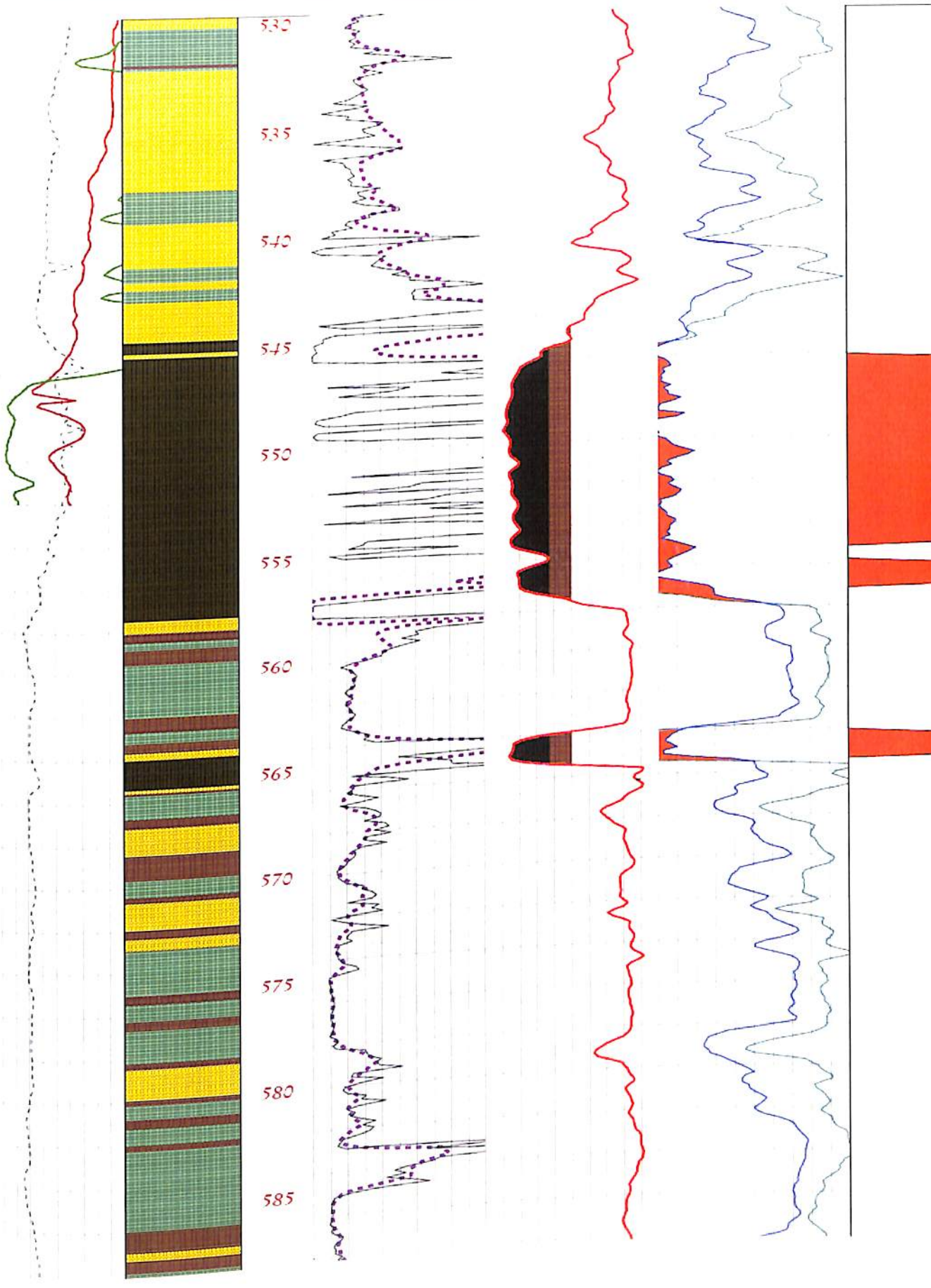
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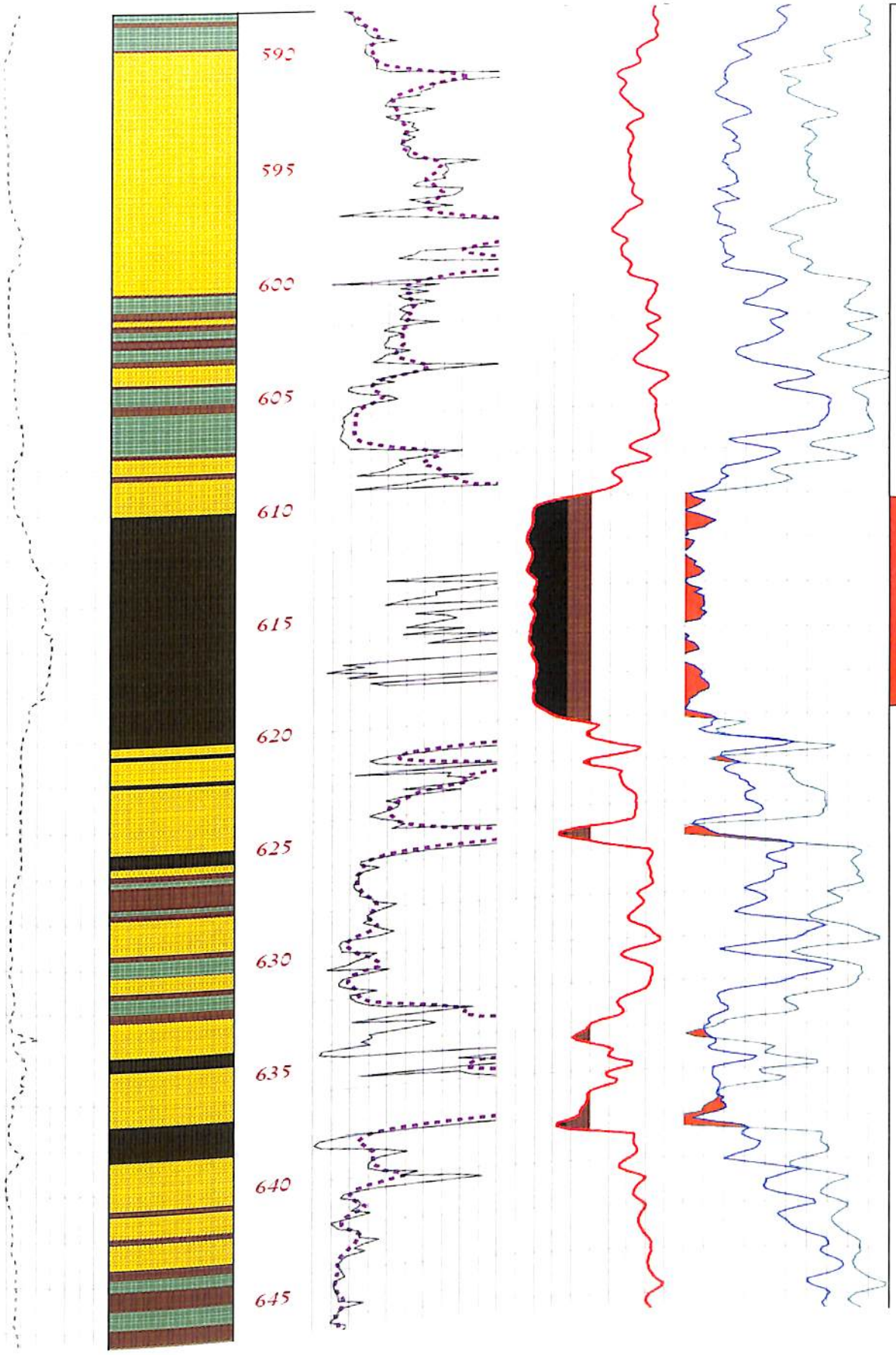
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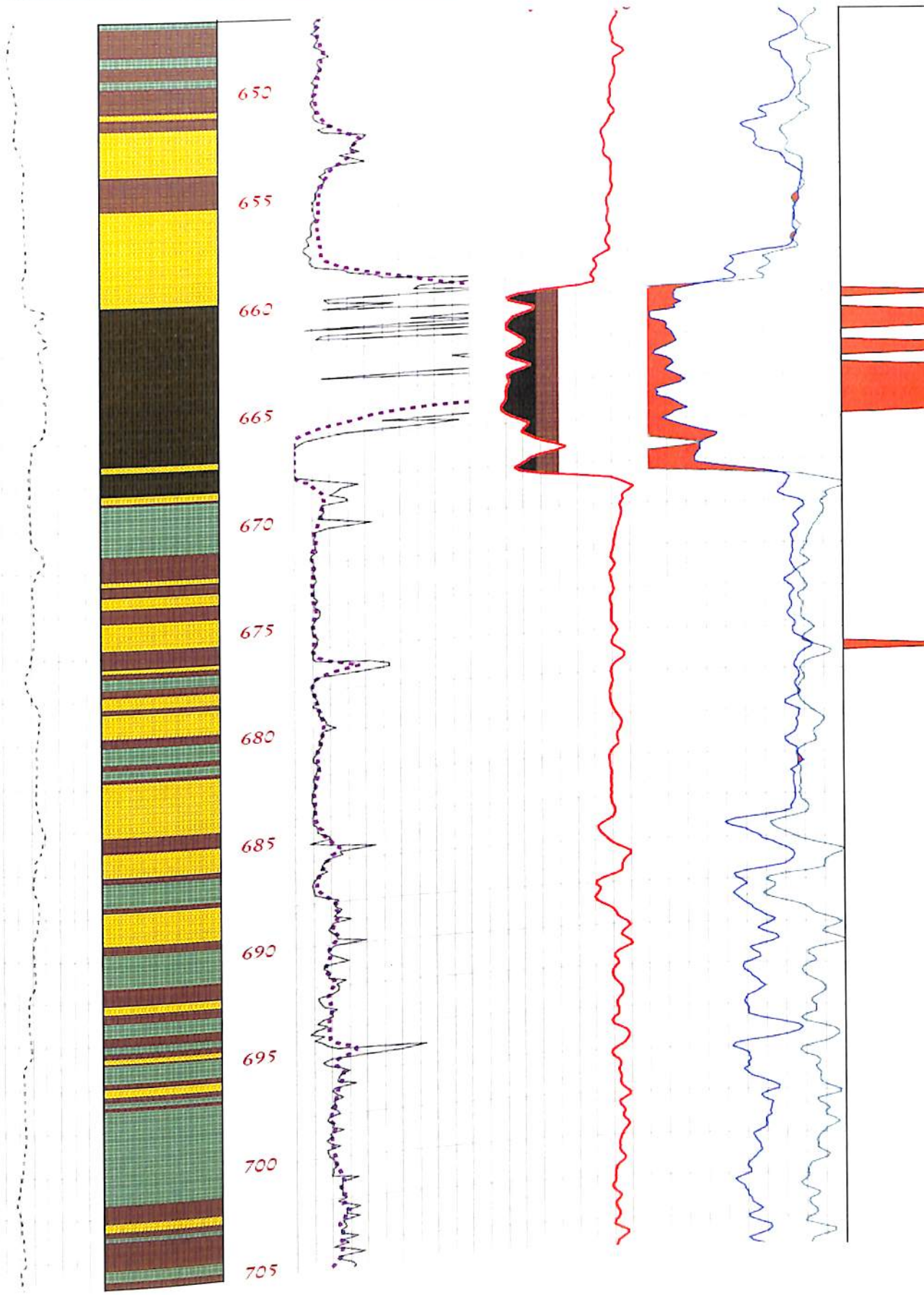
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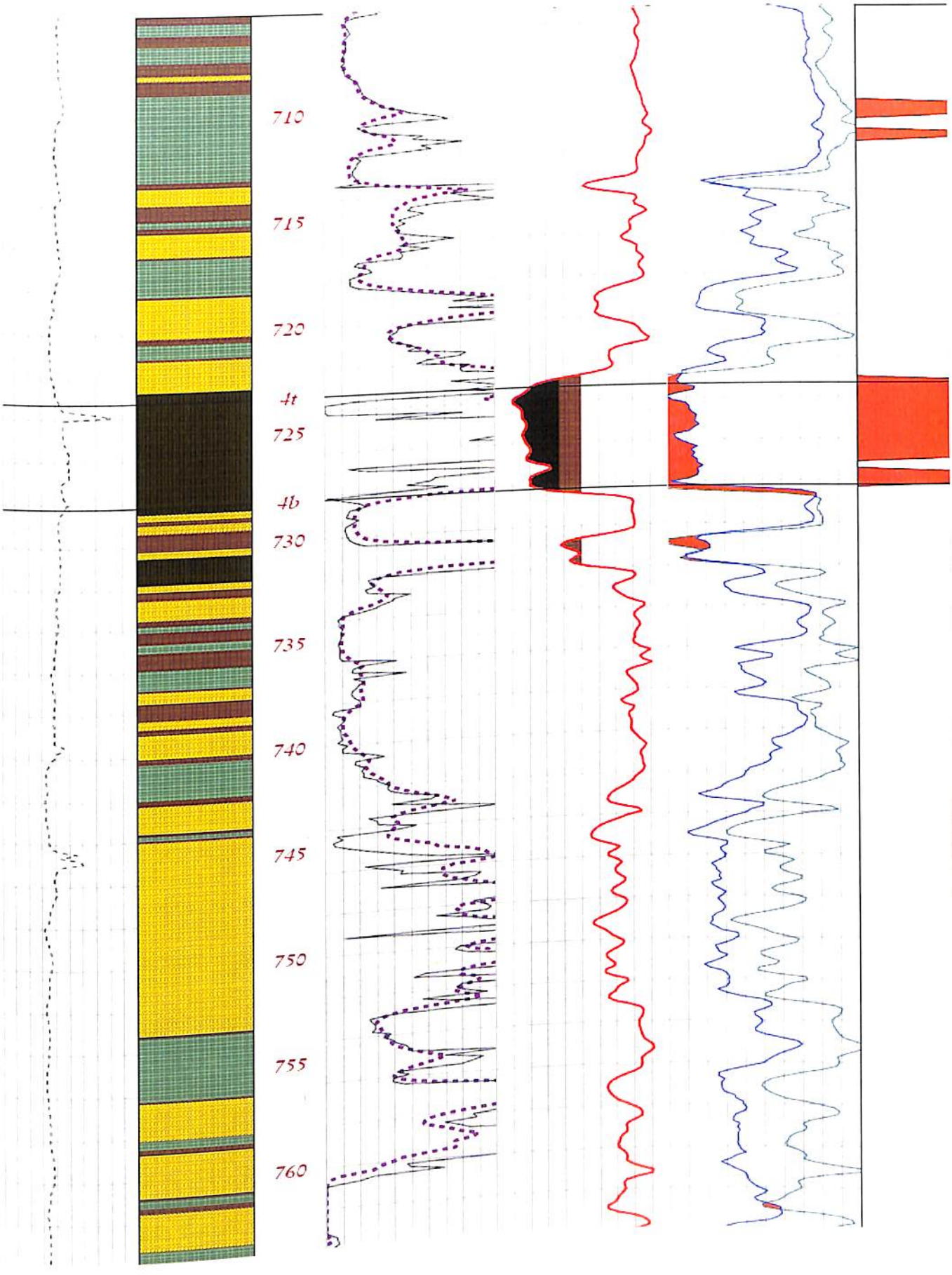
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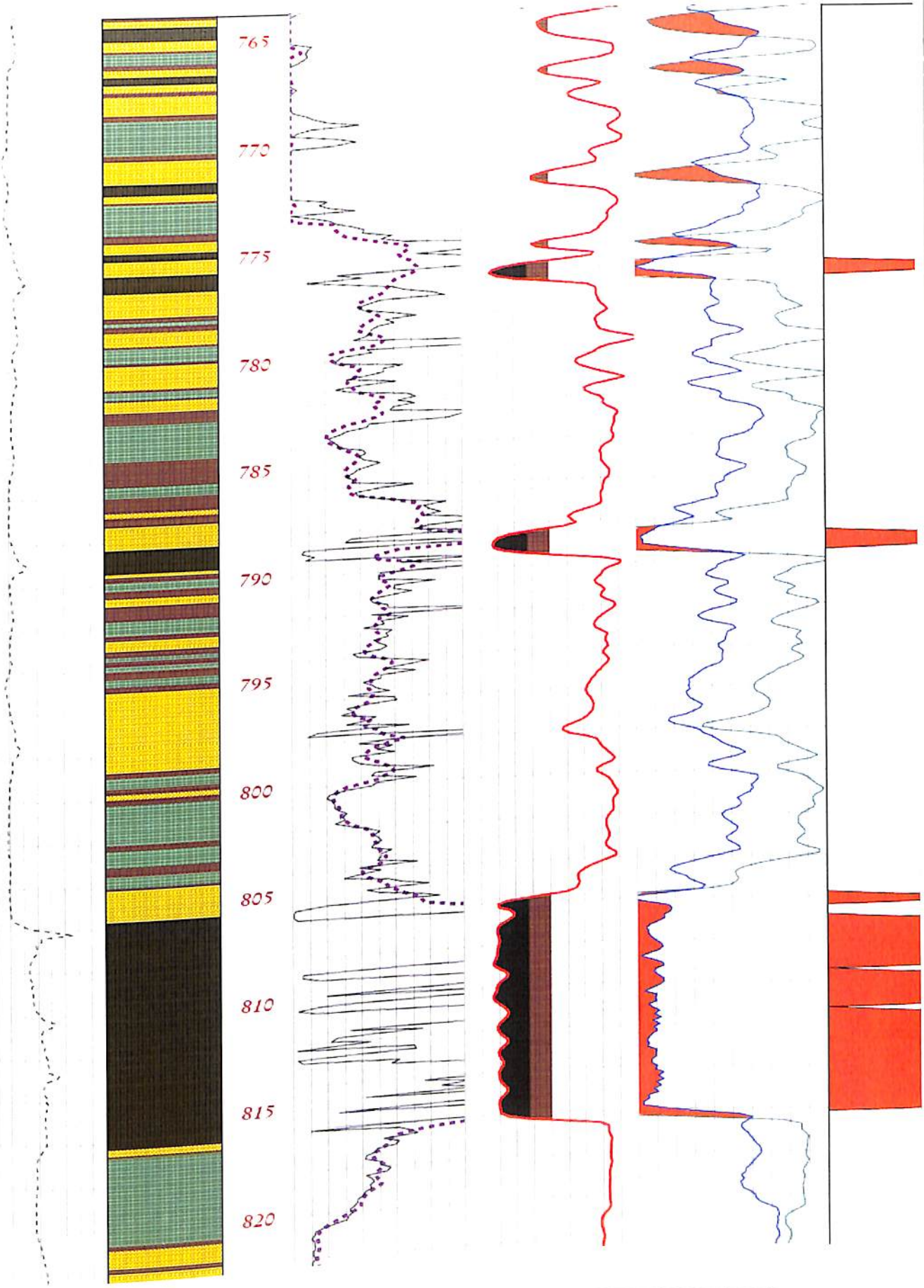
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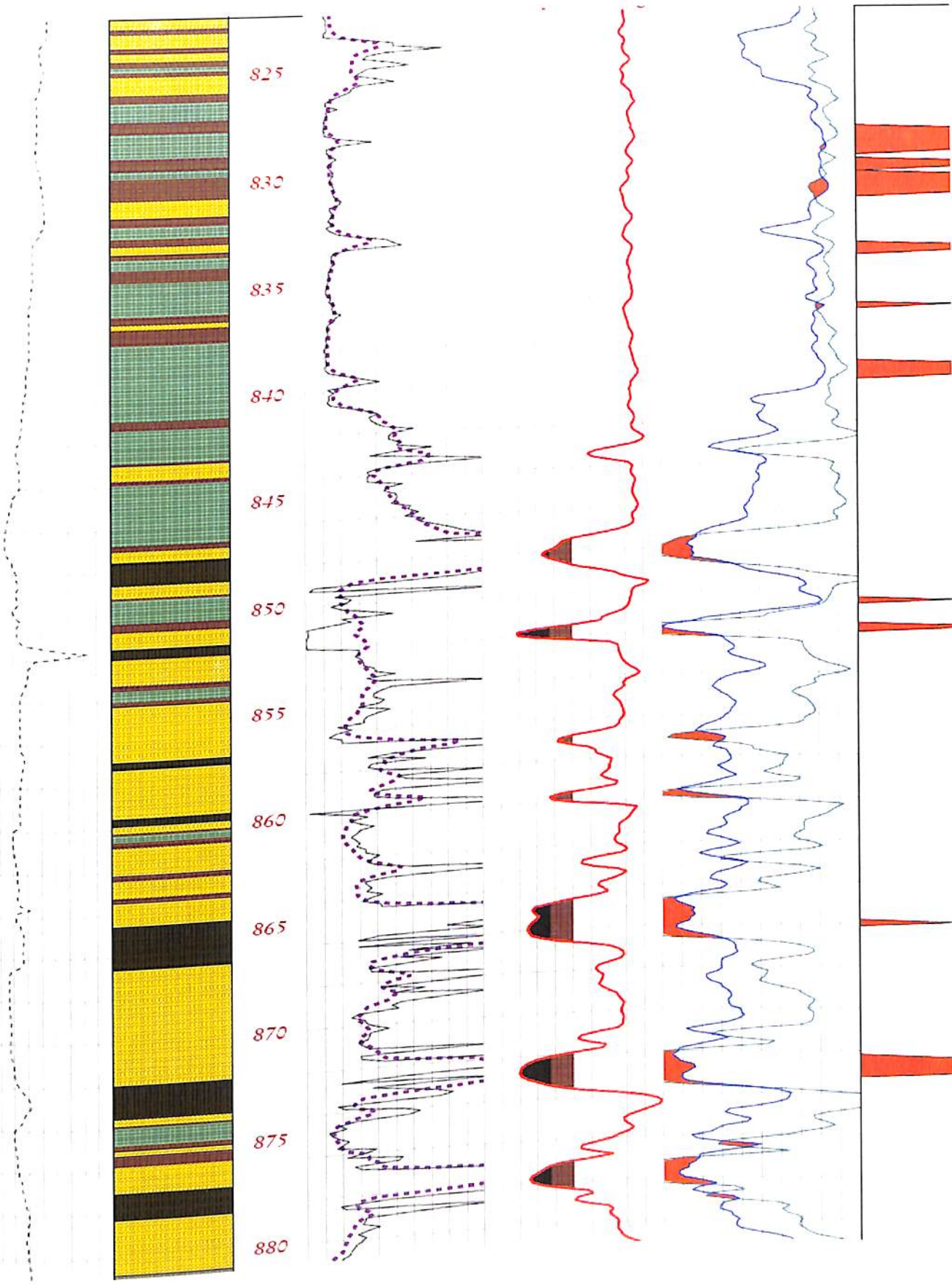
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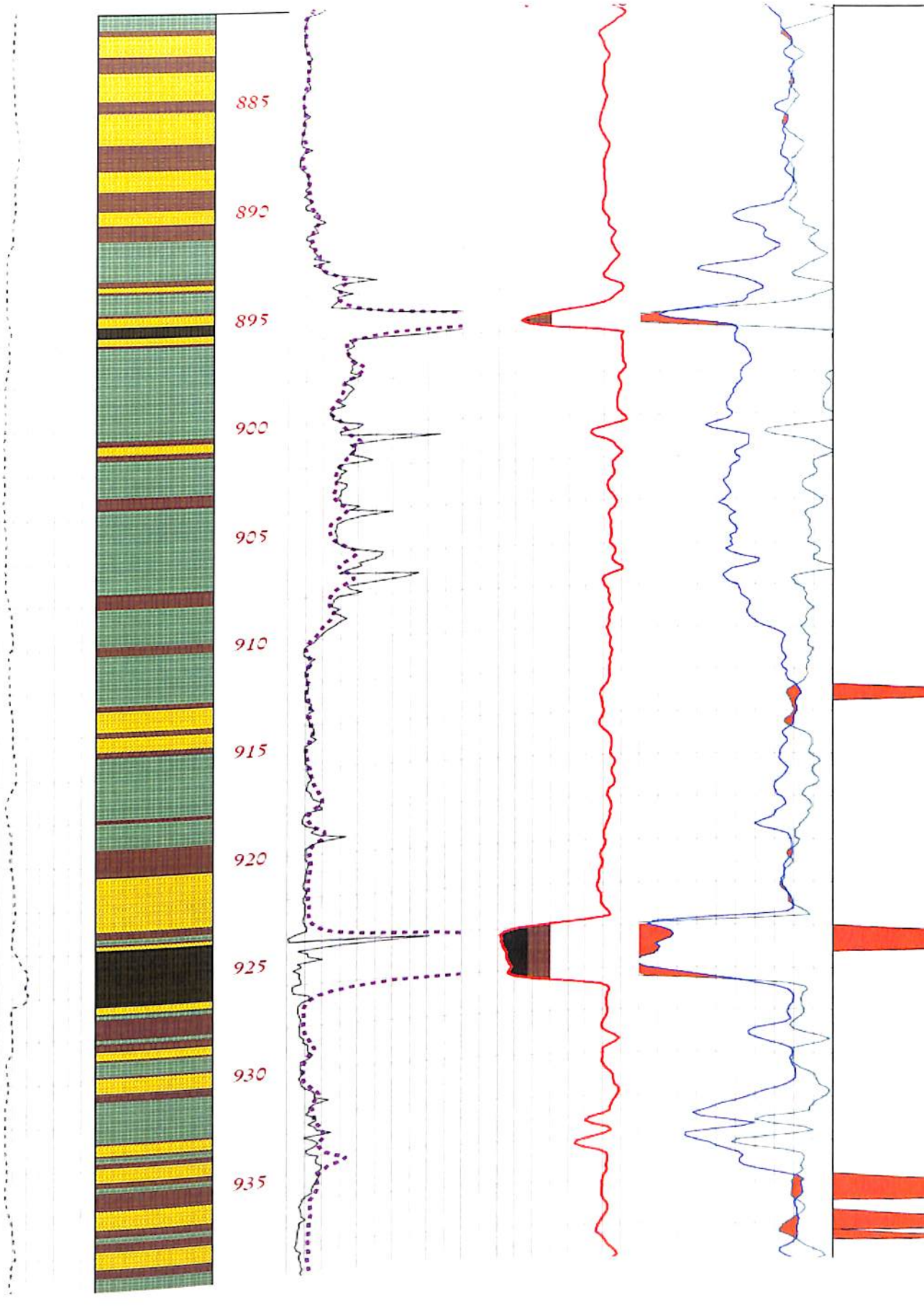
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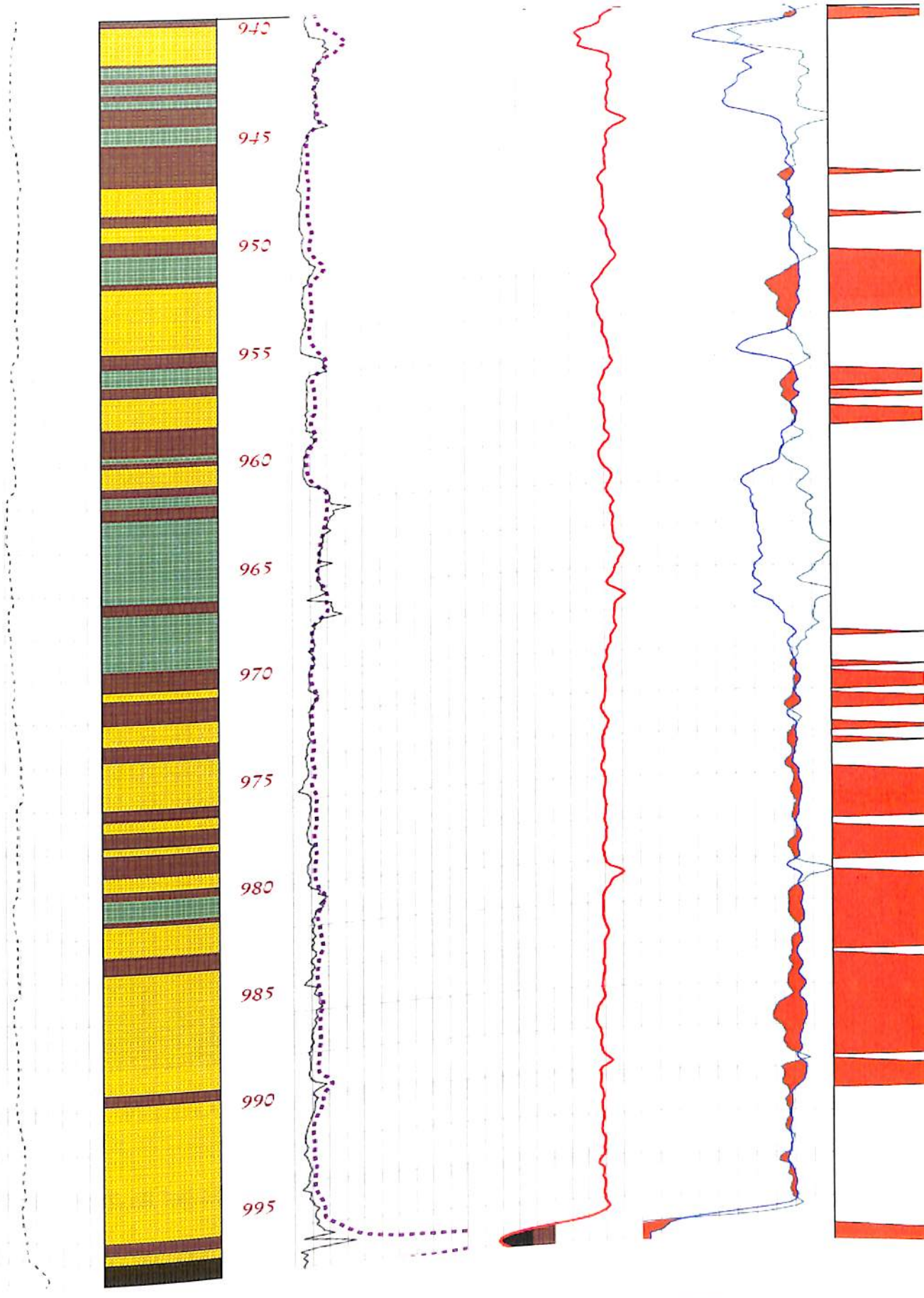
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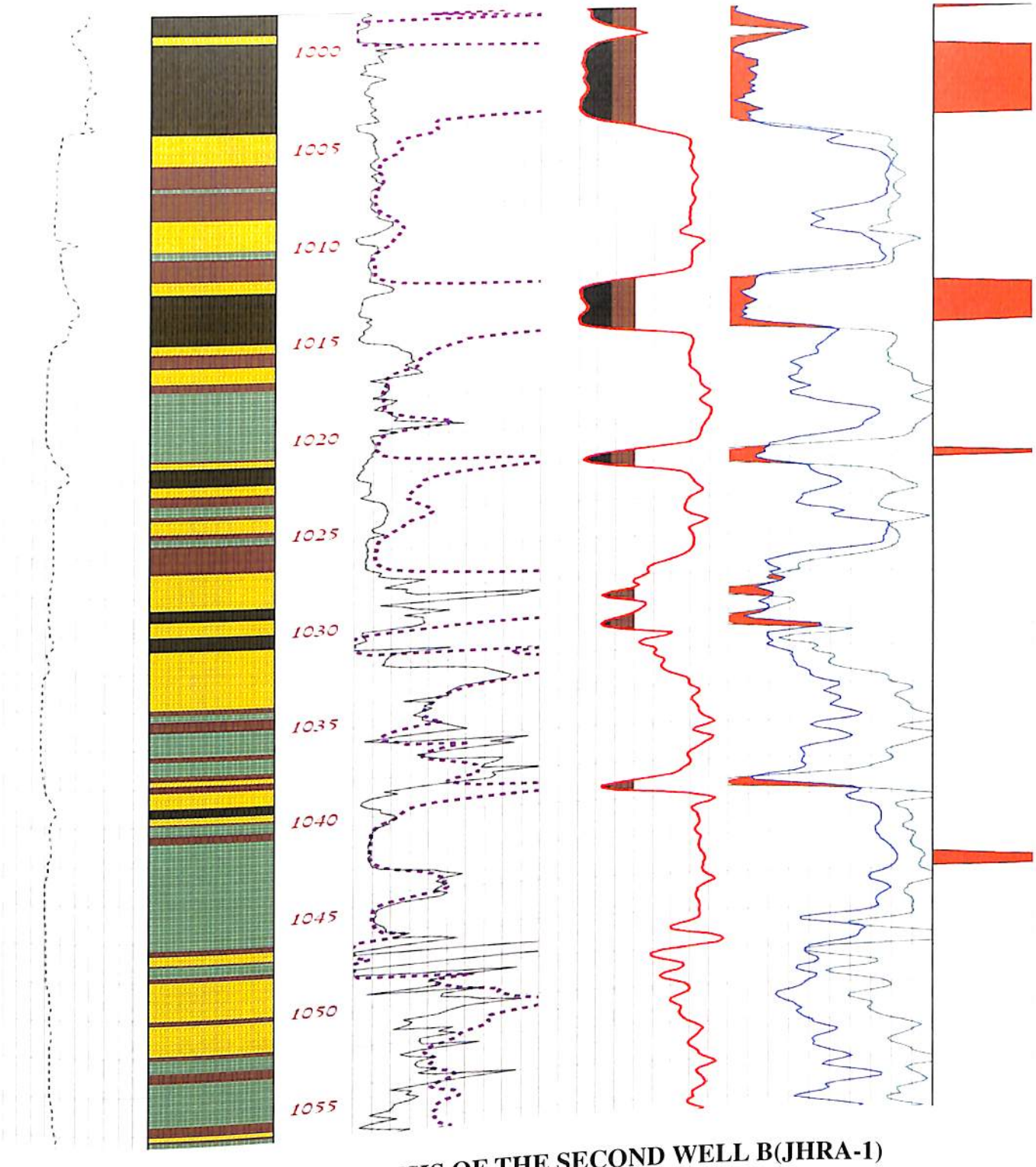
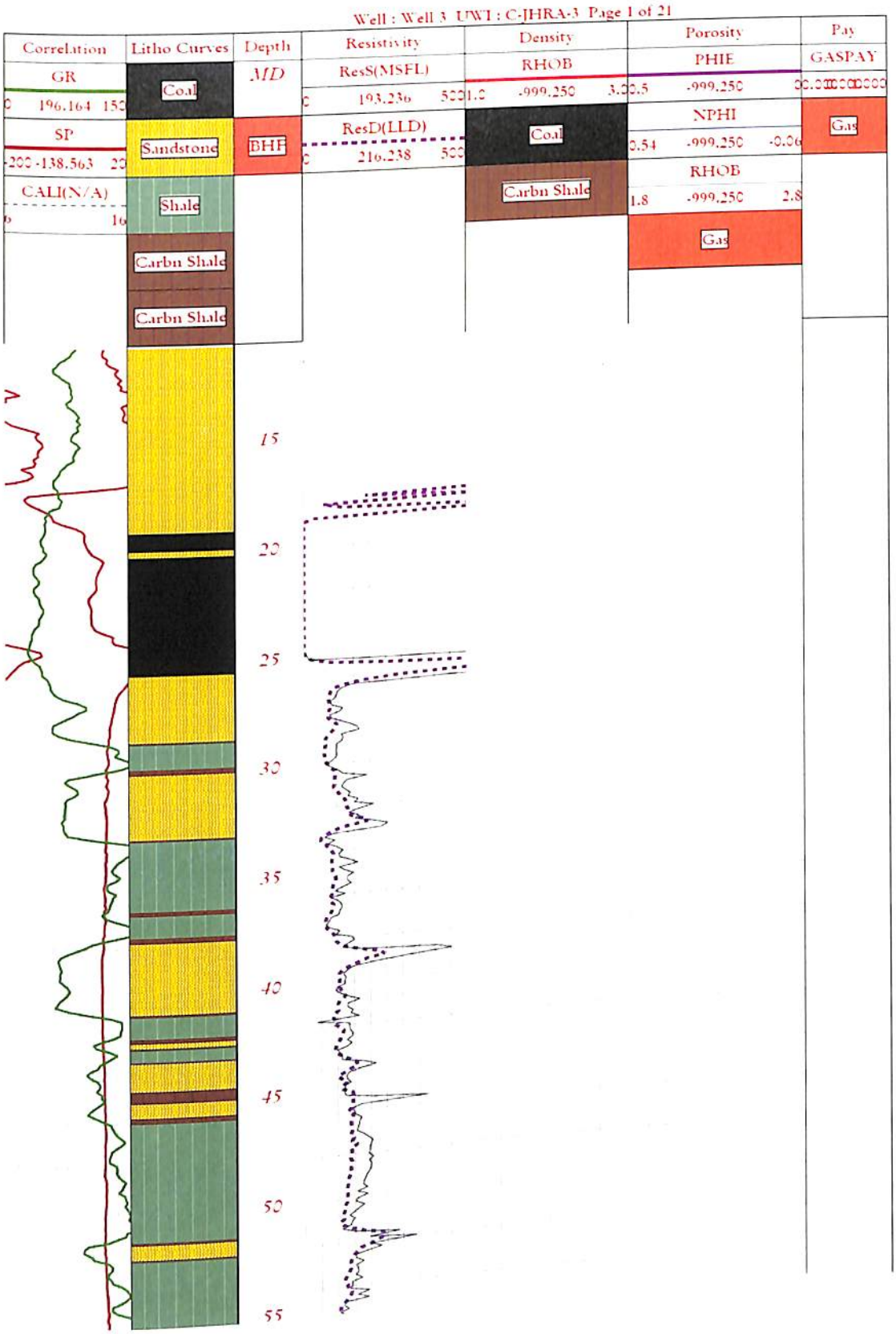


FIGURE:7.5 WELL LOG ANALYSIS OF THE SECOND WELL B(JHRA-1)

Similarly the Well log analysis for the well number 3(C) [JHRA-3] has been depicted below as Figure number 7.6.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Correlation
Litho Curves
Depth
Resistivity
Density
Porosity
Pay
GR
MD
ResS(MSFL)
RHOB
PHIE
GASPAY
196.164
193.236
-999.250
-999.250
SP
Coal
ResD(LLD)
NPHI
Gas
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Sandstone
BHF
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-999.250
CALI(N/A)
Coal
RHOB
Shale
Carbn Shale
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Carbn Shale
Gas
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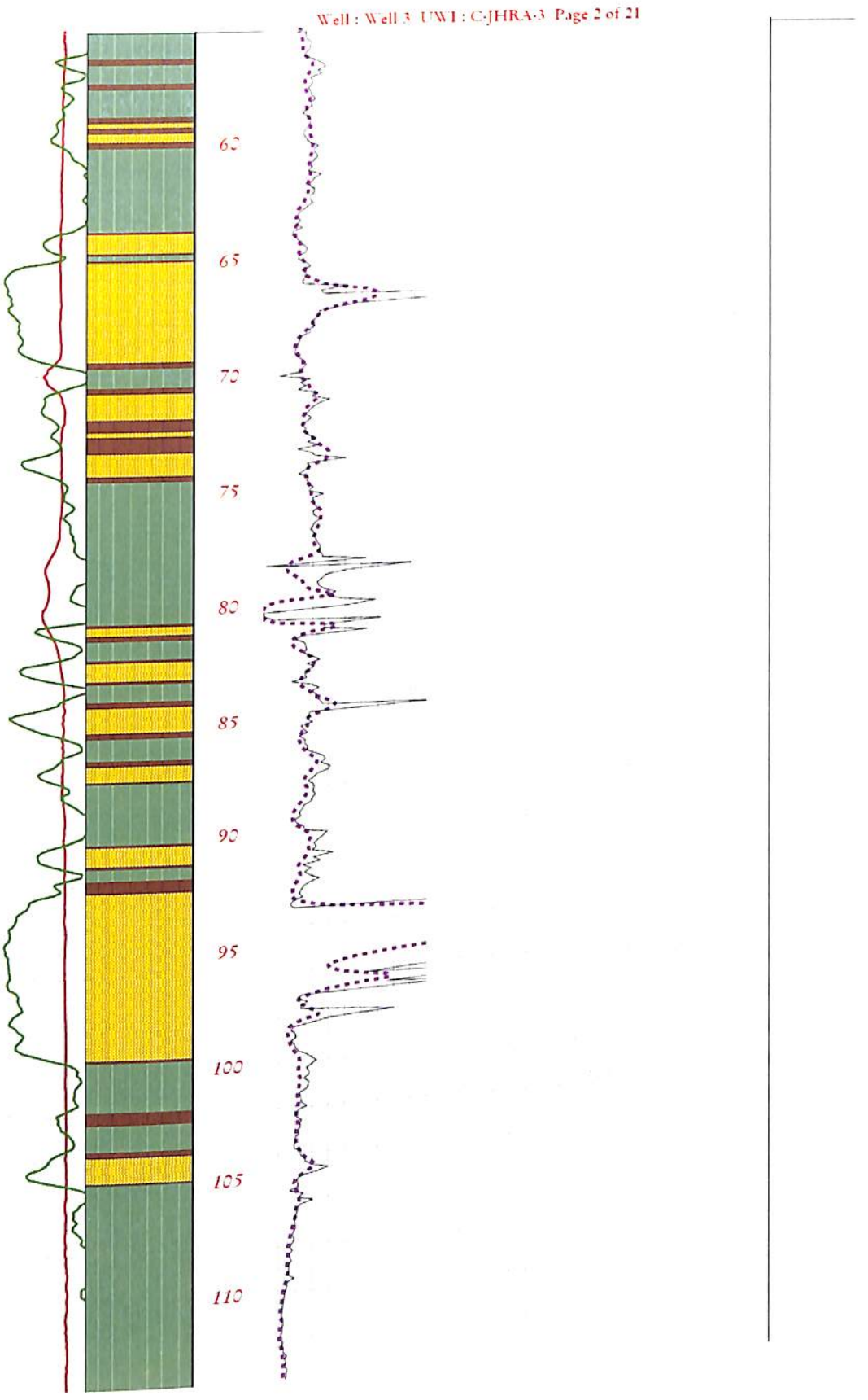
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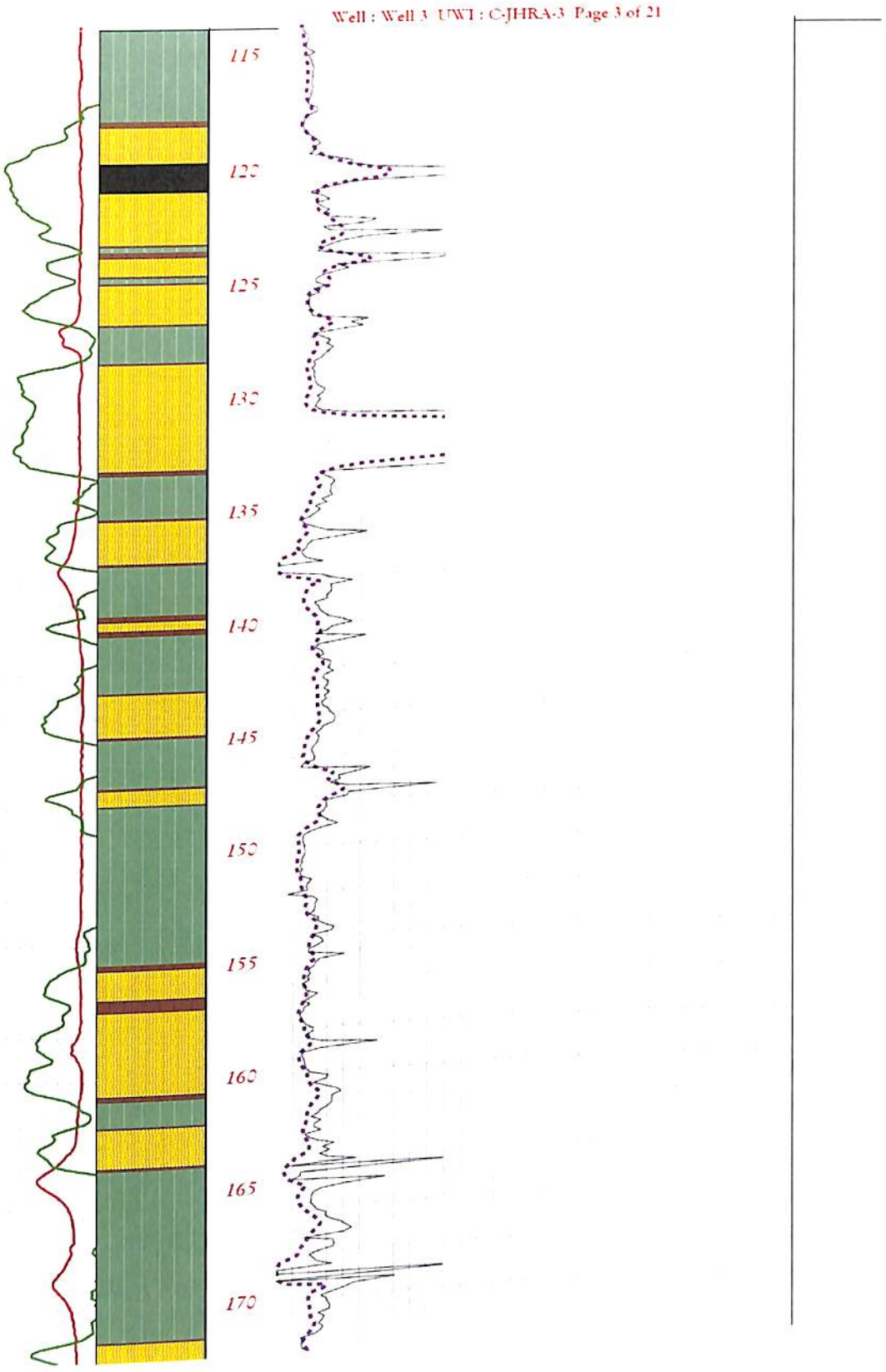
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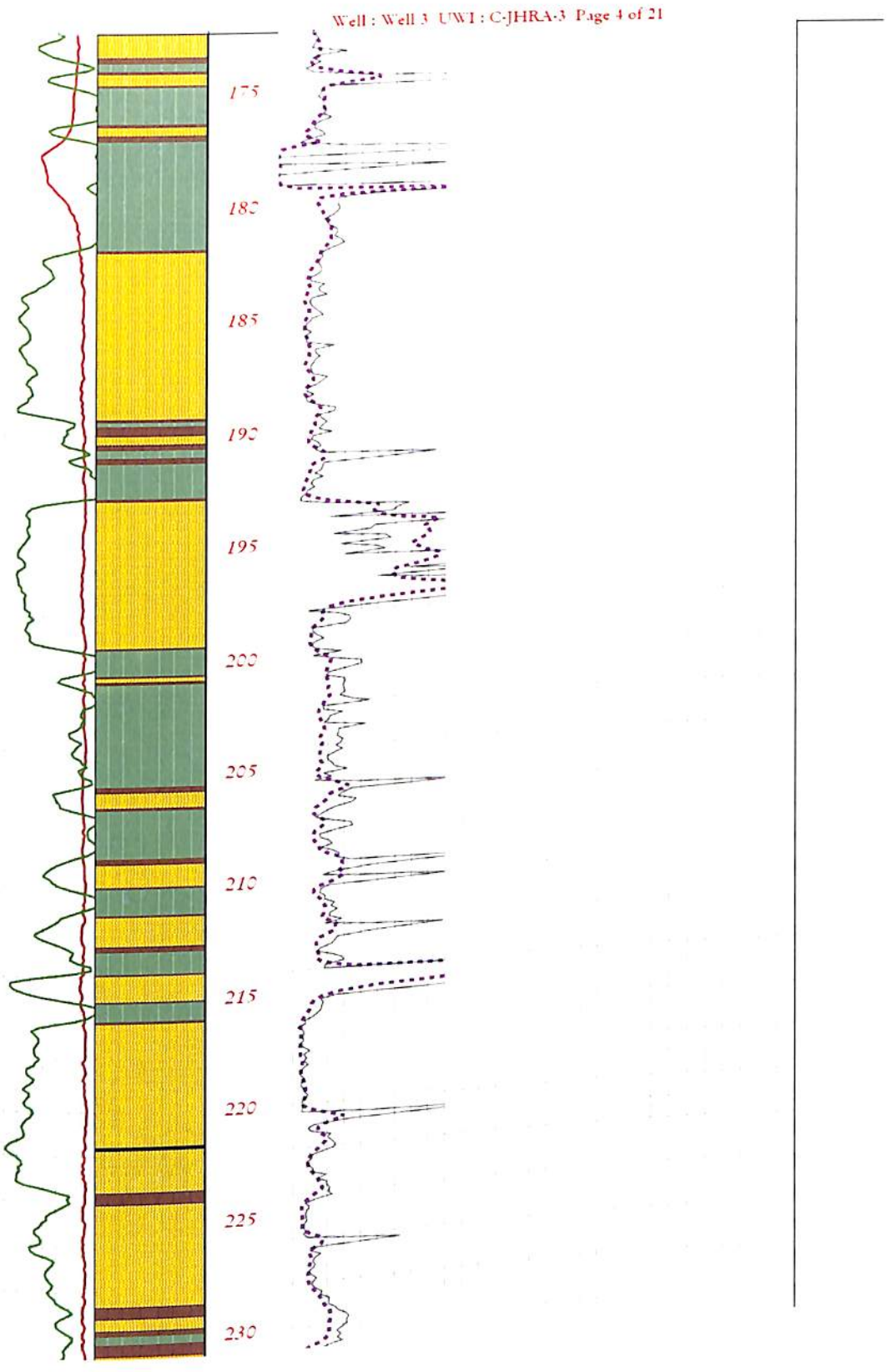
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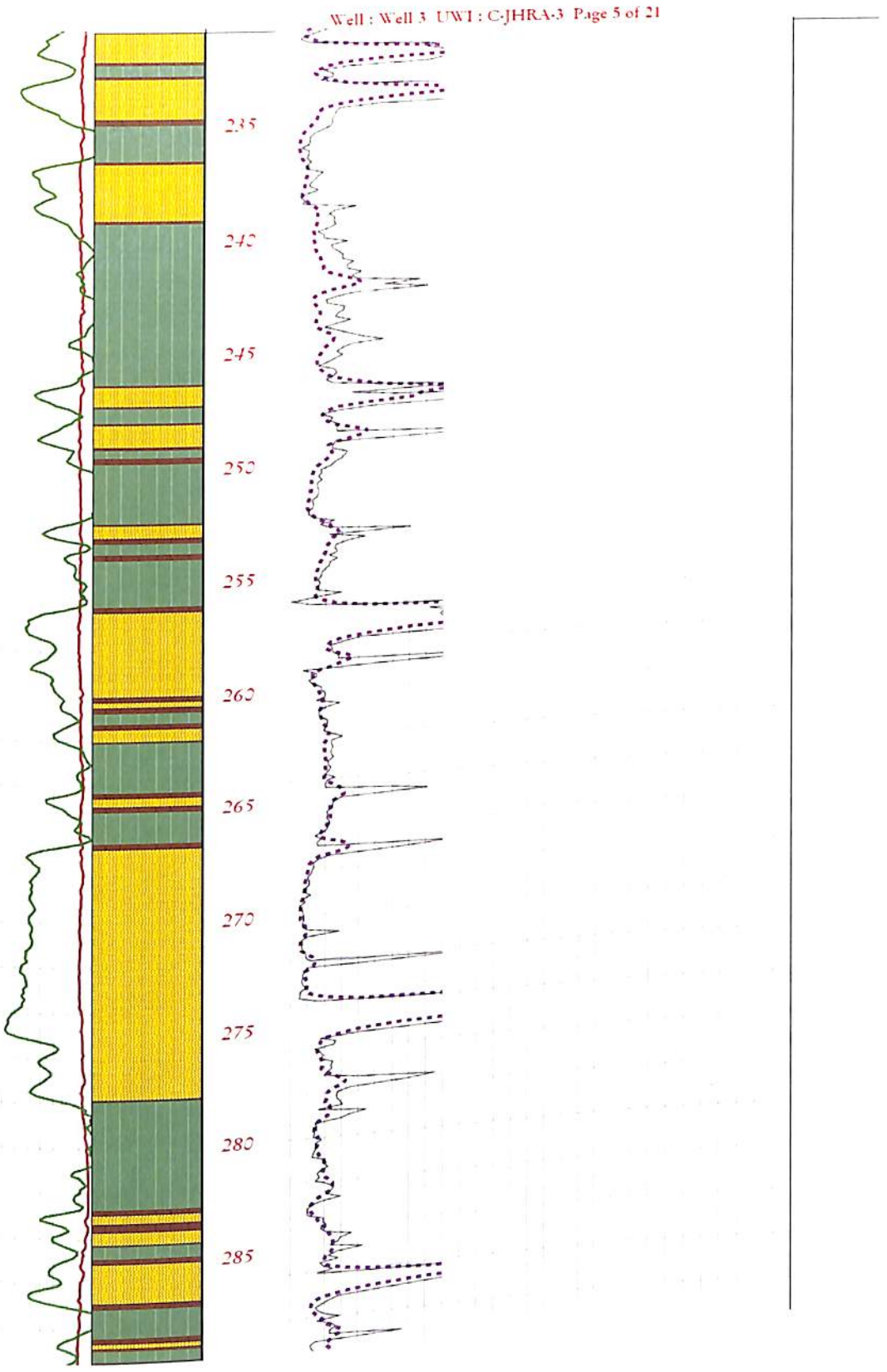
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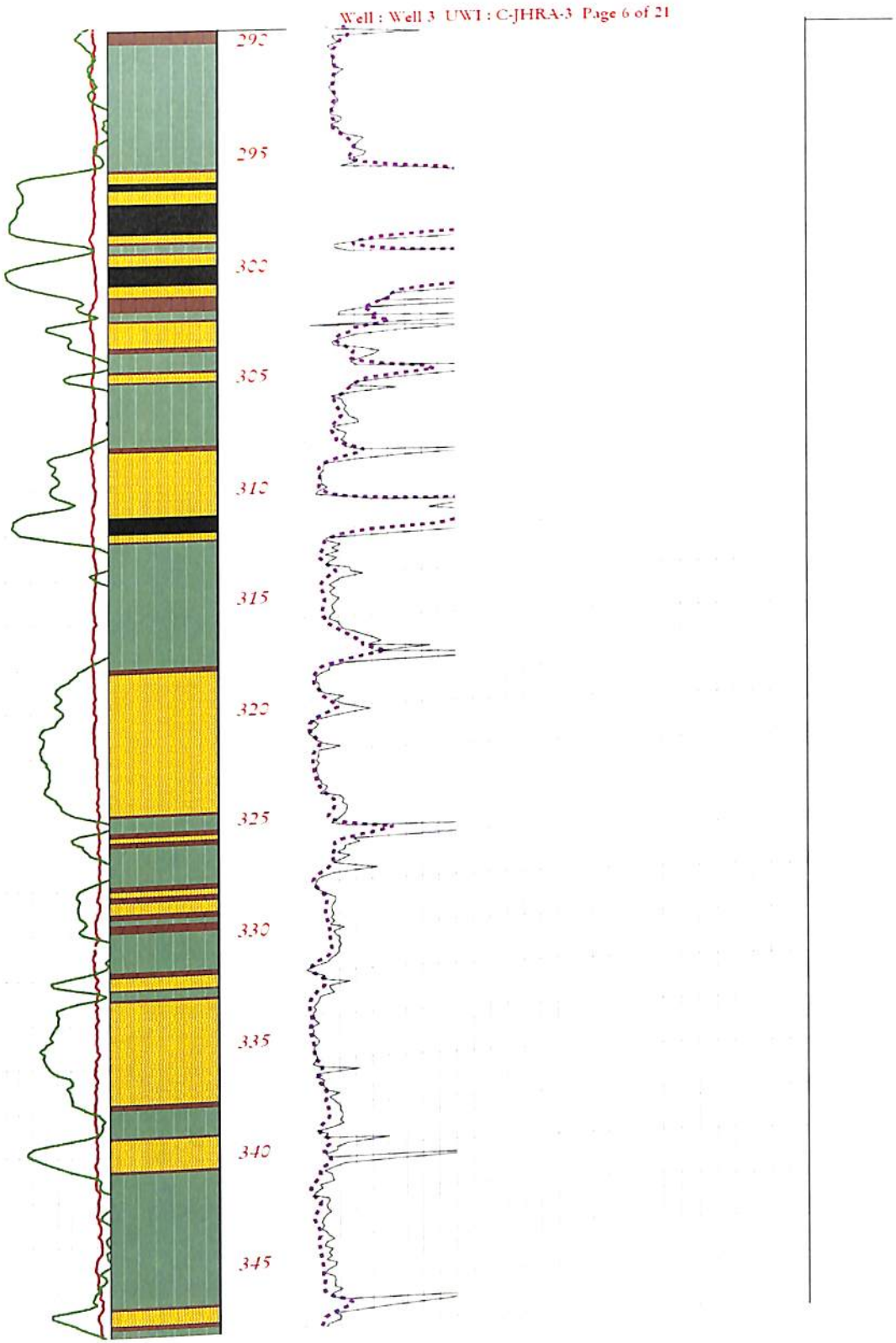
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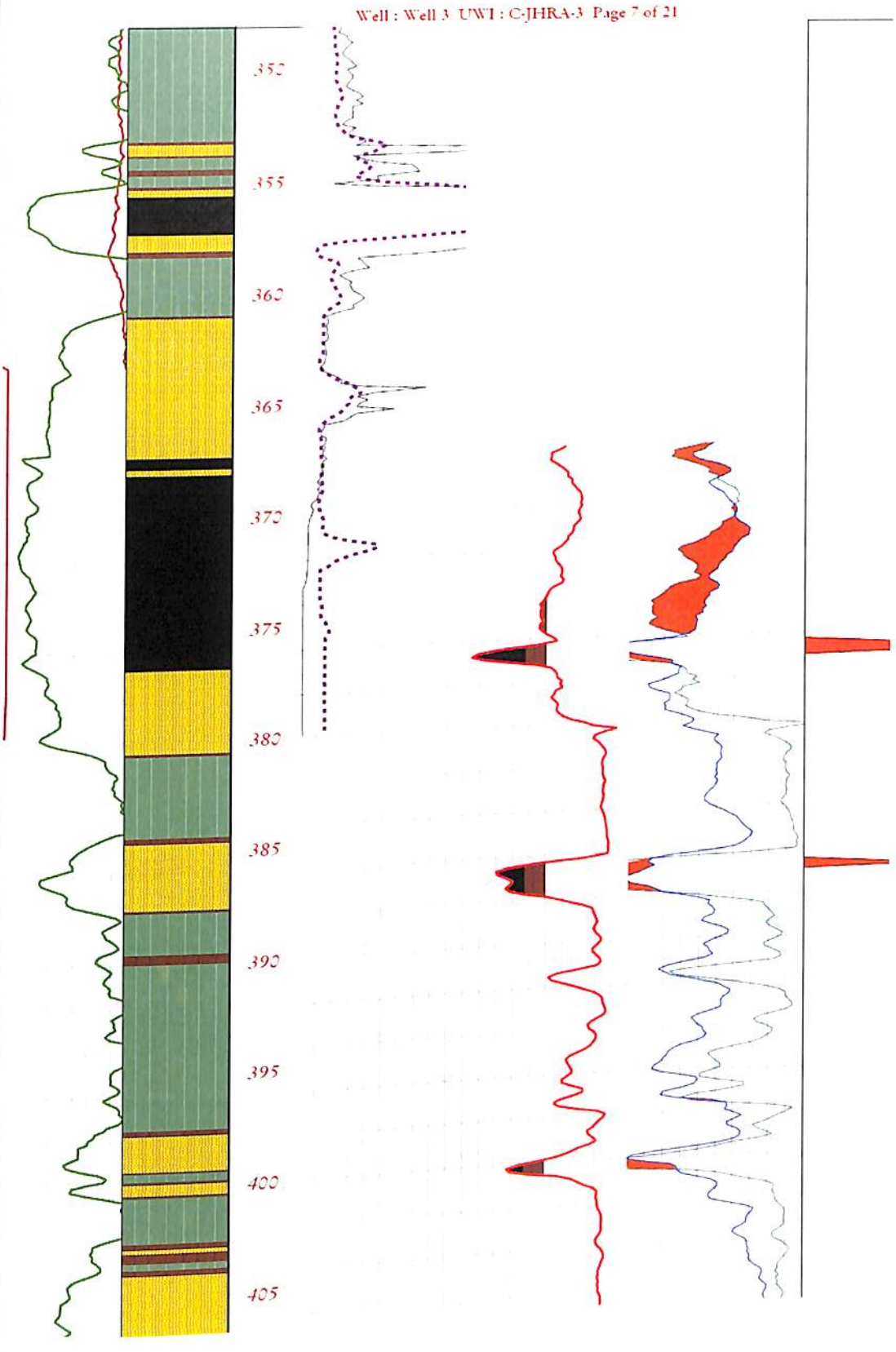
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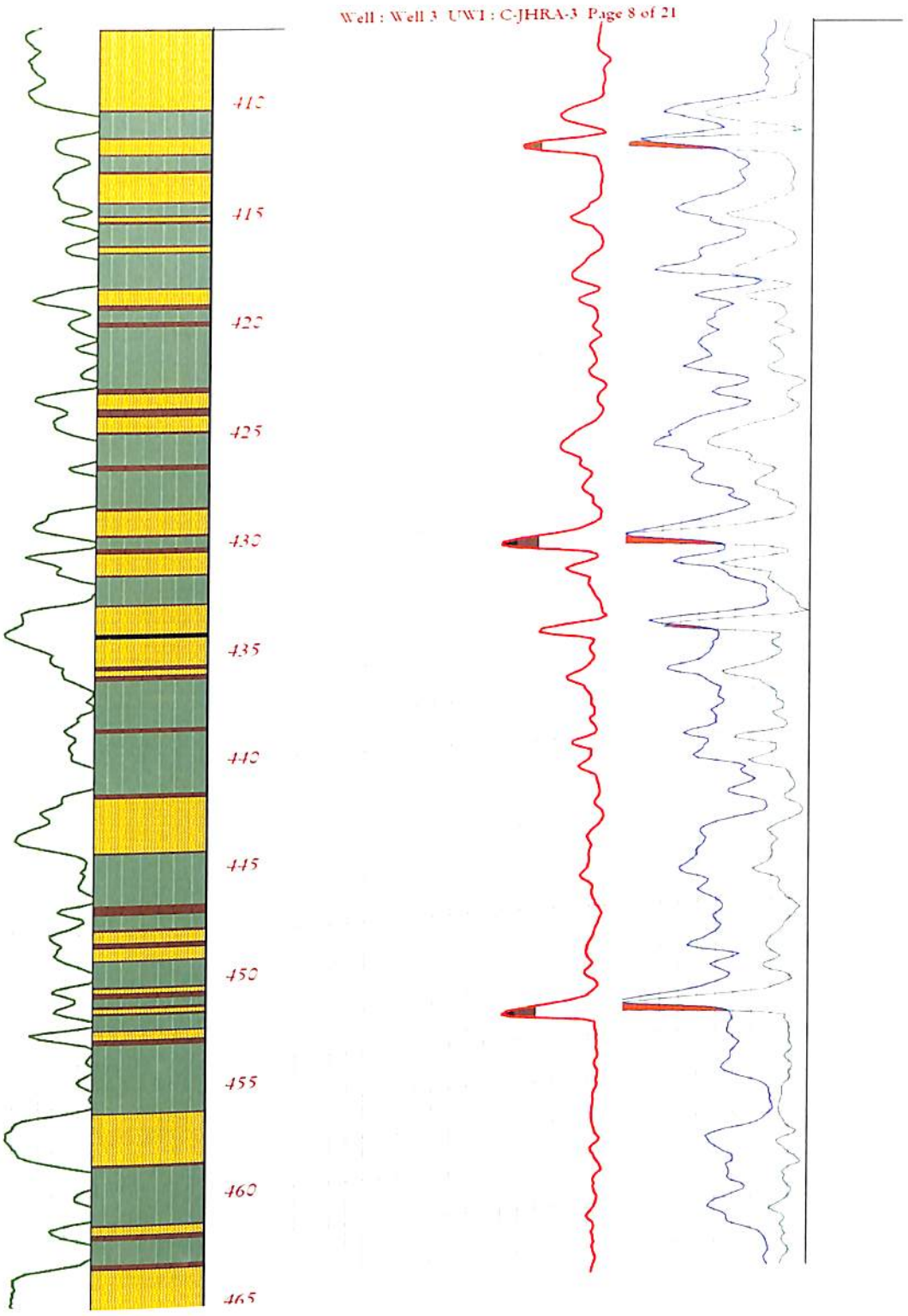
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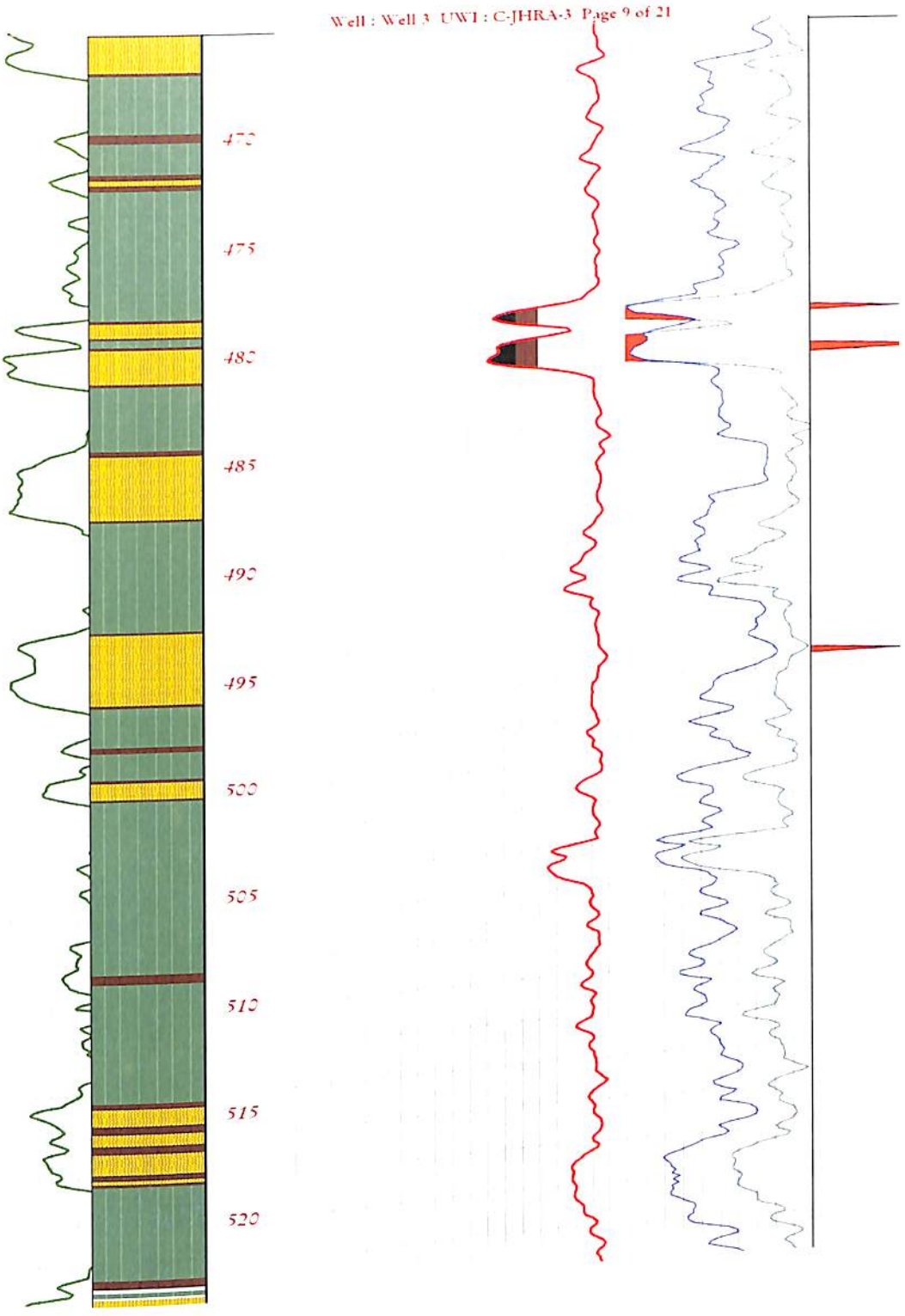
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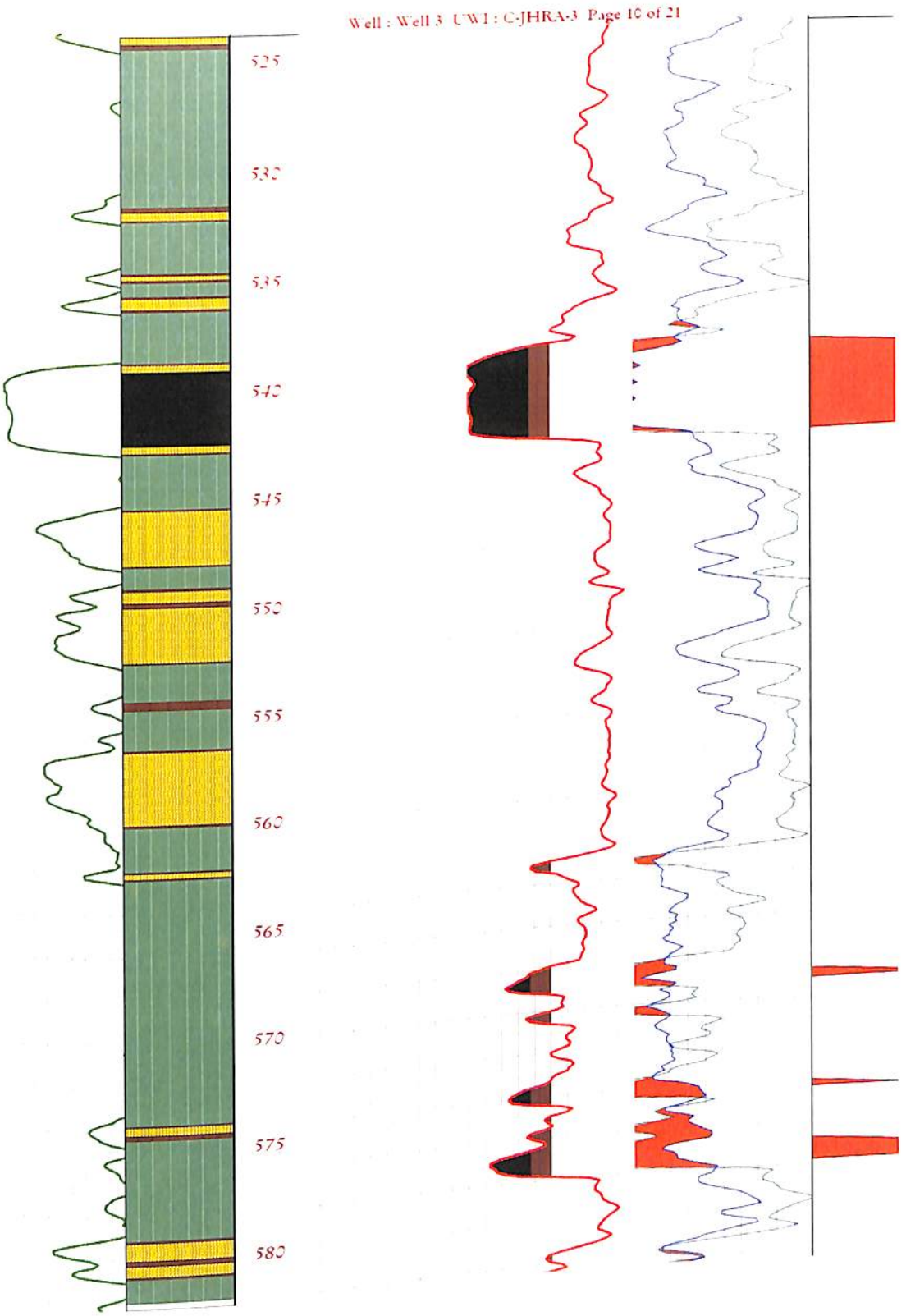
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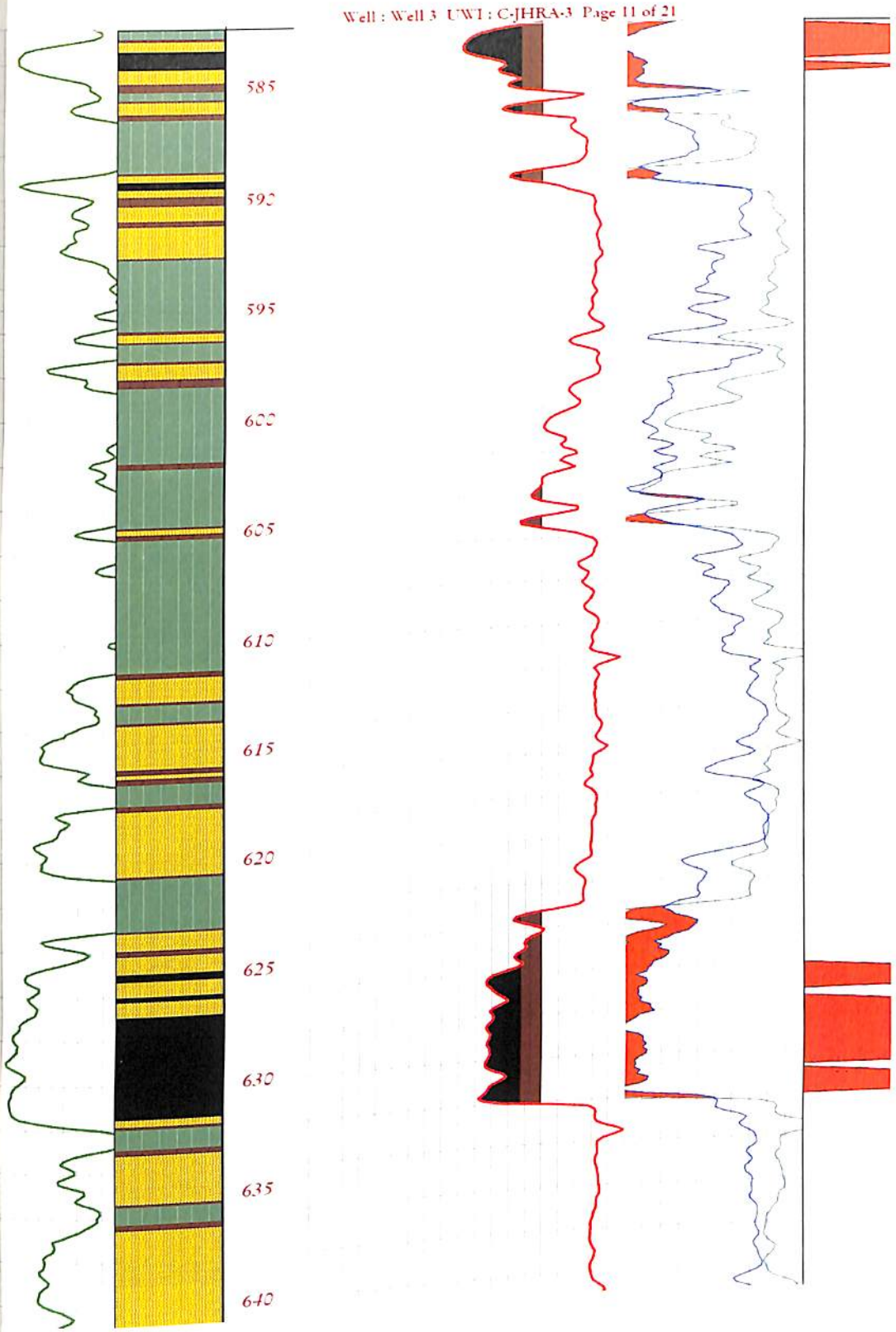
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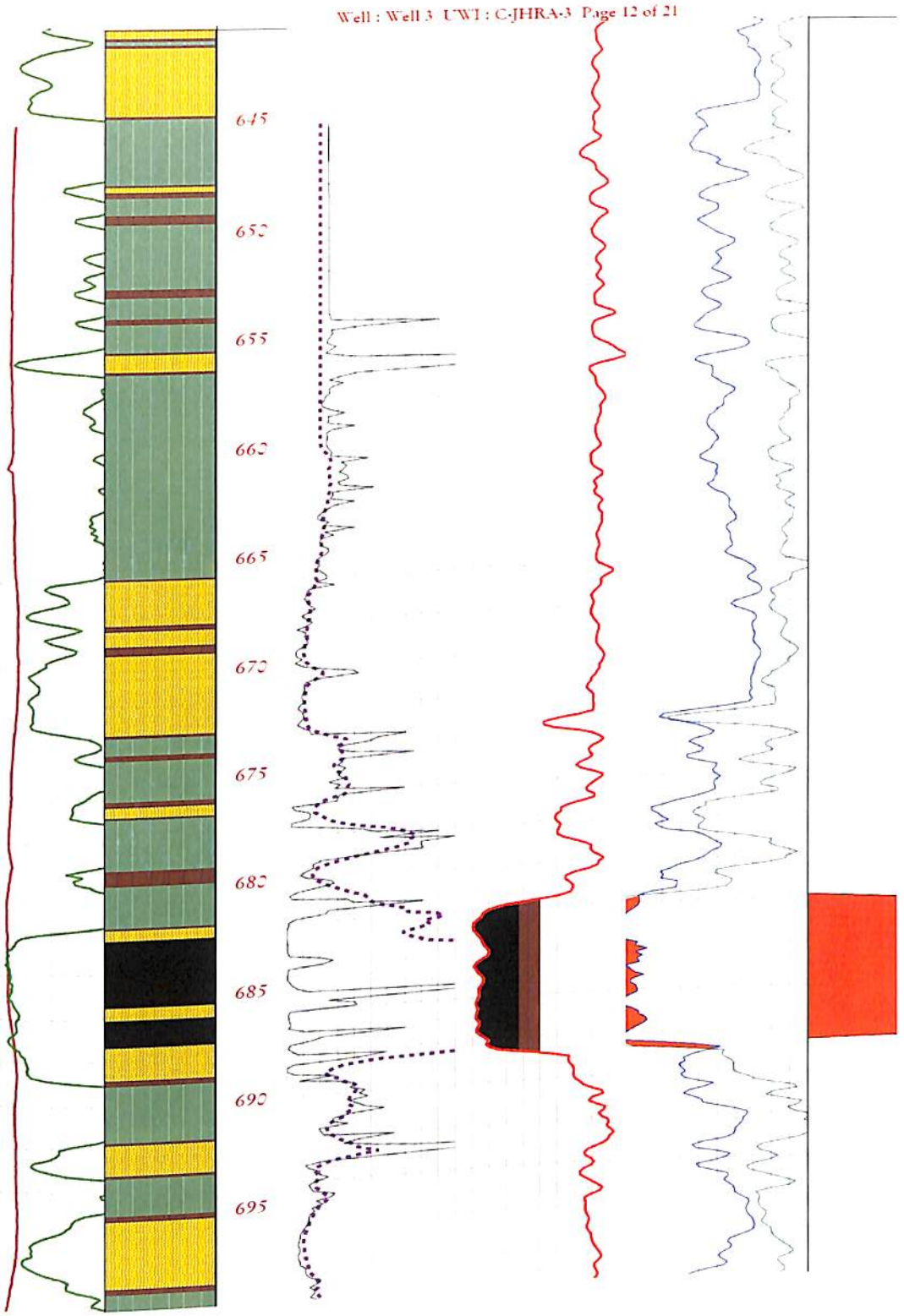
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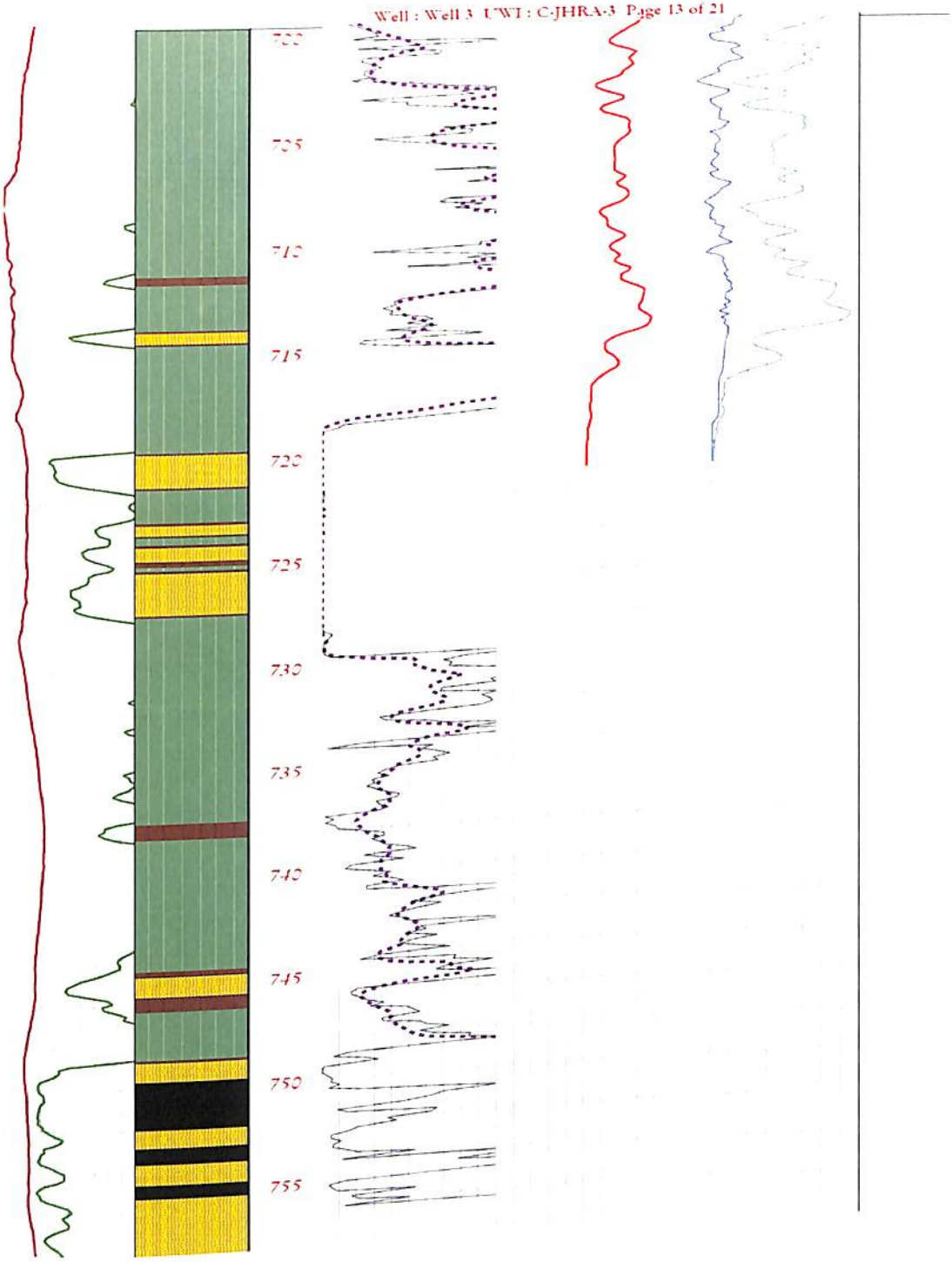
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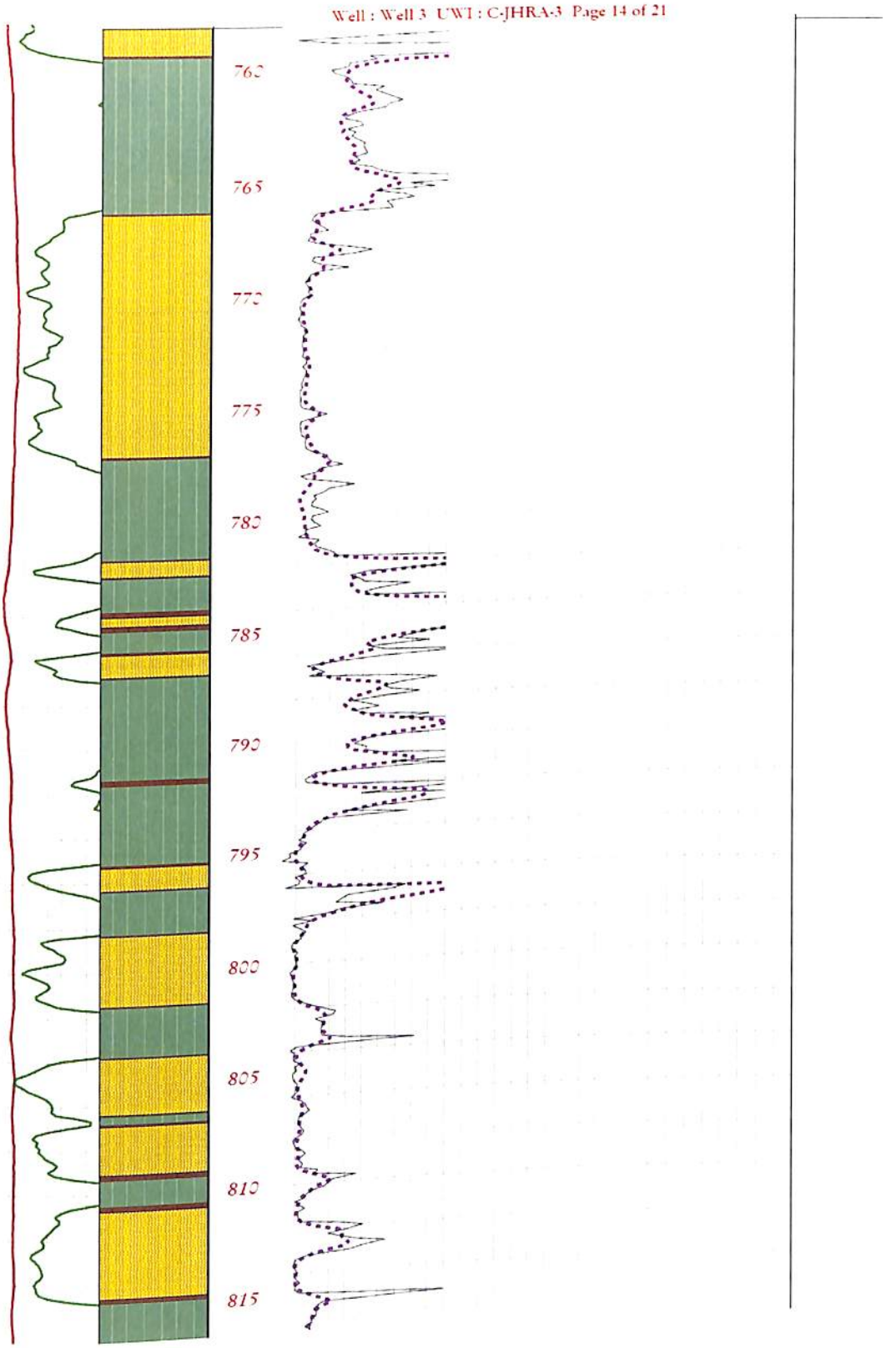
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770
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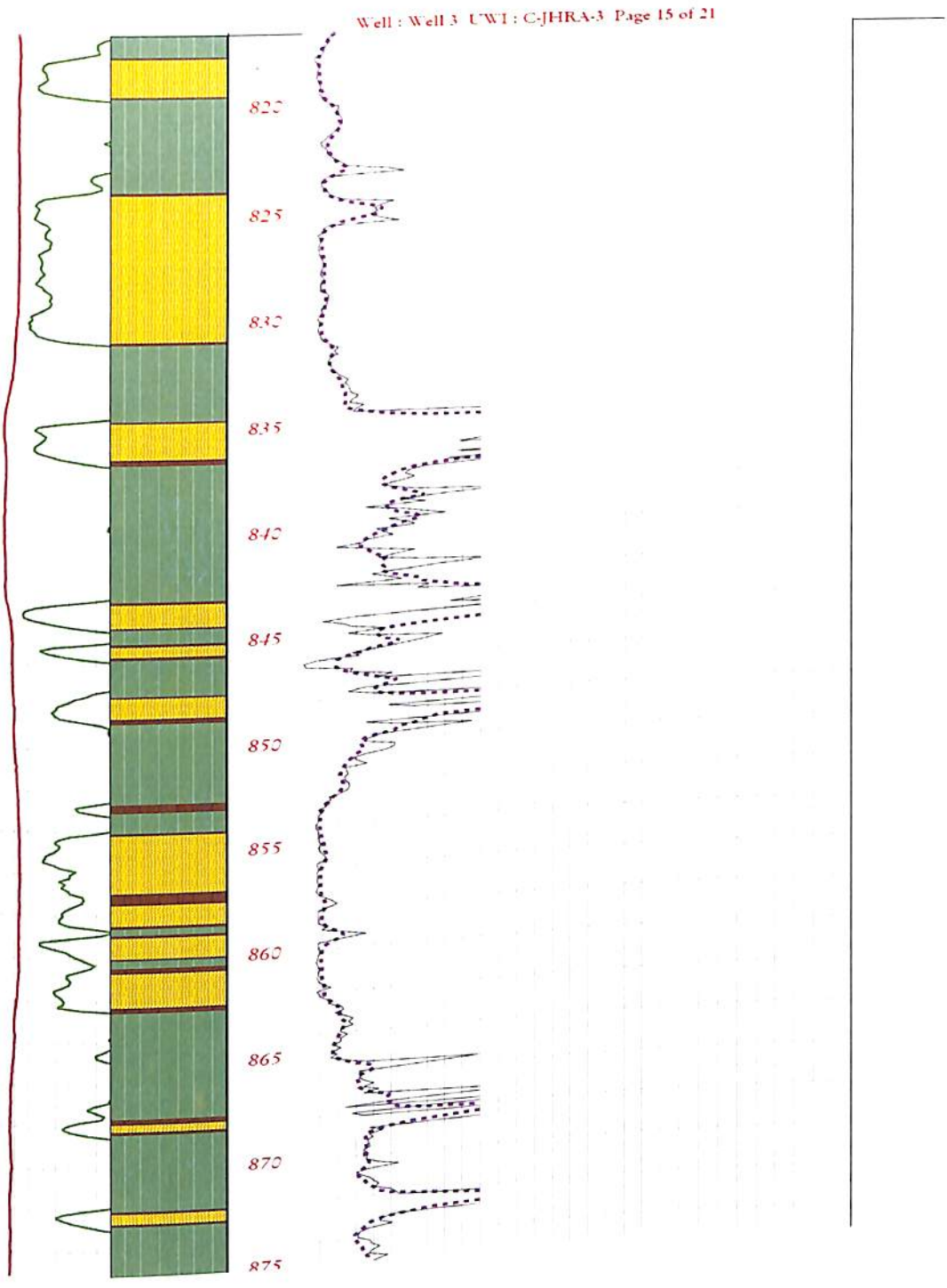
780
785
790
795
800
805
810
815


Well : Well 3 UWI : C-JHRA-3 Page 15 of 21
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825
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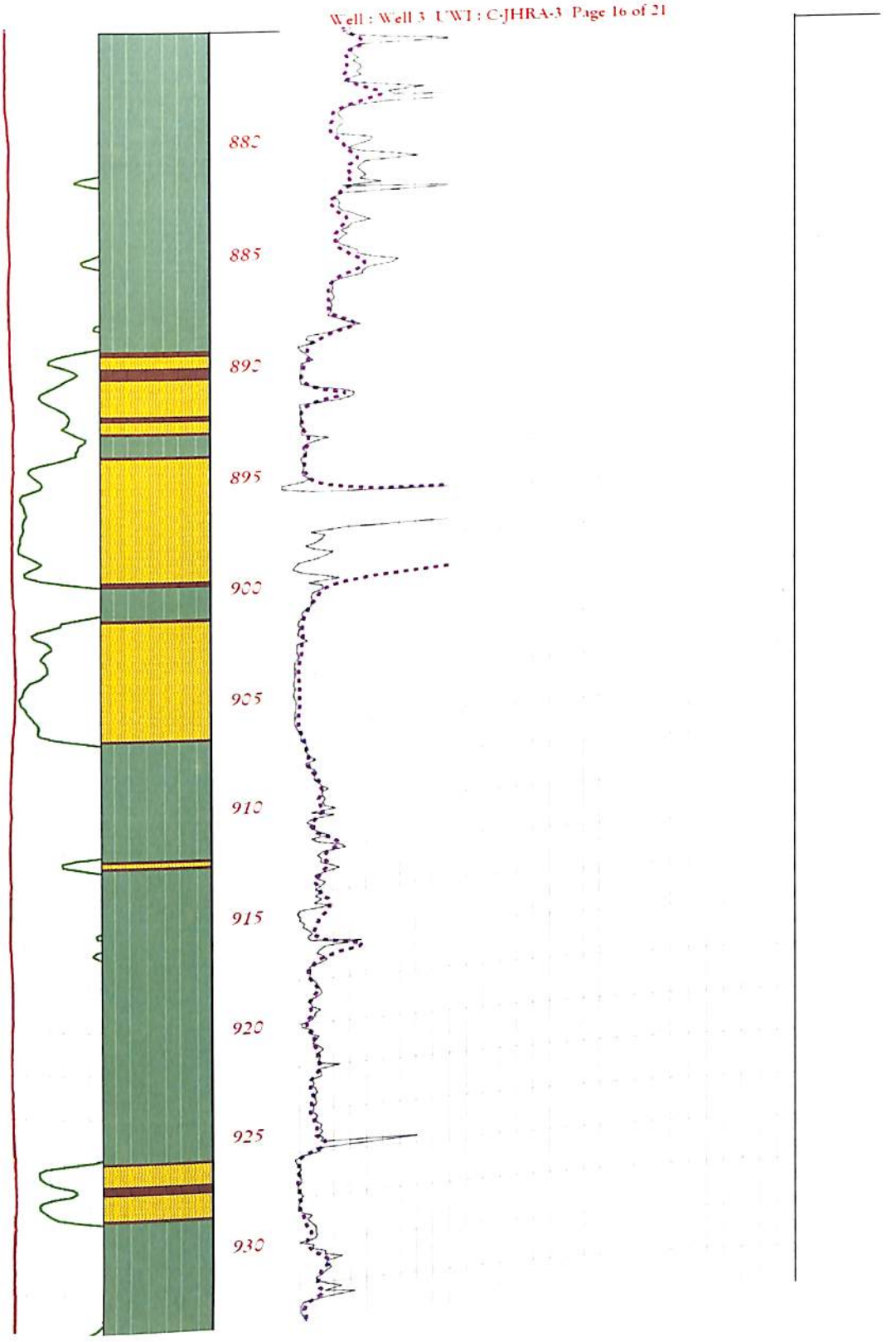
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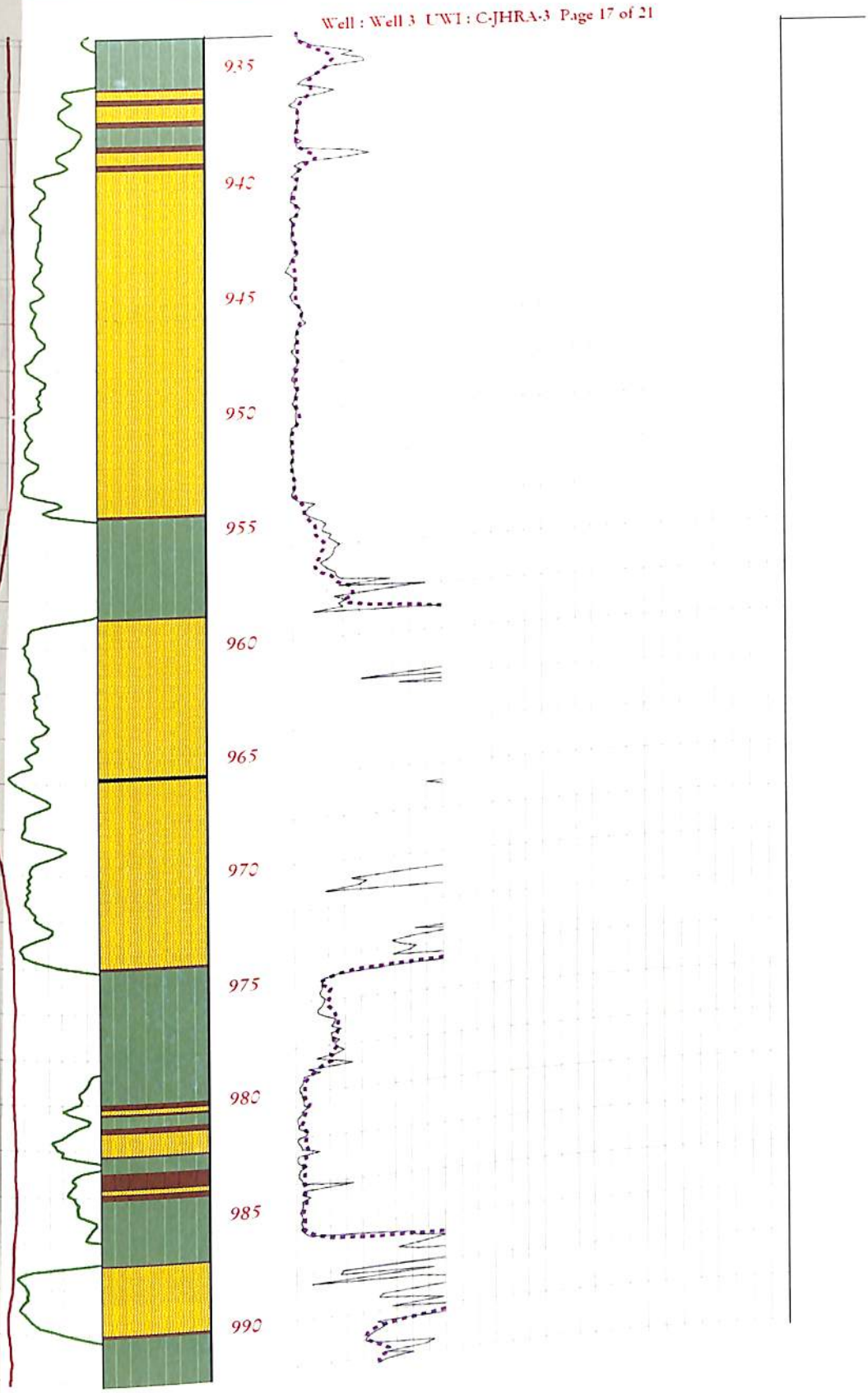
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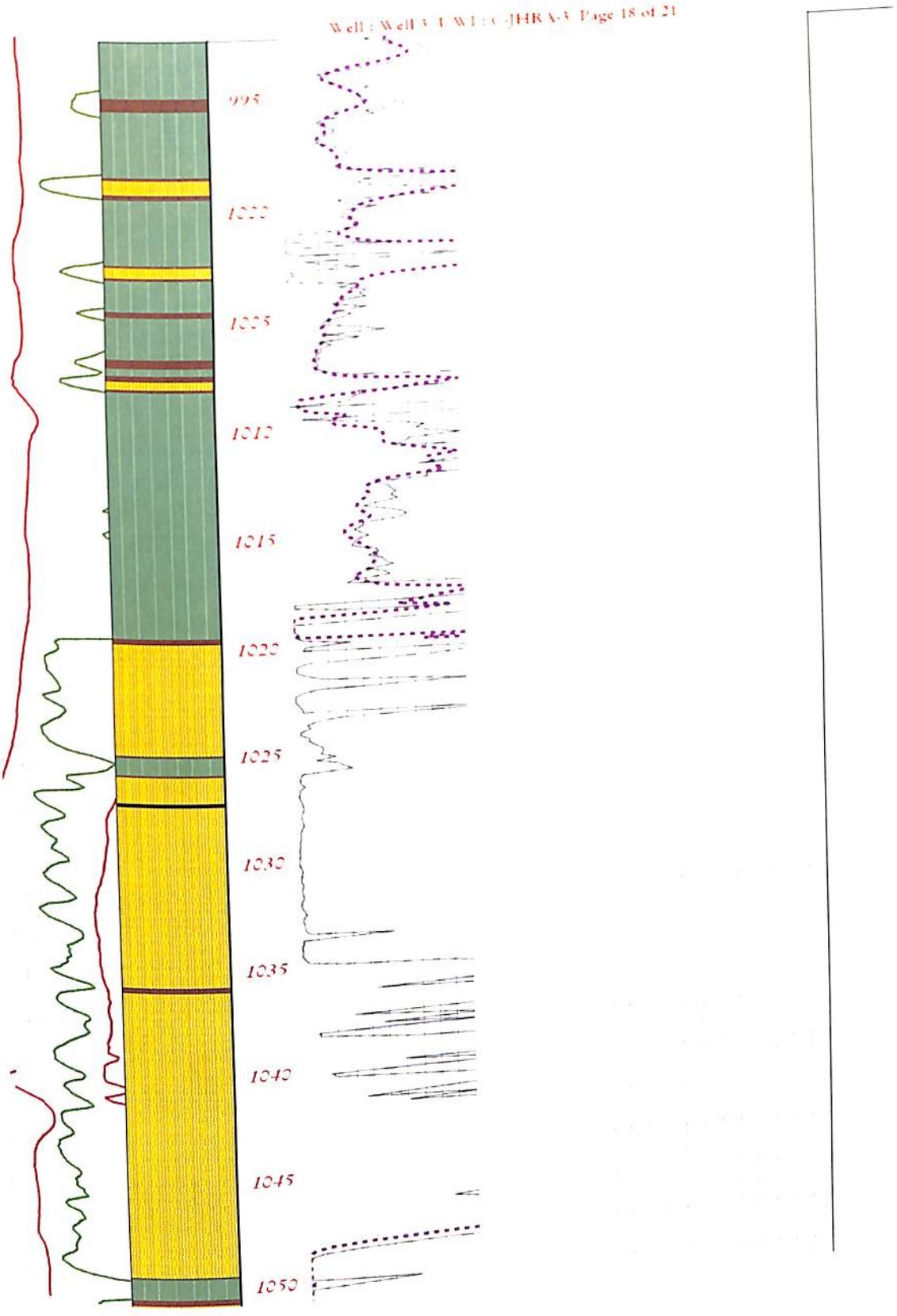
Well : Well 3 : WI : C:\JHRA\3 Page 18 of 21
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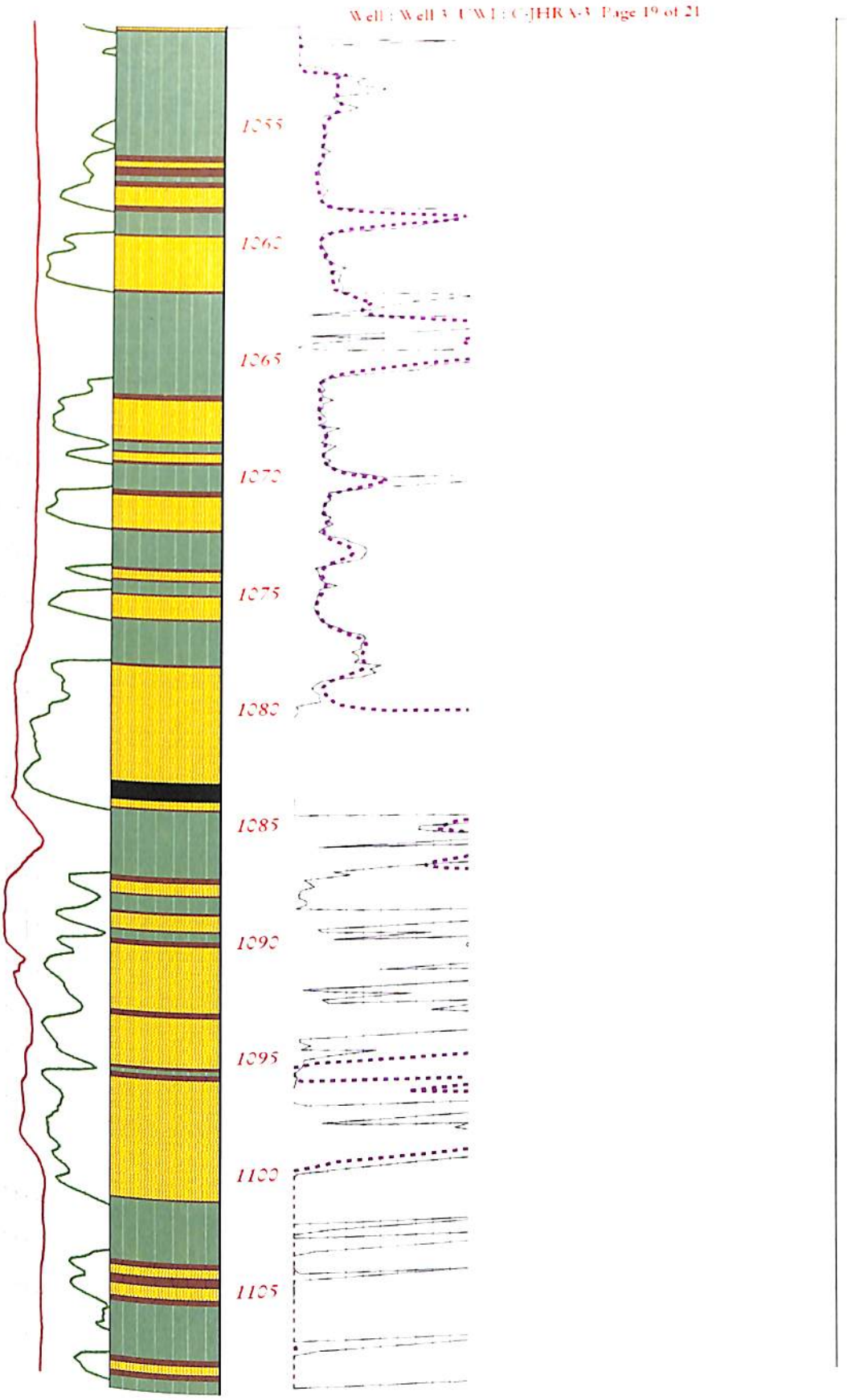
1050


Well : Well 3 UWI : C-JHRA-3 Page 19 of 21
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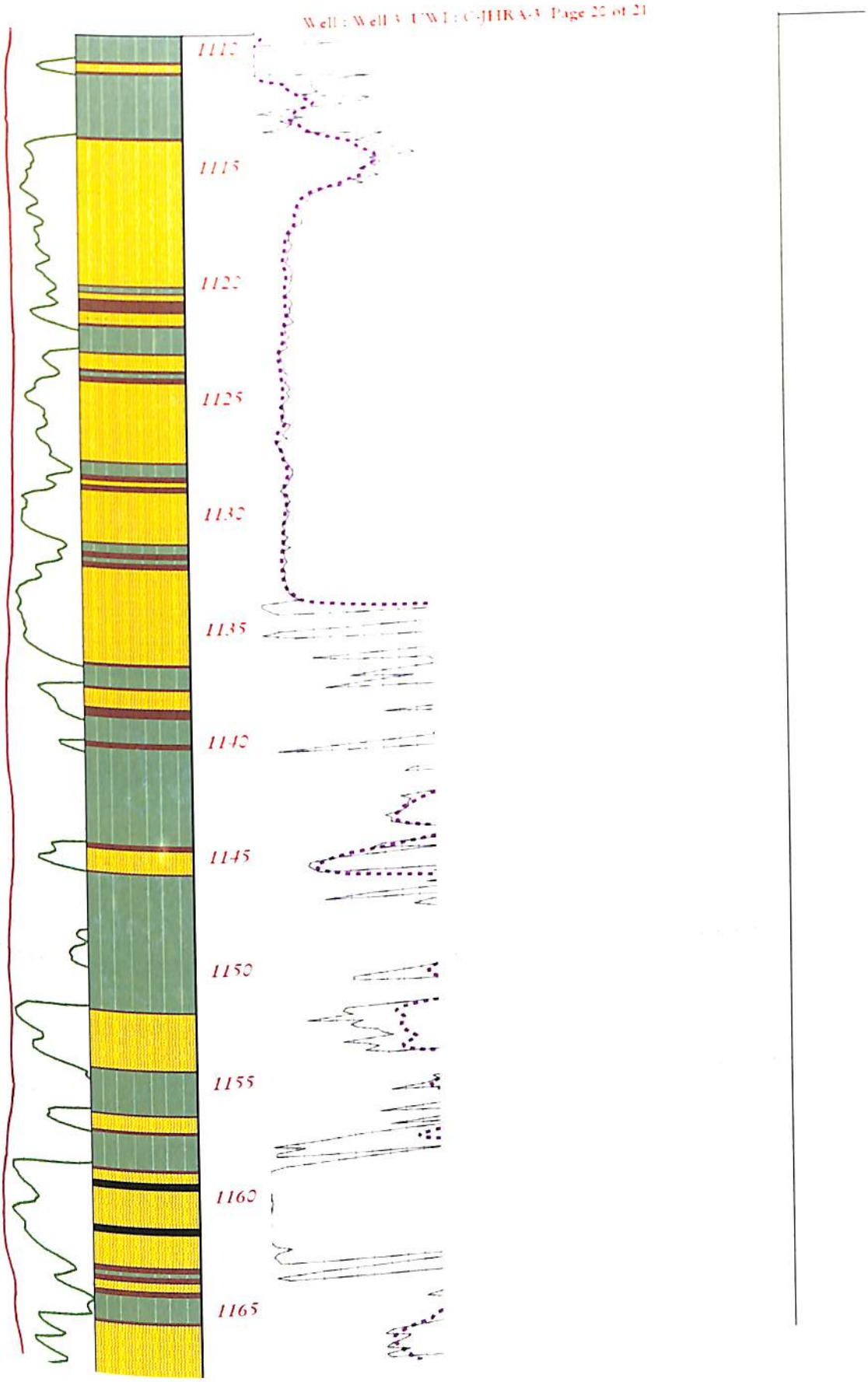
Well : Well-3 (UWI : C-JHRA-3 Page 20 of 21
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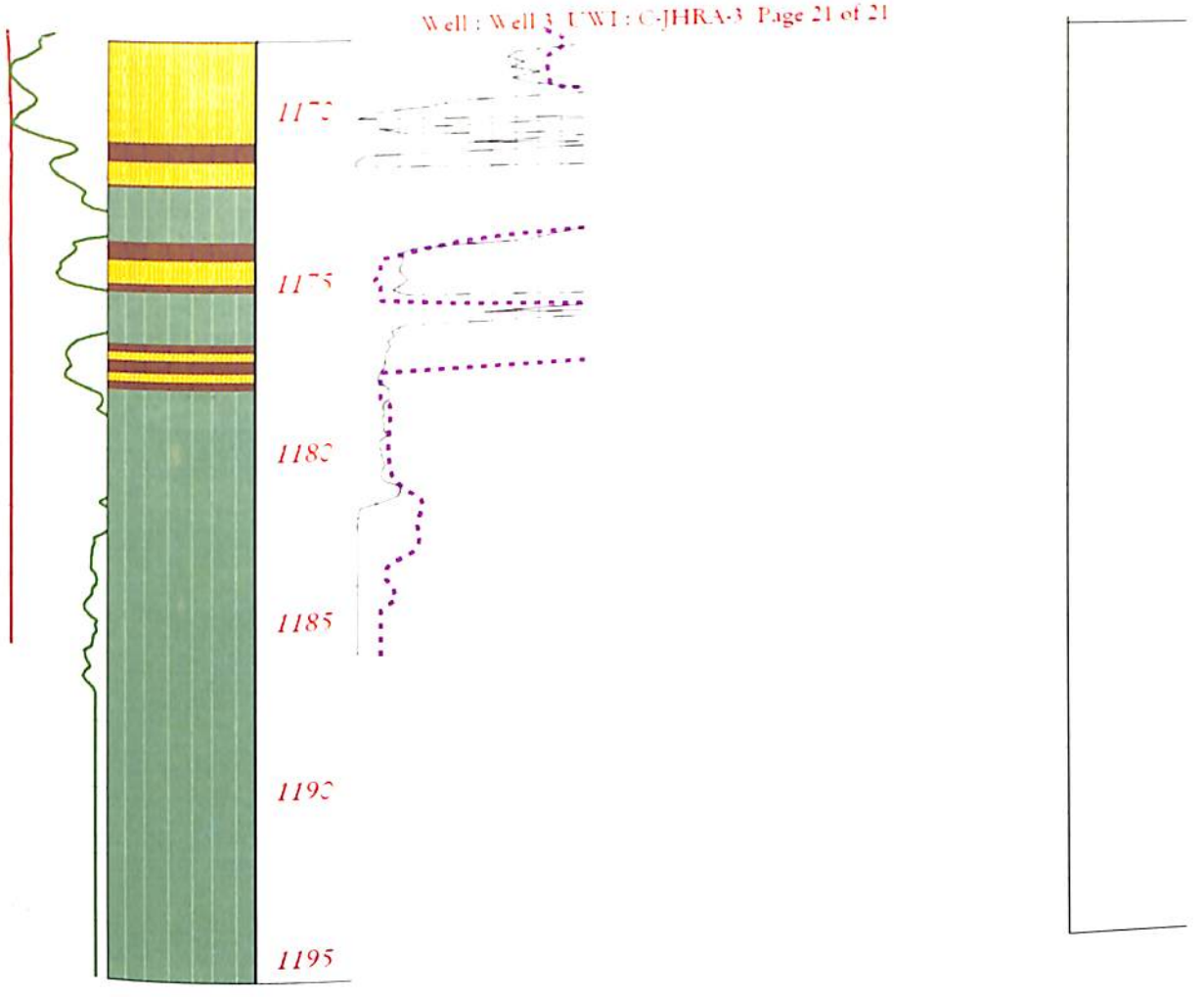
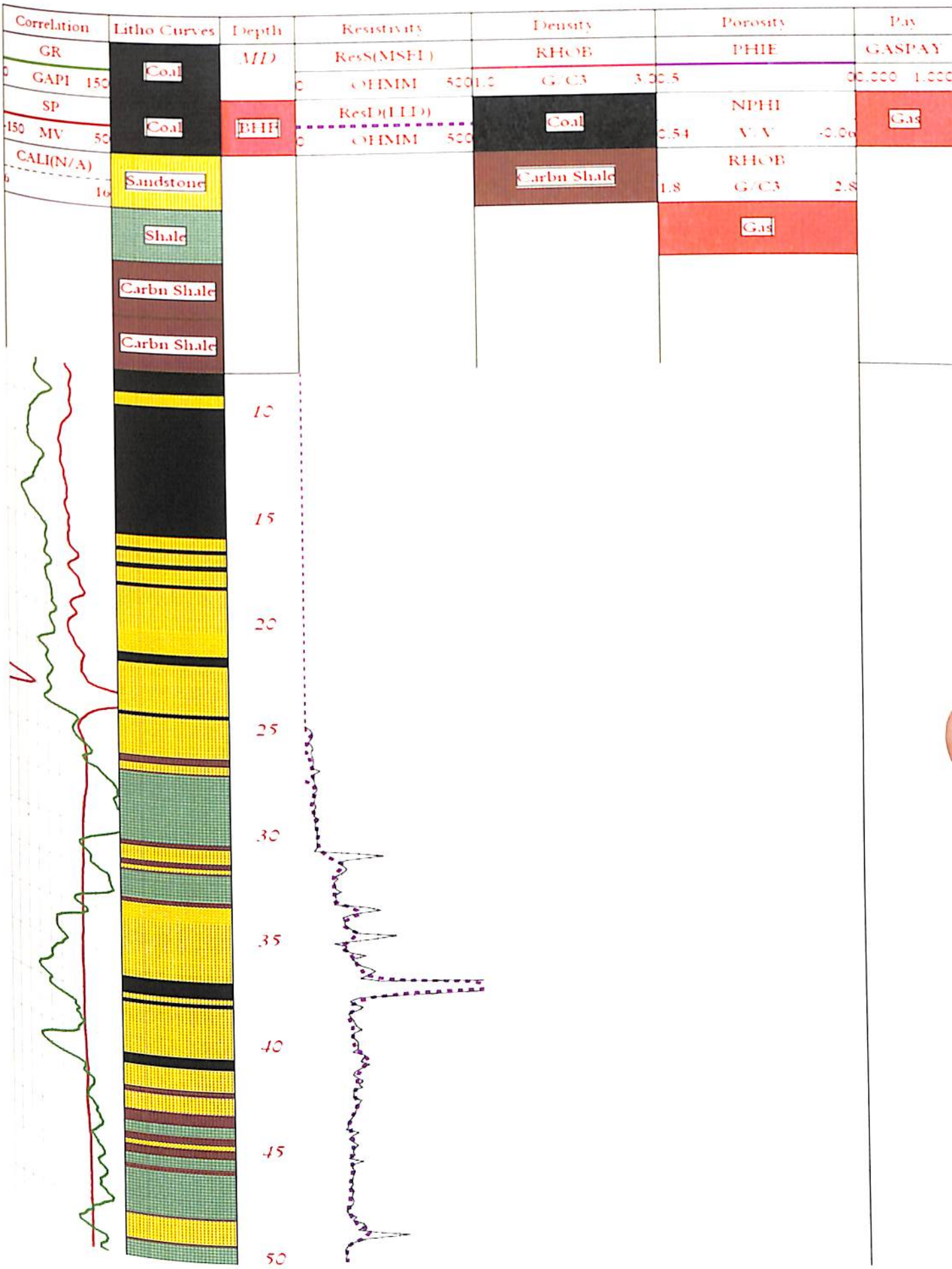


FIGURE:7.6 WELL LOG ANALYSIS OF THE THIRD WELL C(JHRA-3)

The Well log analysis of the 4th Major well for our area of Interest is shown below with the help of Figure 7.7.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Litho Curves
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Resistivity
Density
Porosity
Pay
GR
GAPI
SP
MV
CALI(N/A)
MD
ResS(MSFL)
OHMM
ResD(LLD)
RHOB
G/C3
PHIE
NPHI
V/V
GASPAY
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Shale
Carbn Shale
Gas
BHR
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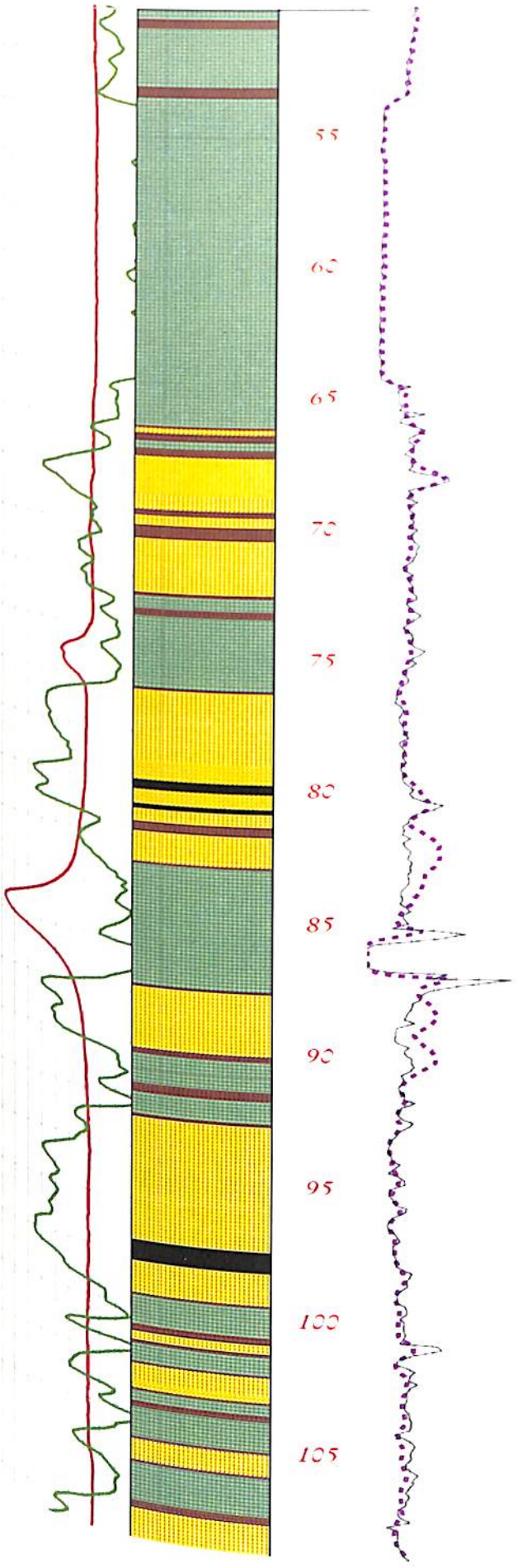
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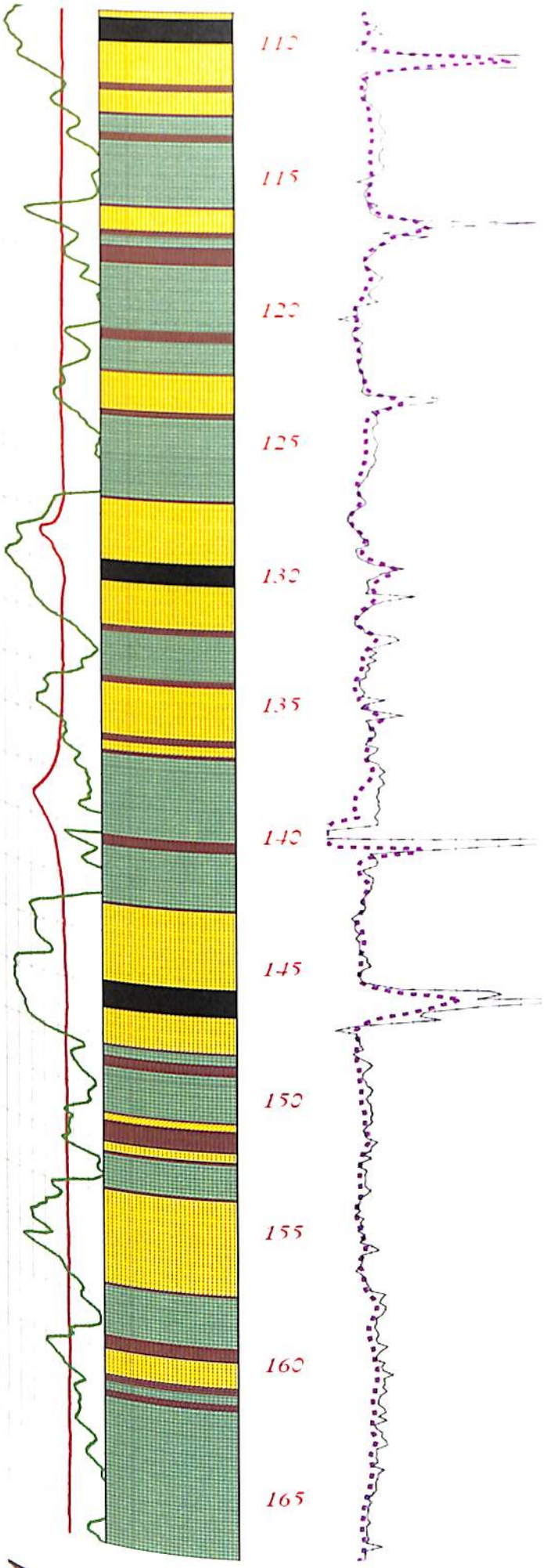
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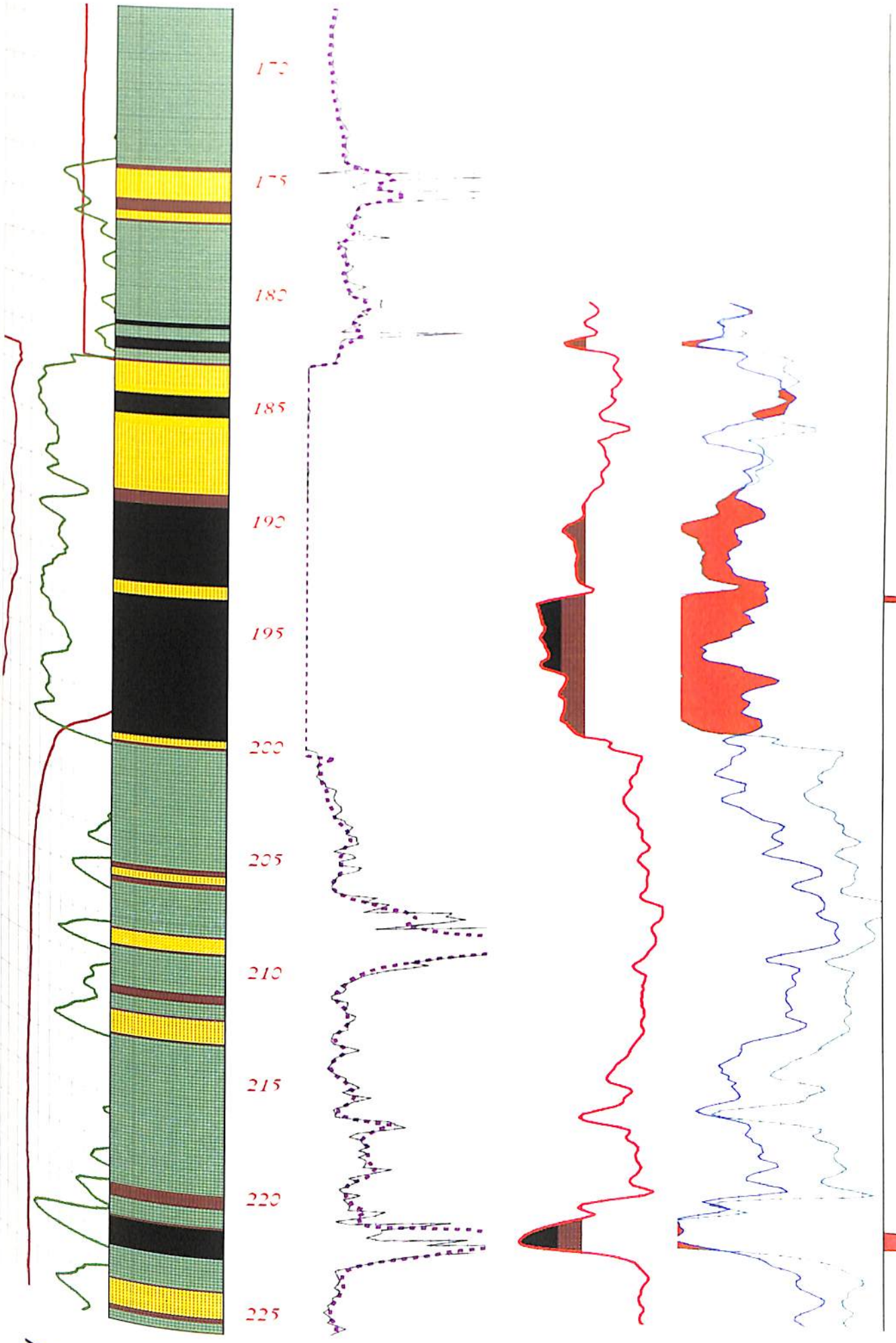
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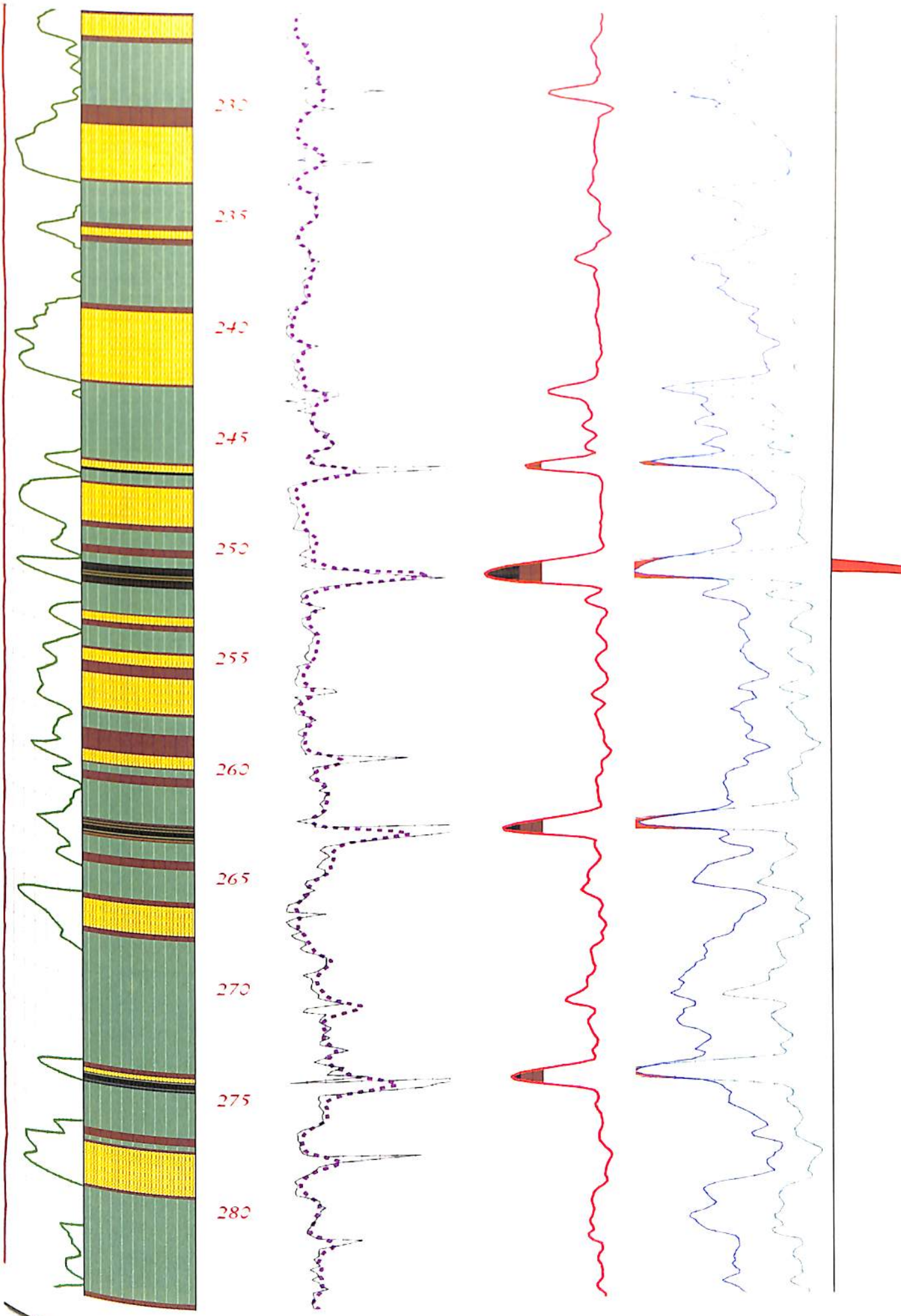
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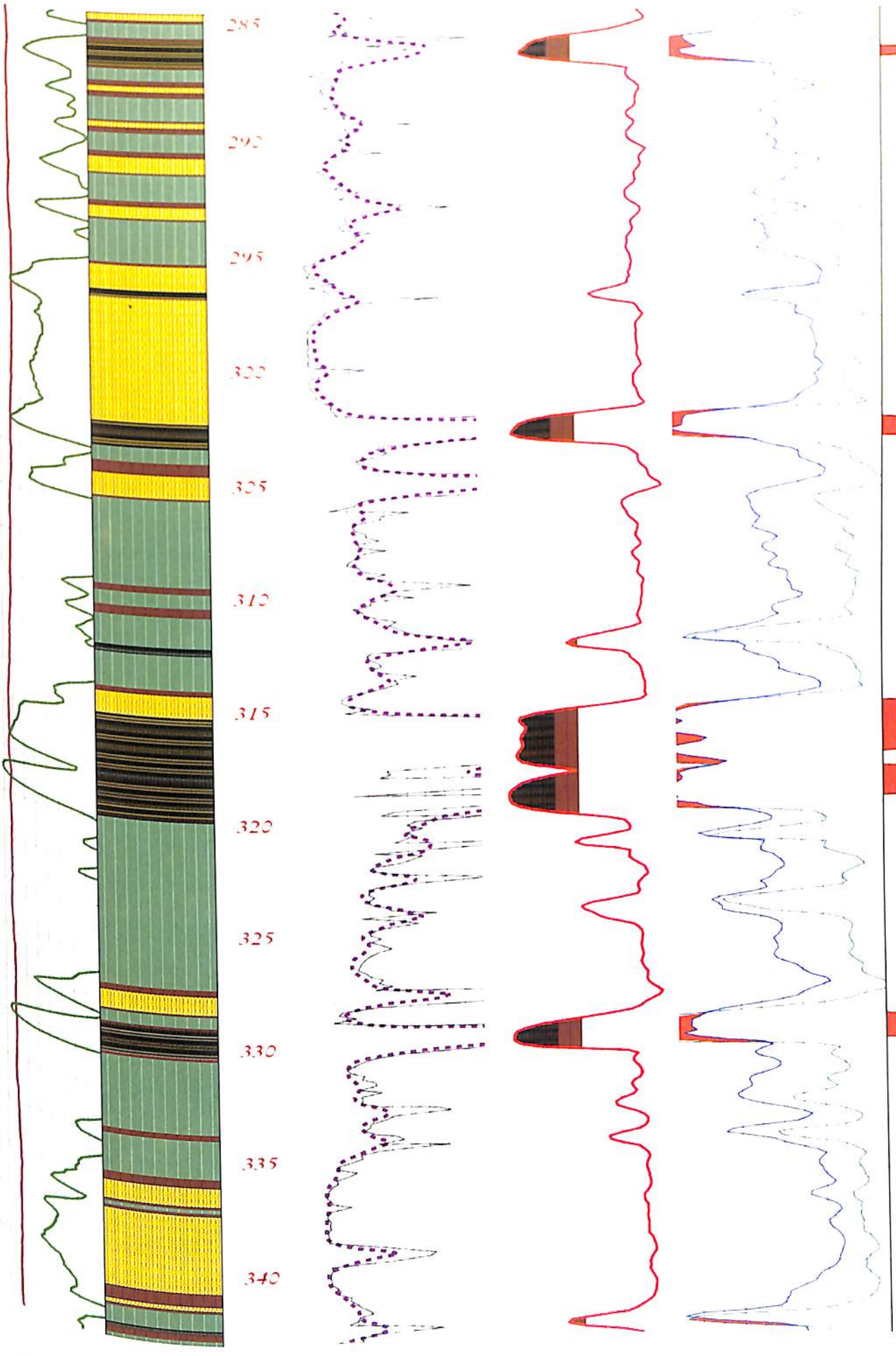
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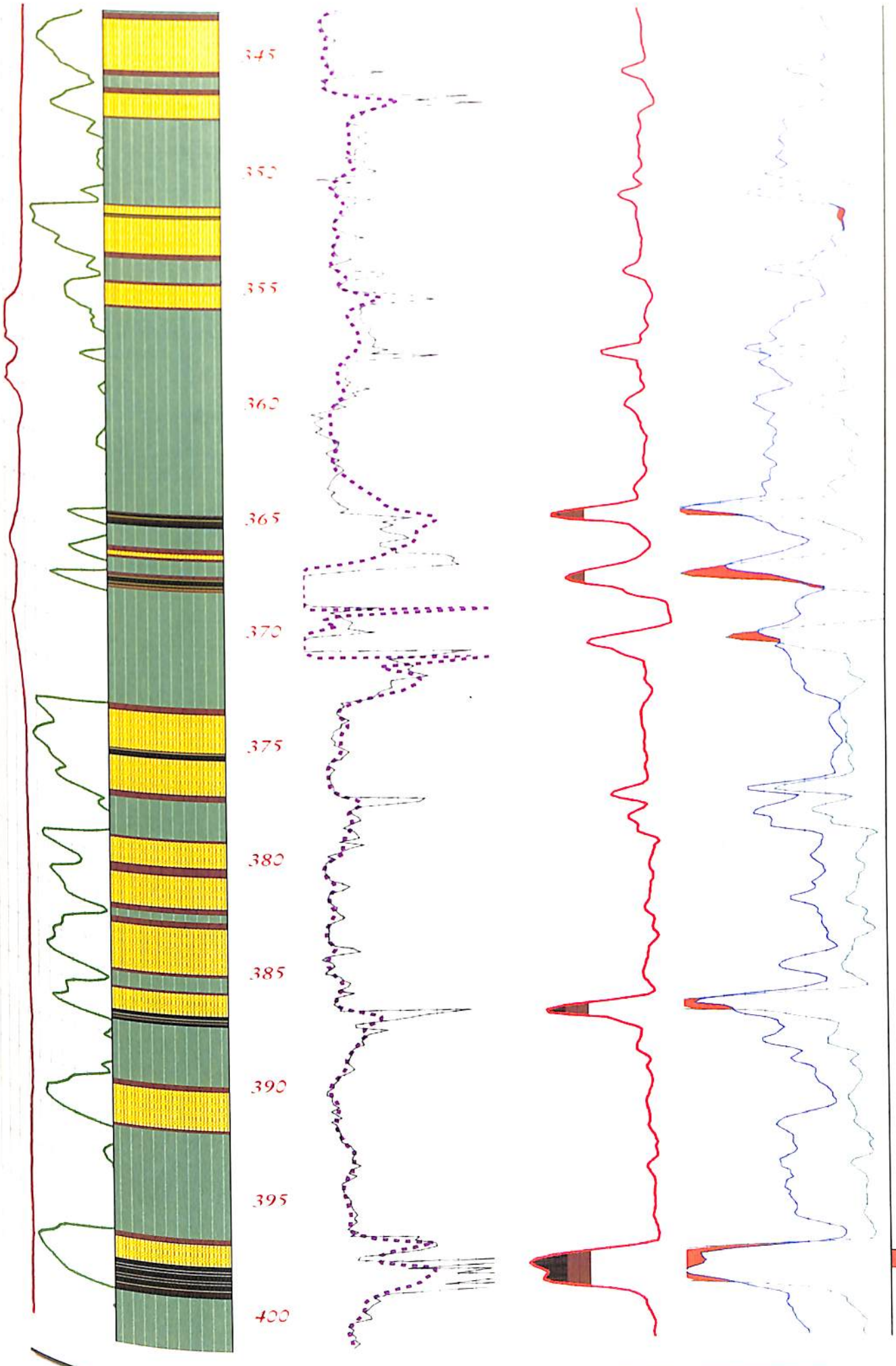
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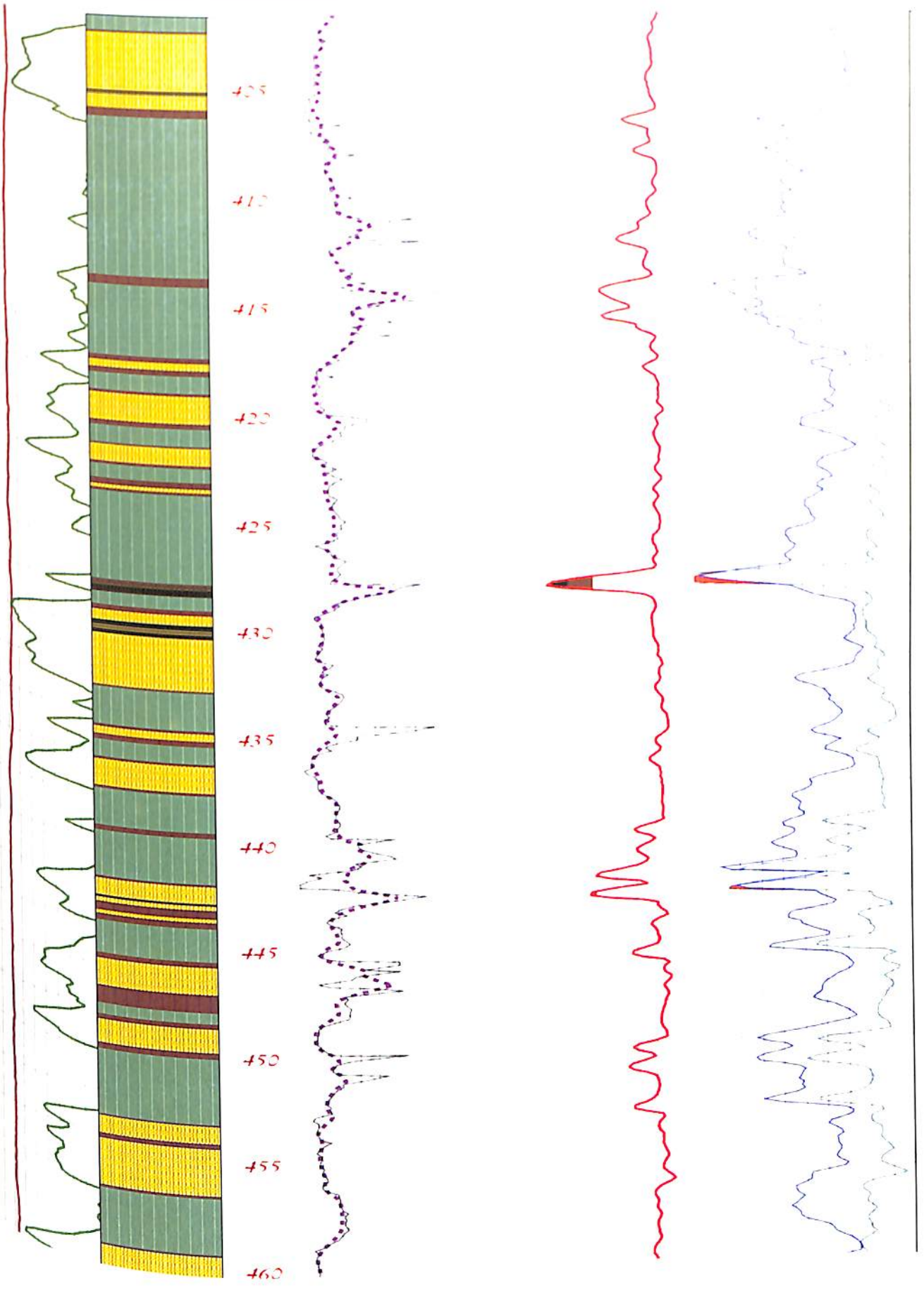
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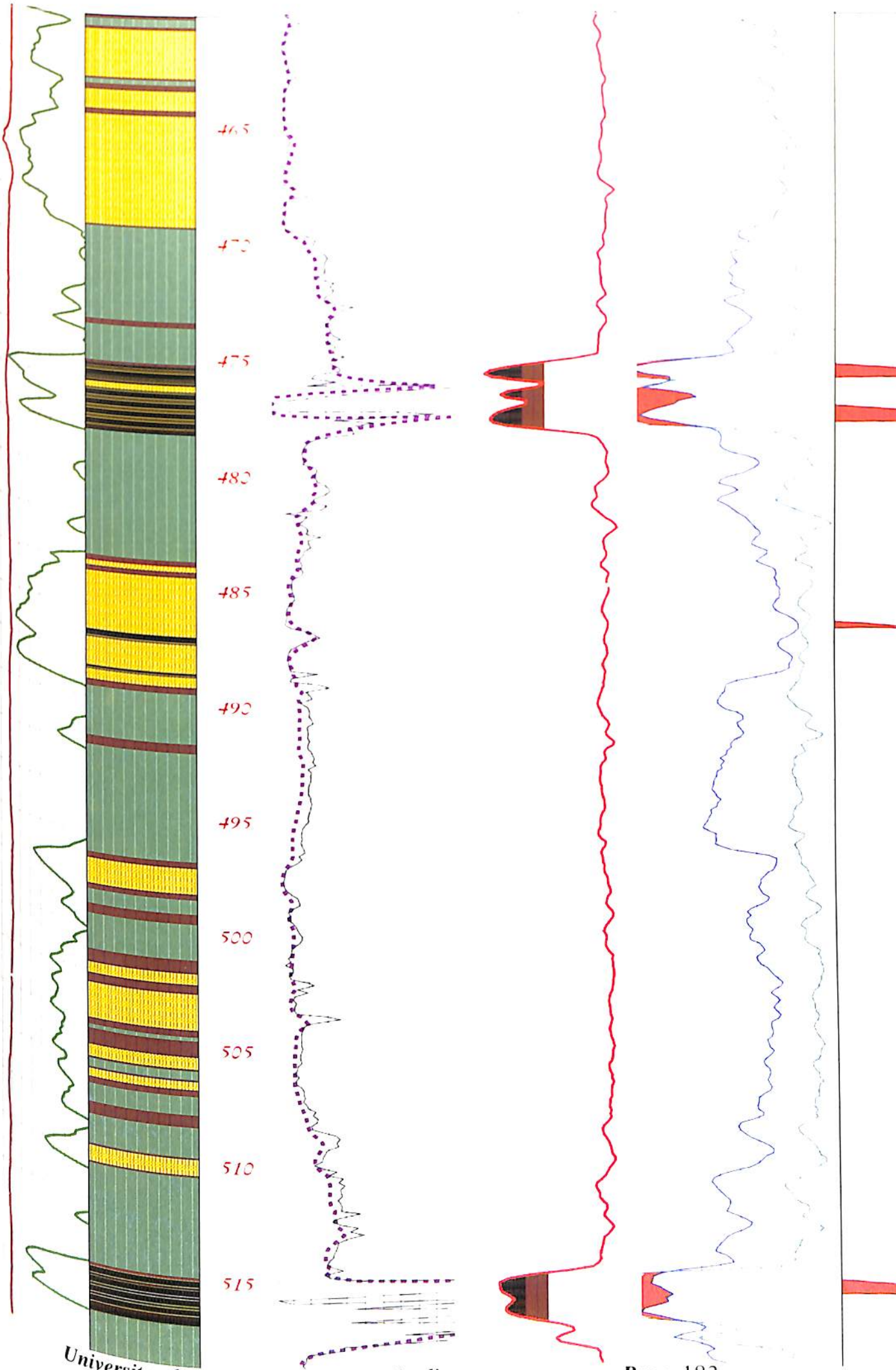
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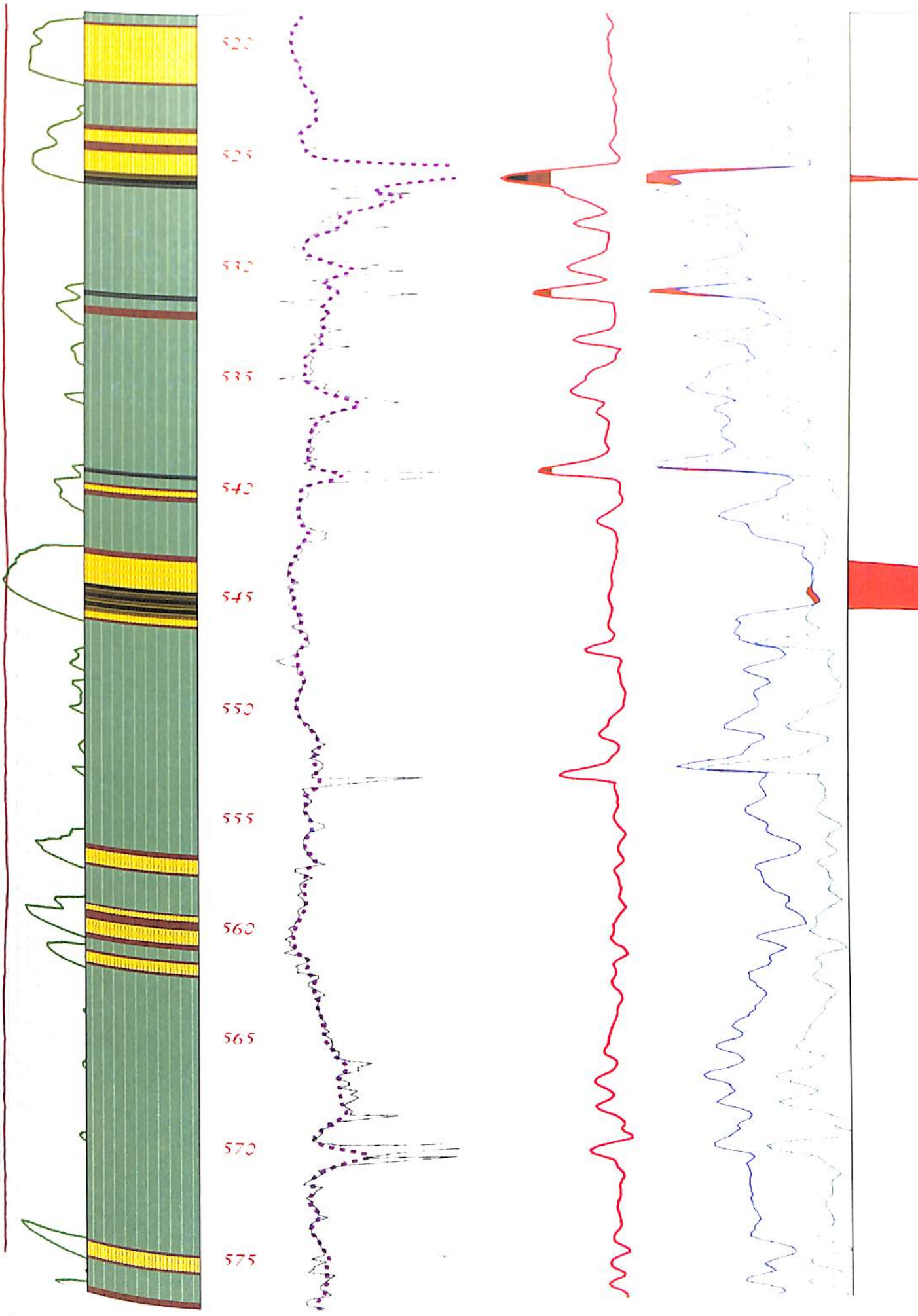
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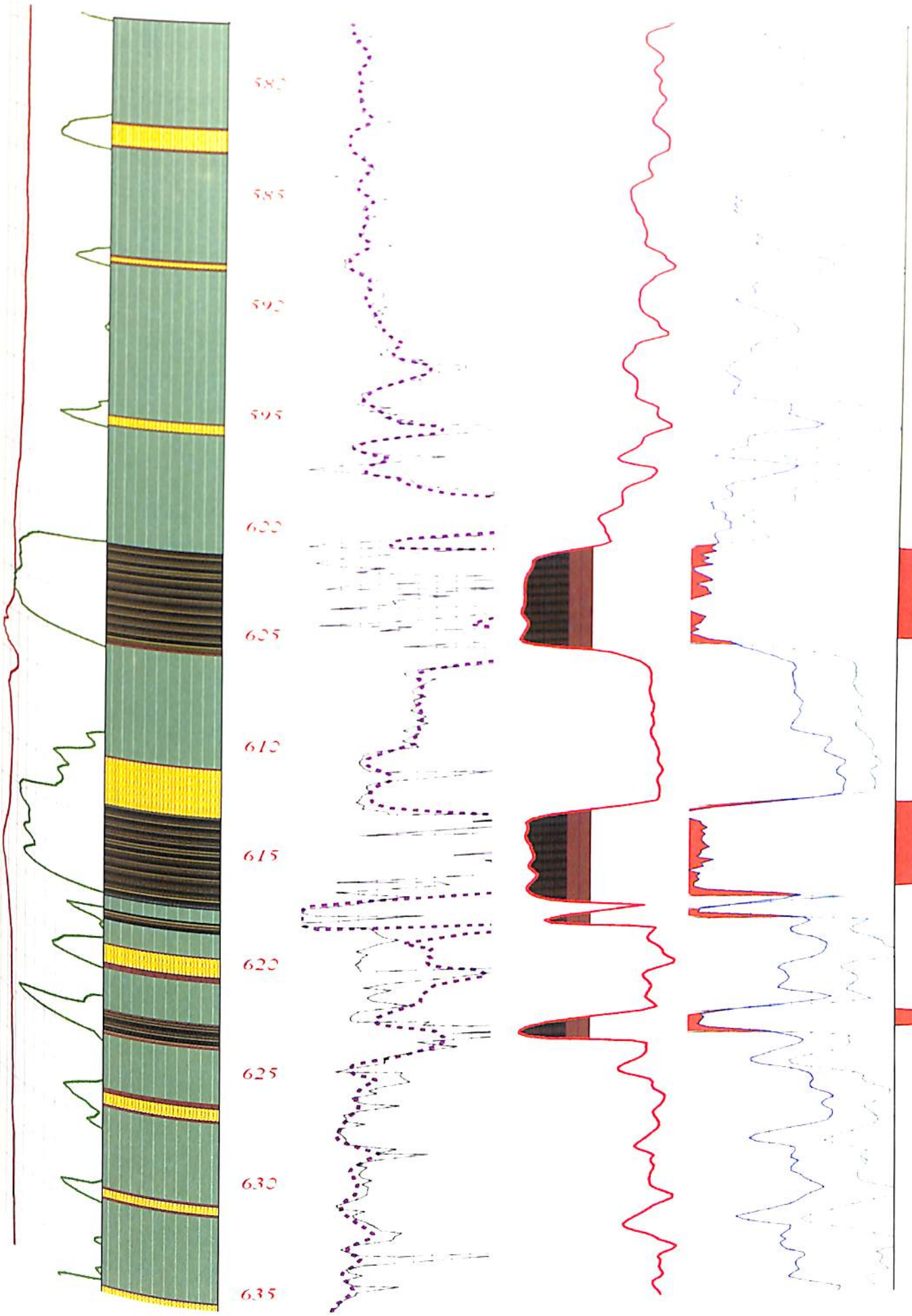
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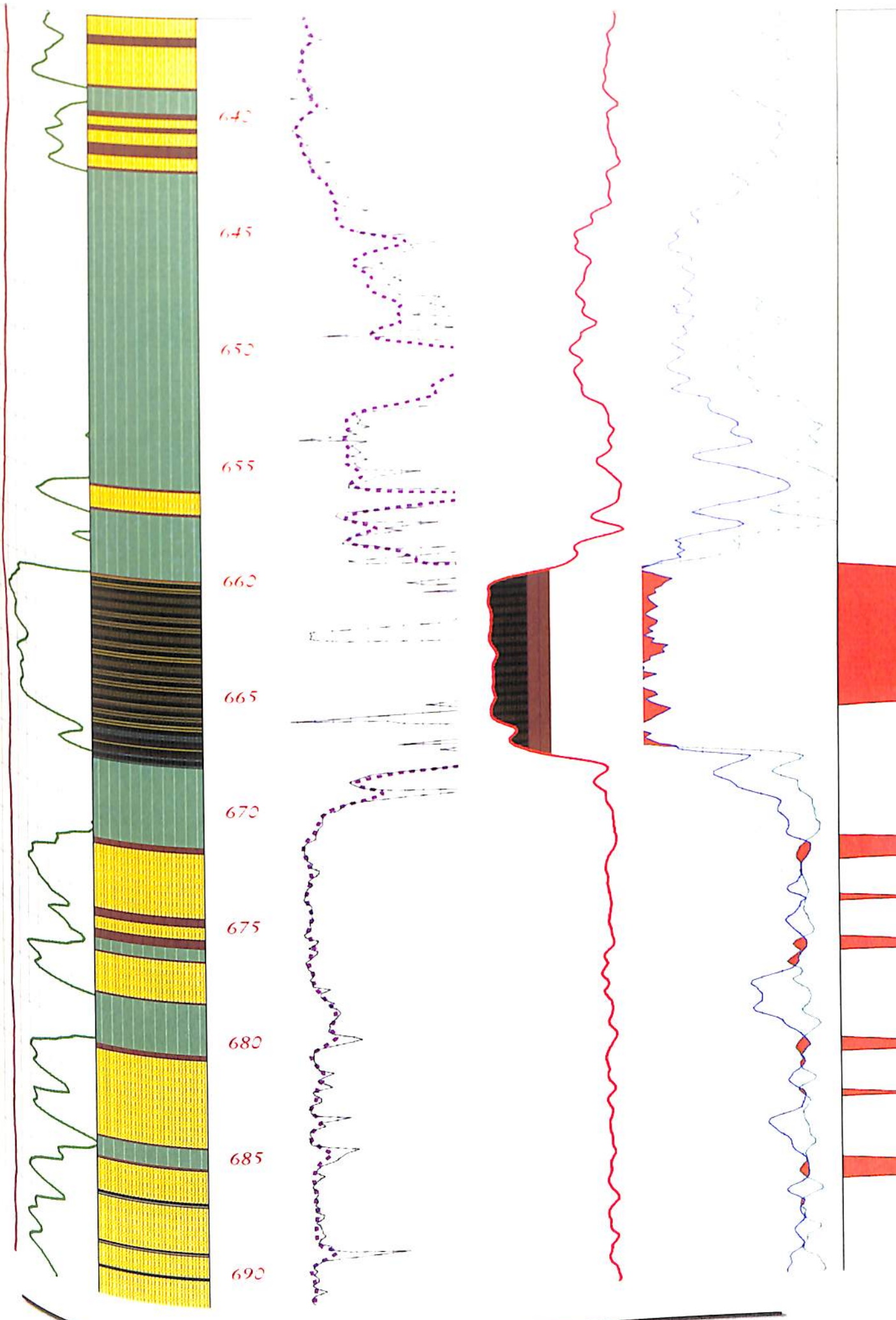
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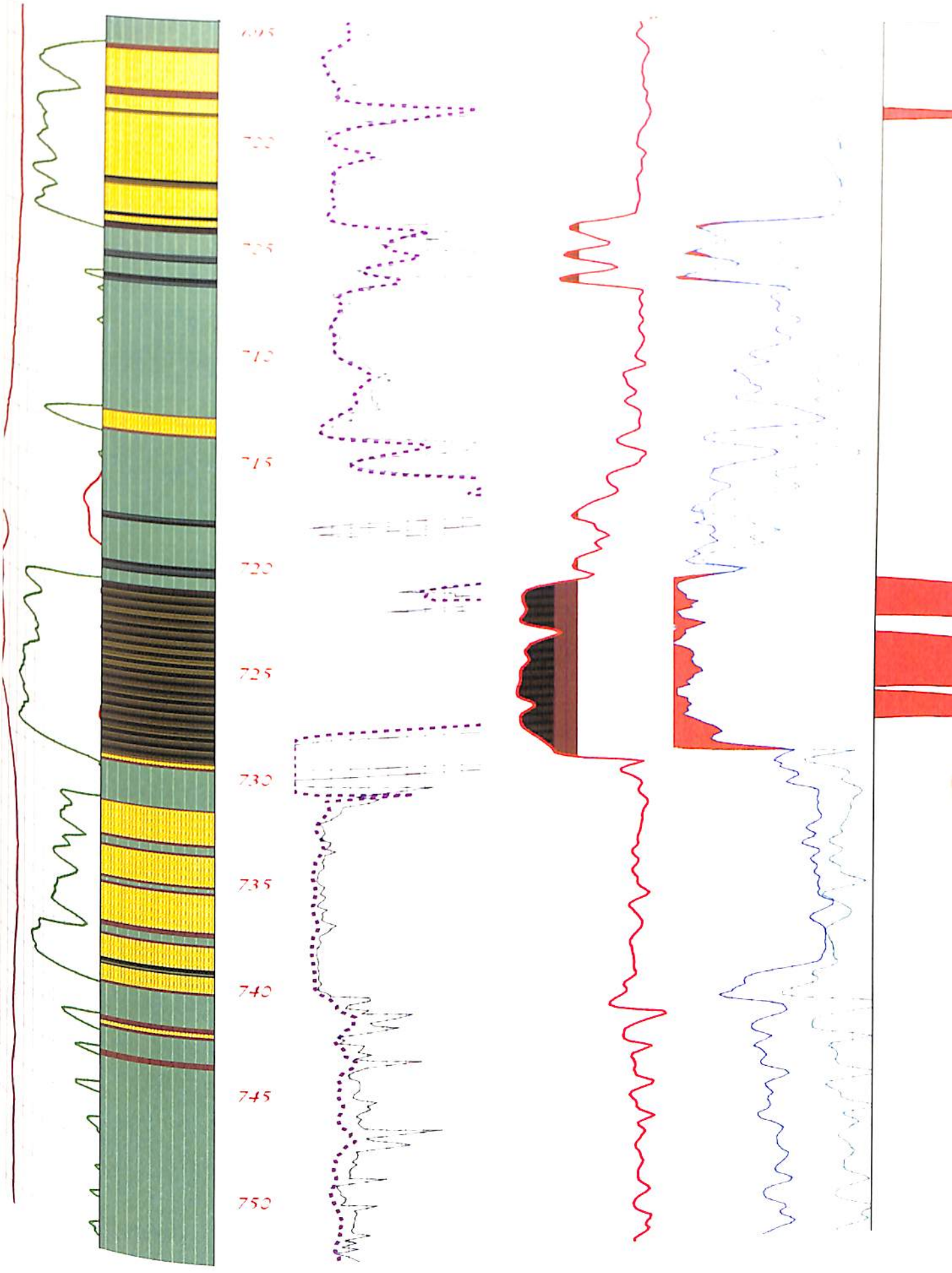
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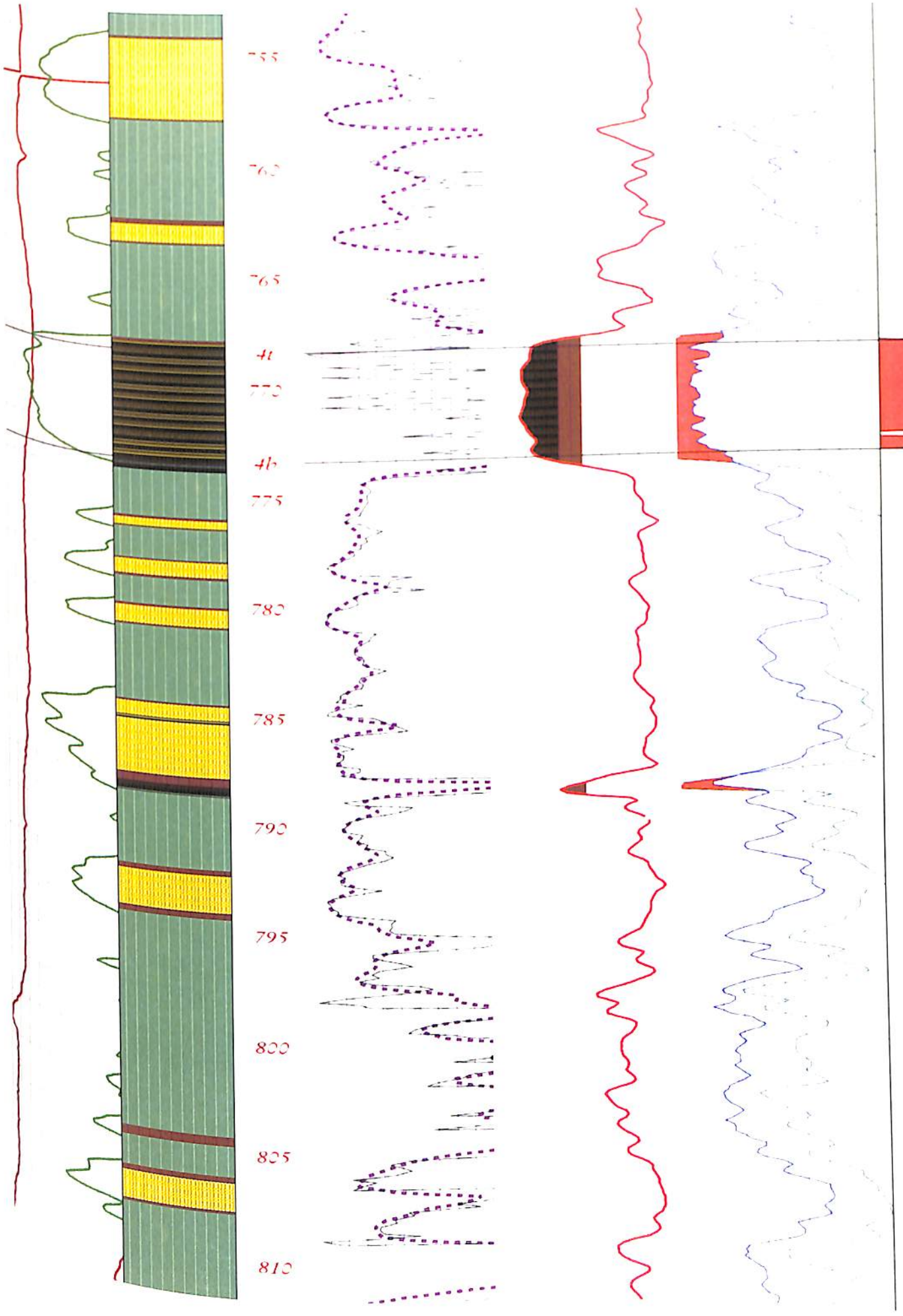
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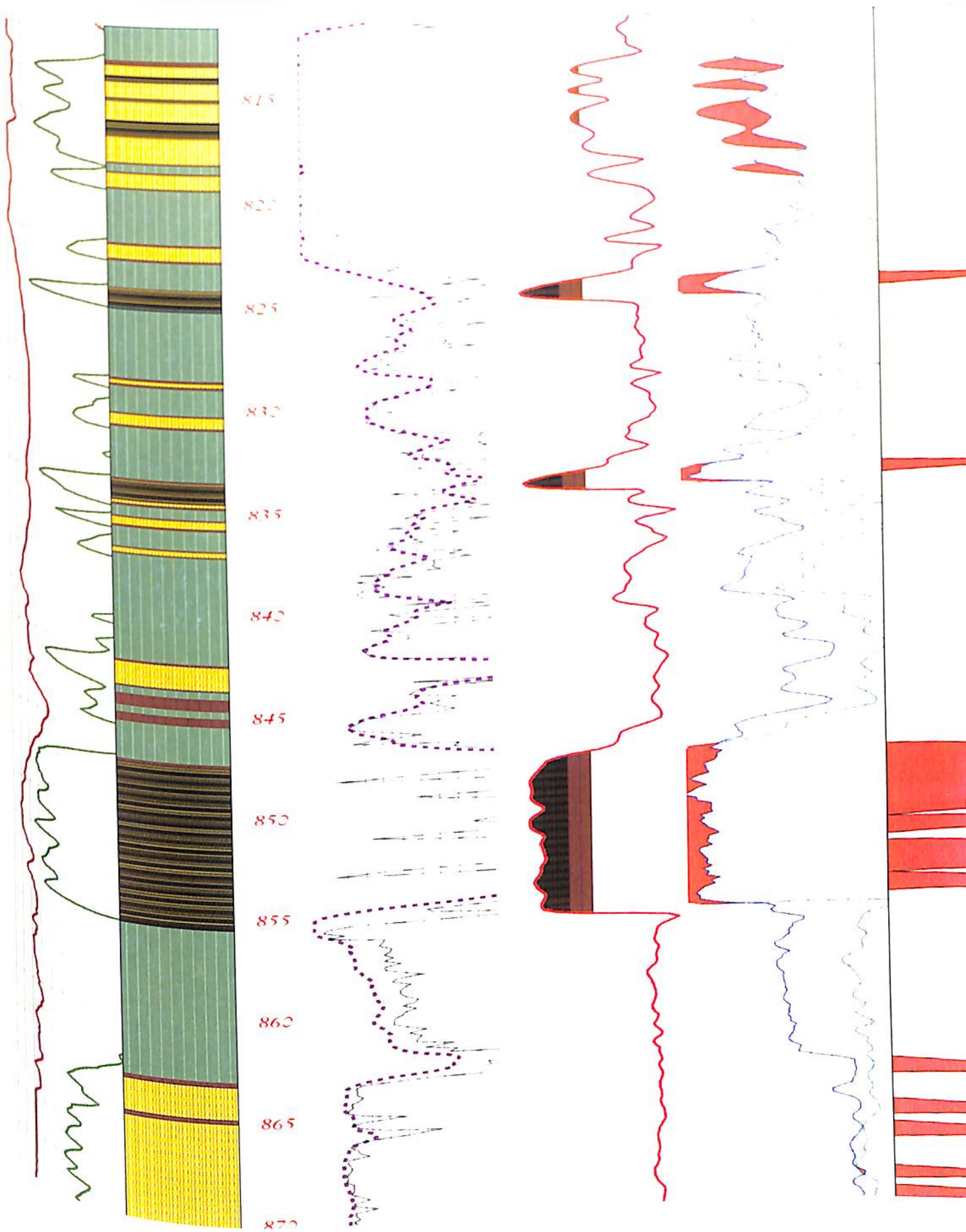
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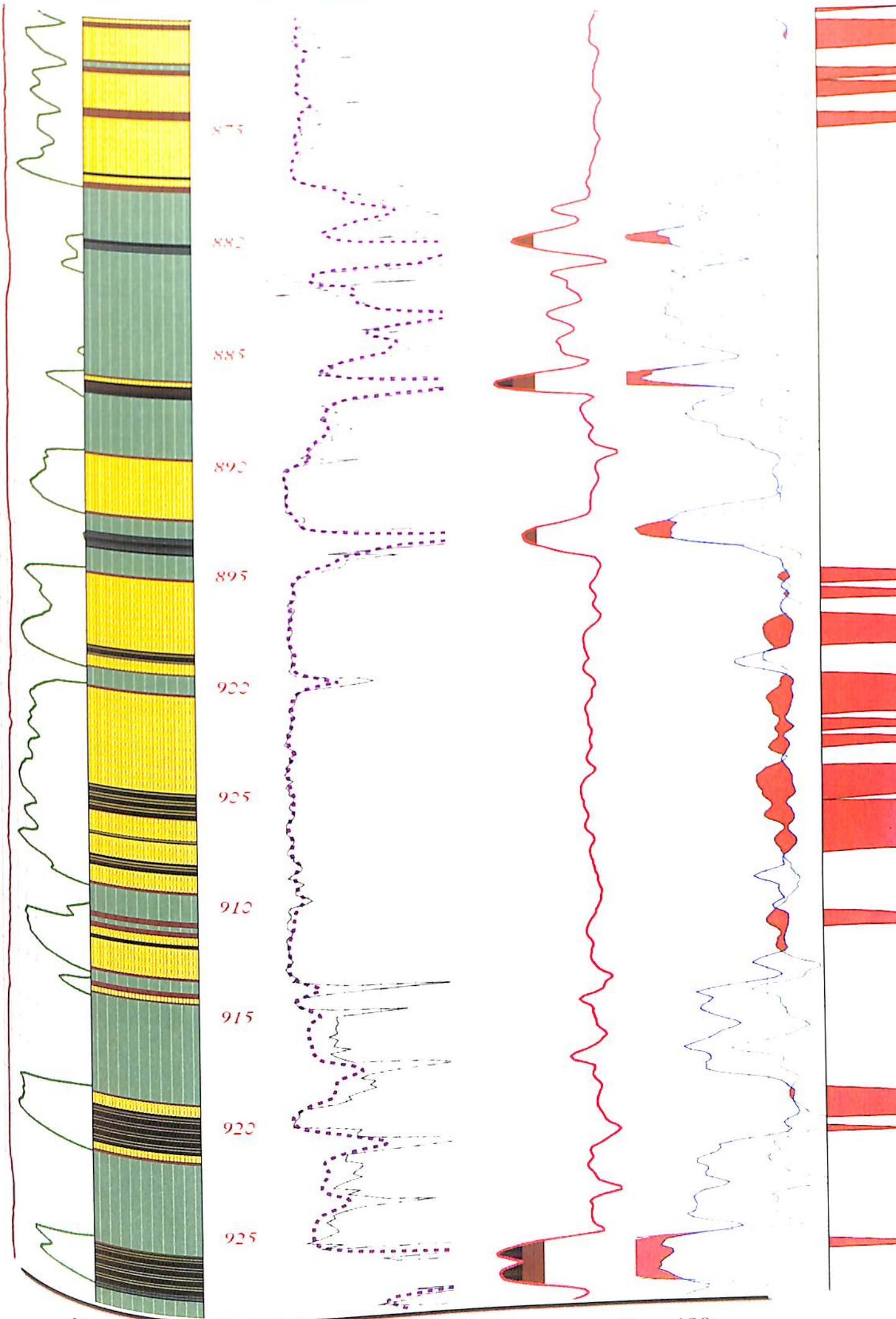
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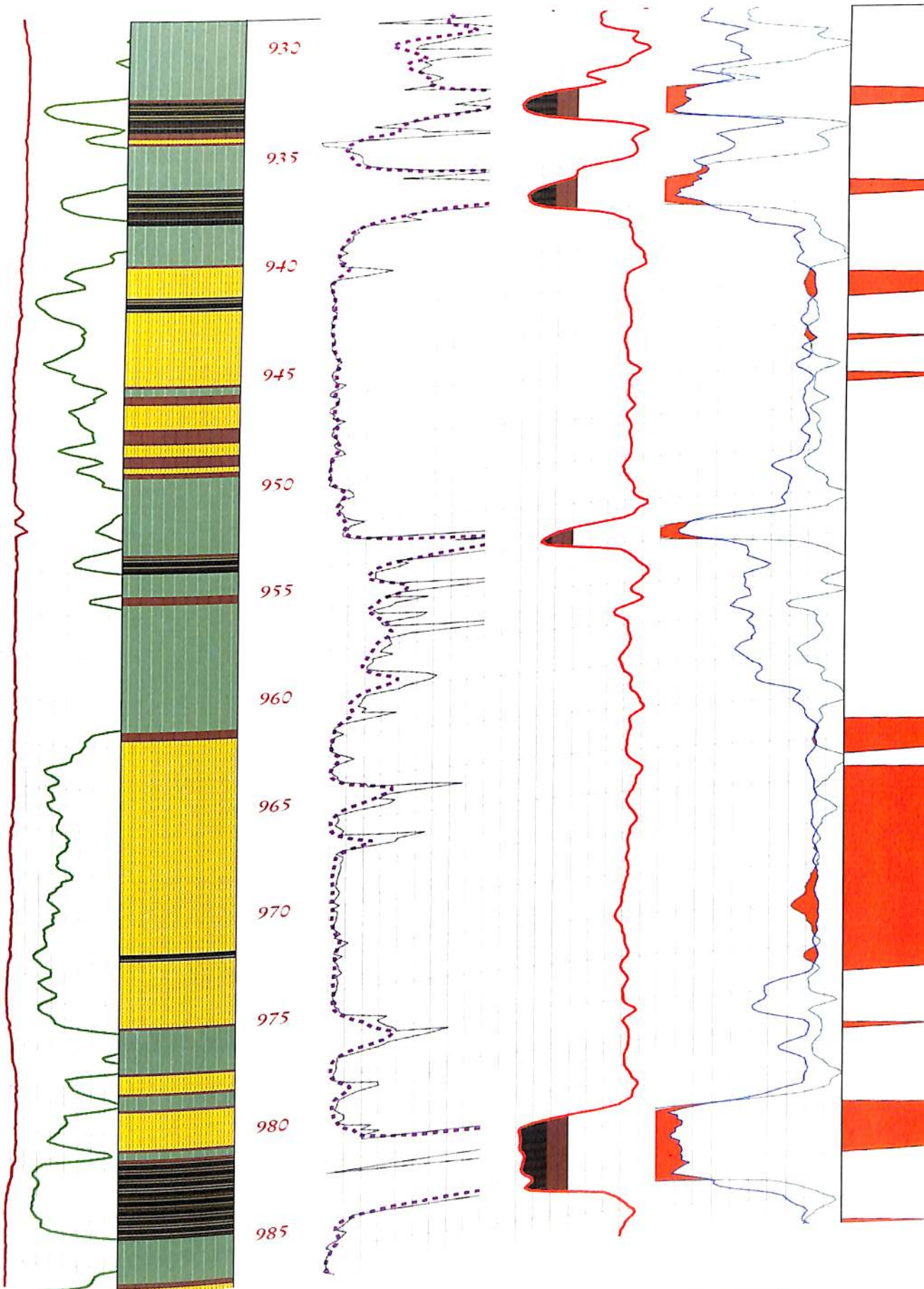
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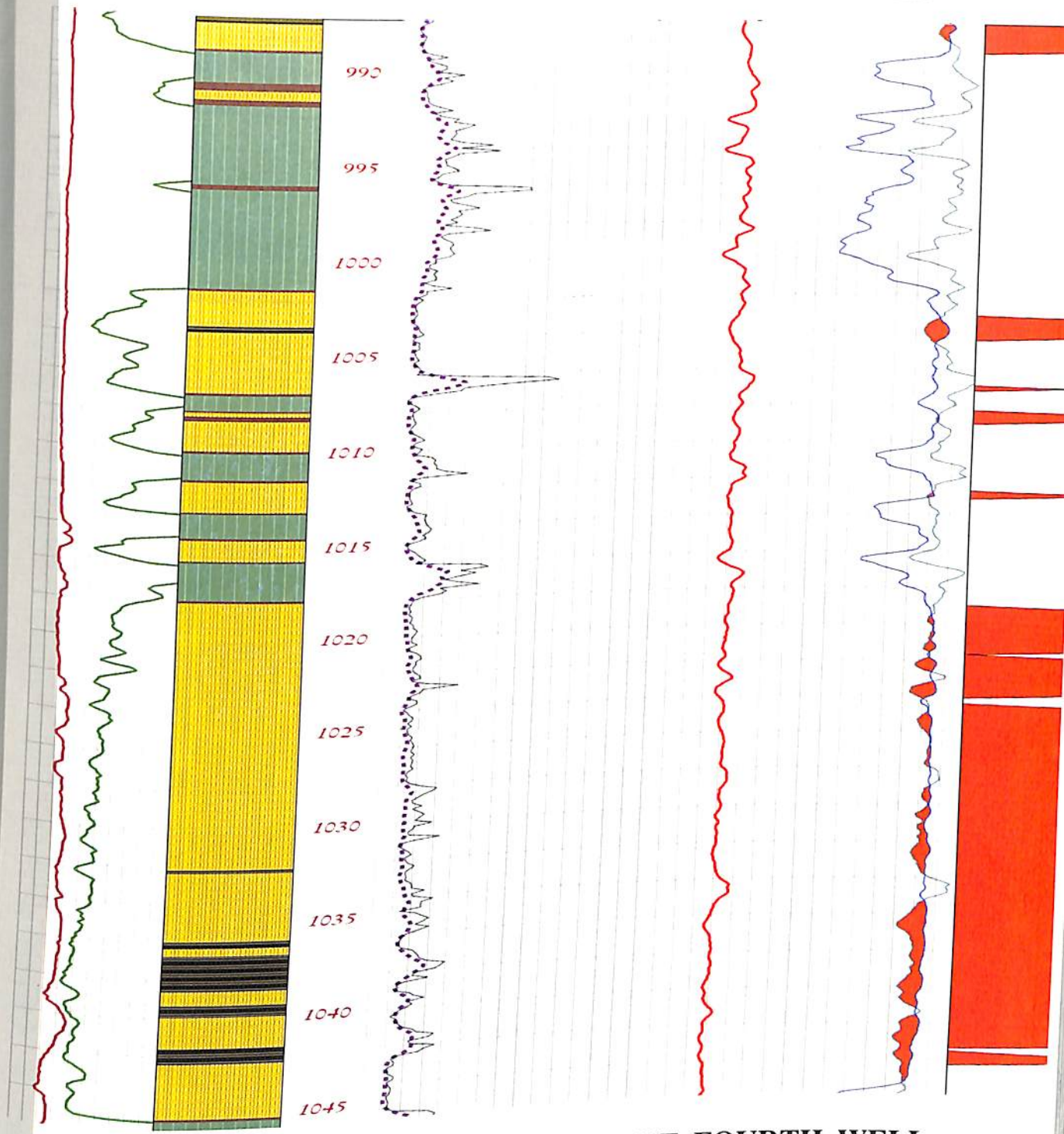
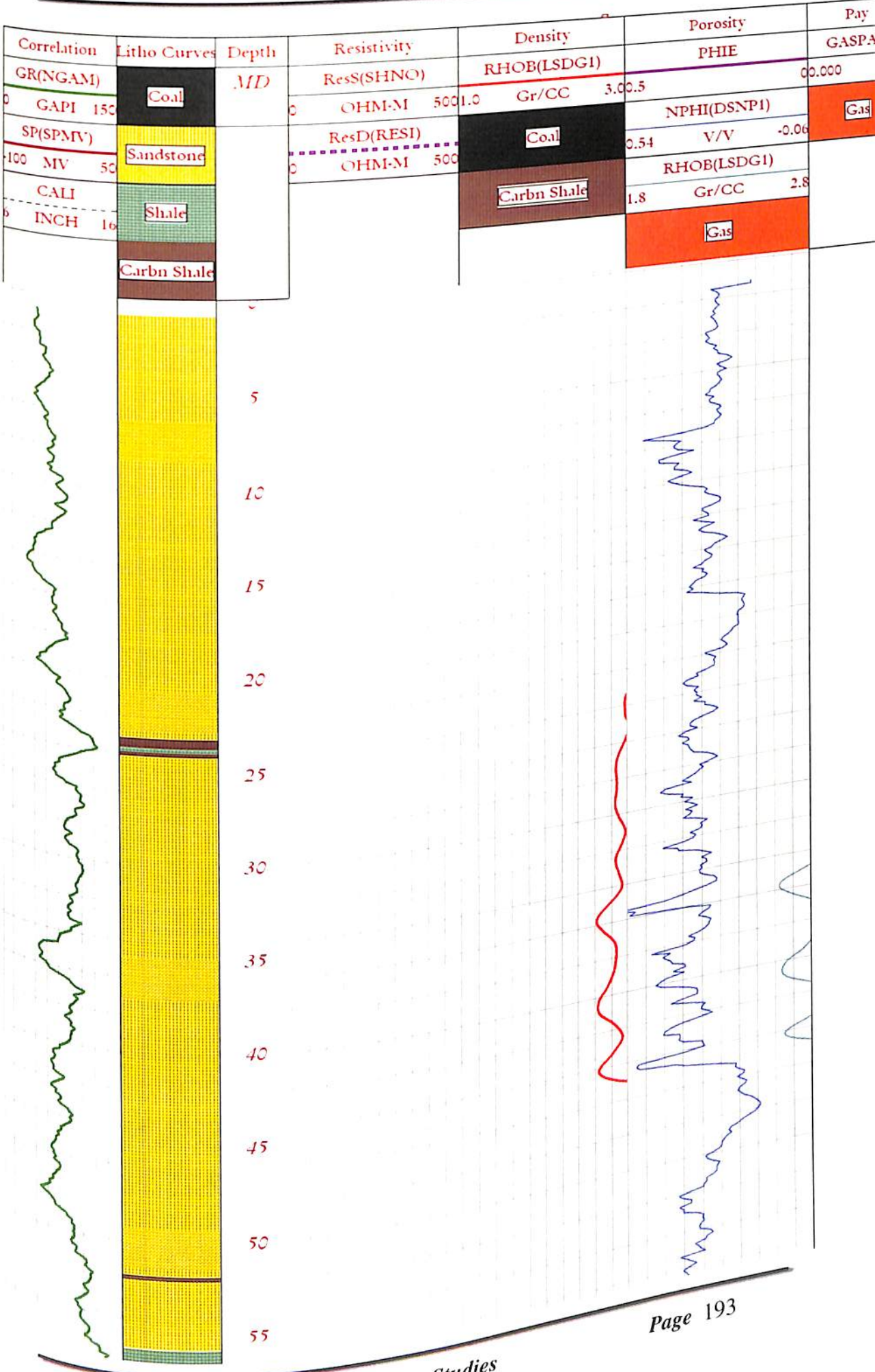


FIGURE:7.7 WELL LOG ANALYSIS OF THE FOURTH WELL D(JHRA-4)

Well logging analysis for core well 1,Core-well 2 and core-well 3 are shown below.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Litho Curves
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Resistivity
Density
Porosity
Pay
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GAPI
SP(SPMV)
MV
CALI
INCH
MD
ResS(SHNO)
OHM-M
ResD(RESI)
OHM-M
RHOB(LSDG1)
Gr/CC
PHIE
NPHI(DSNP1)
V/V
RHOB(LSDG1)
Gr/CC
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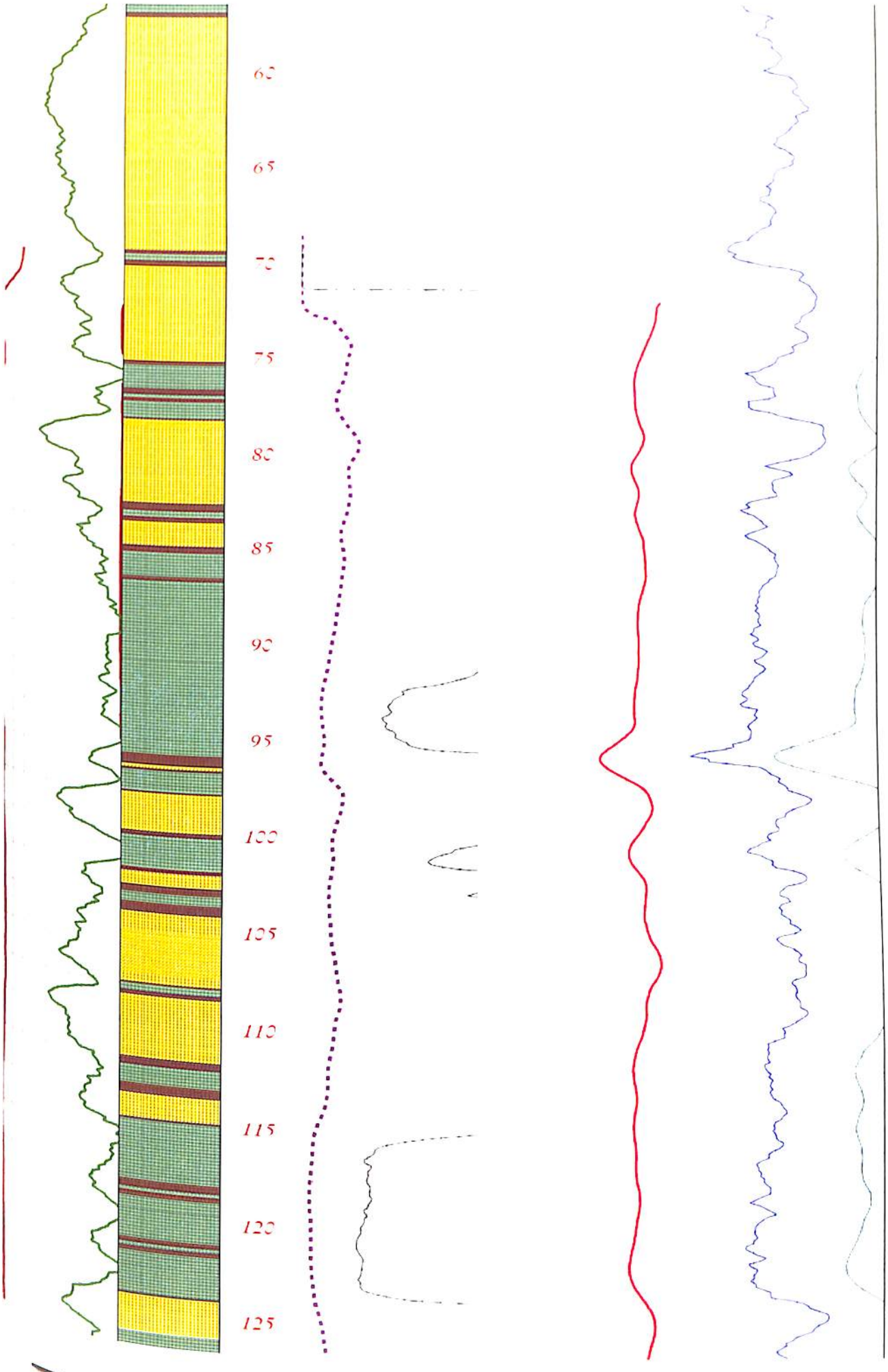
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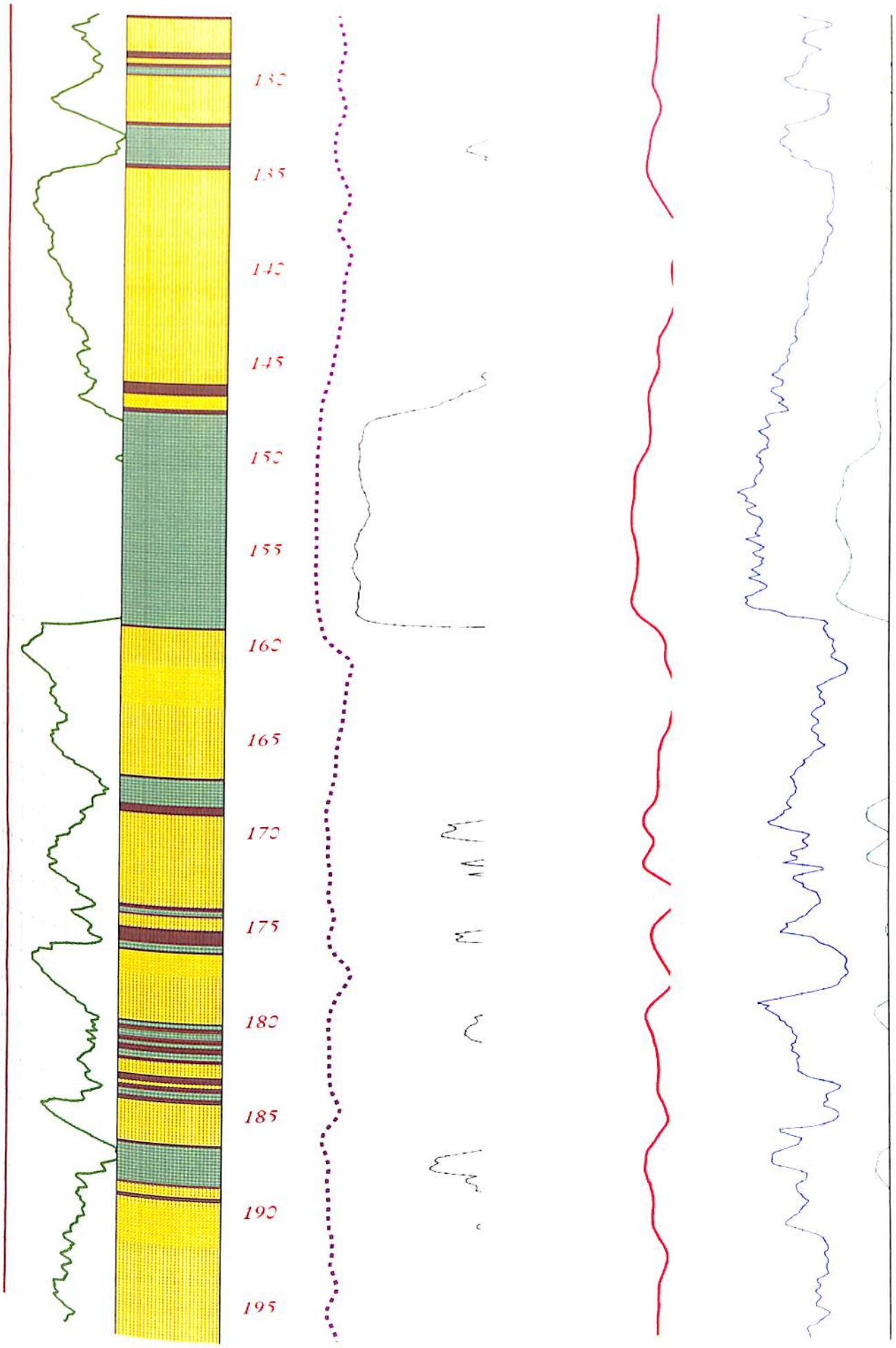
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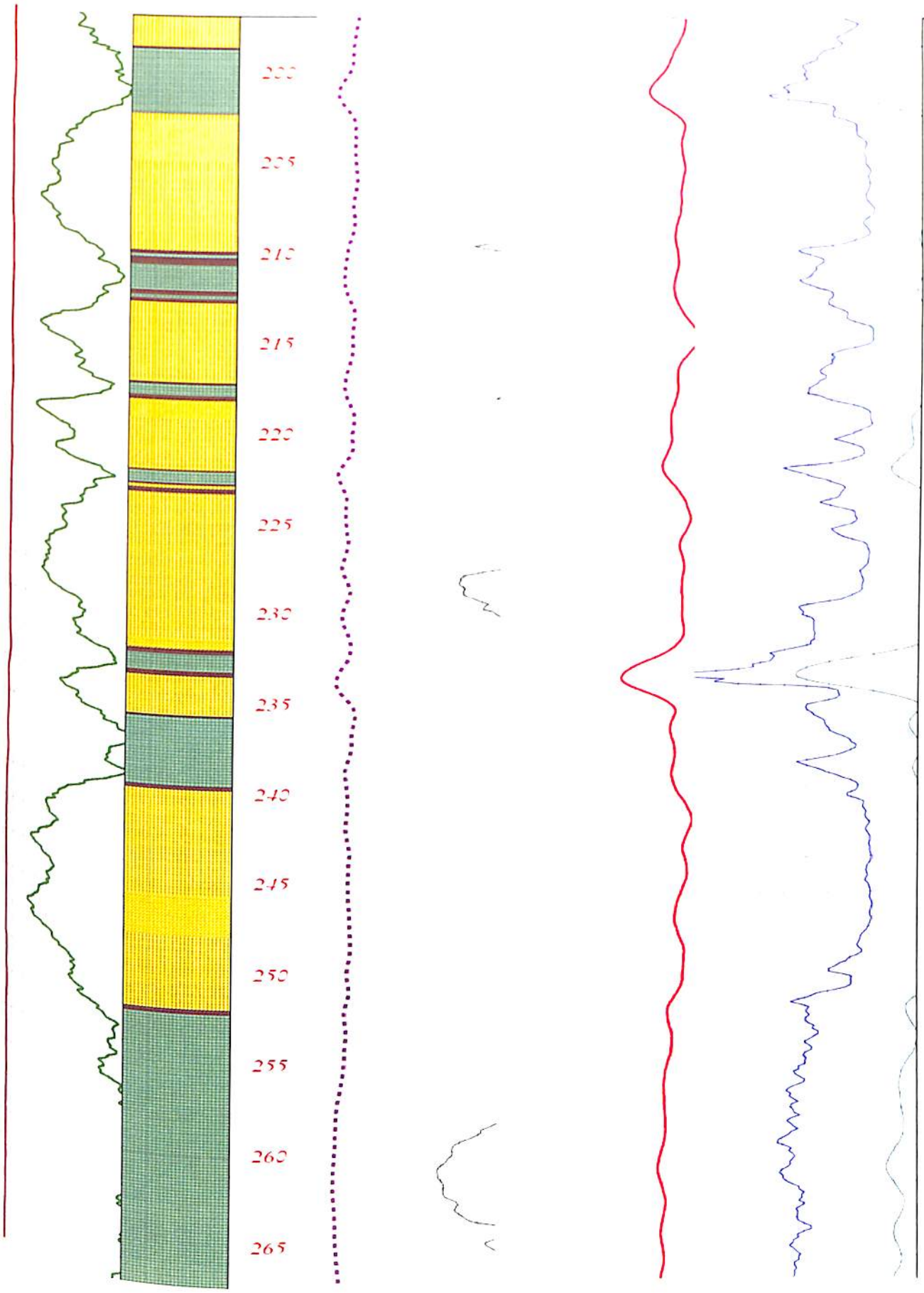
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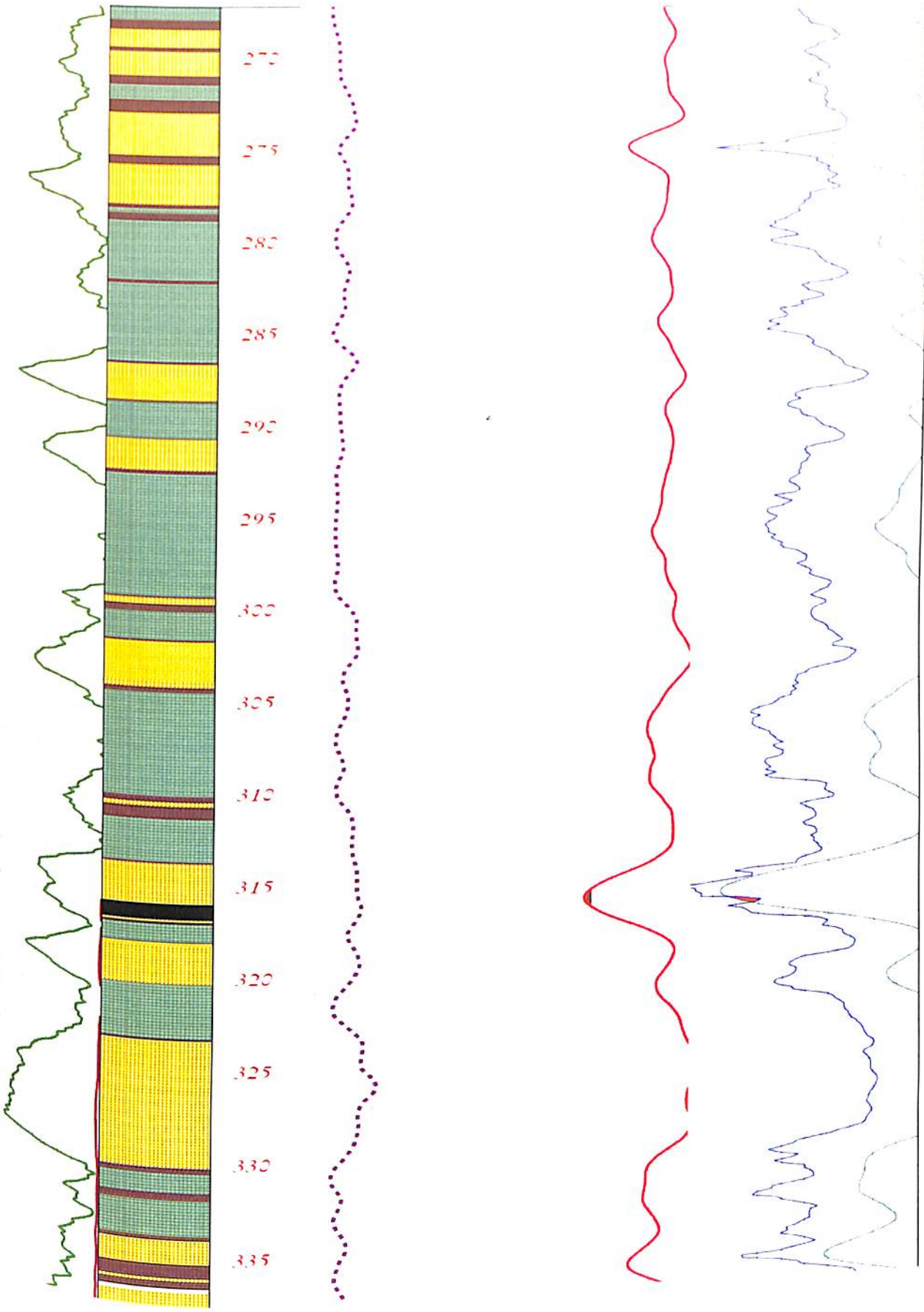
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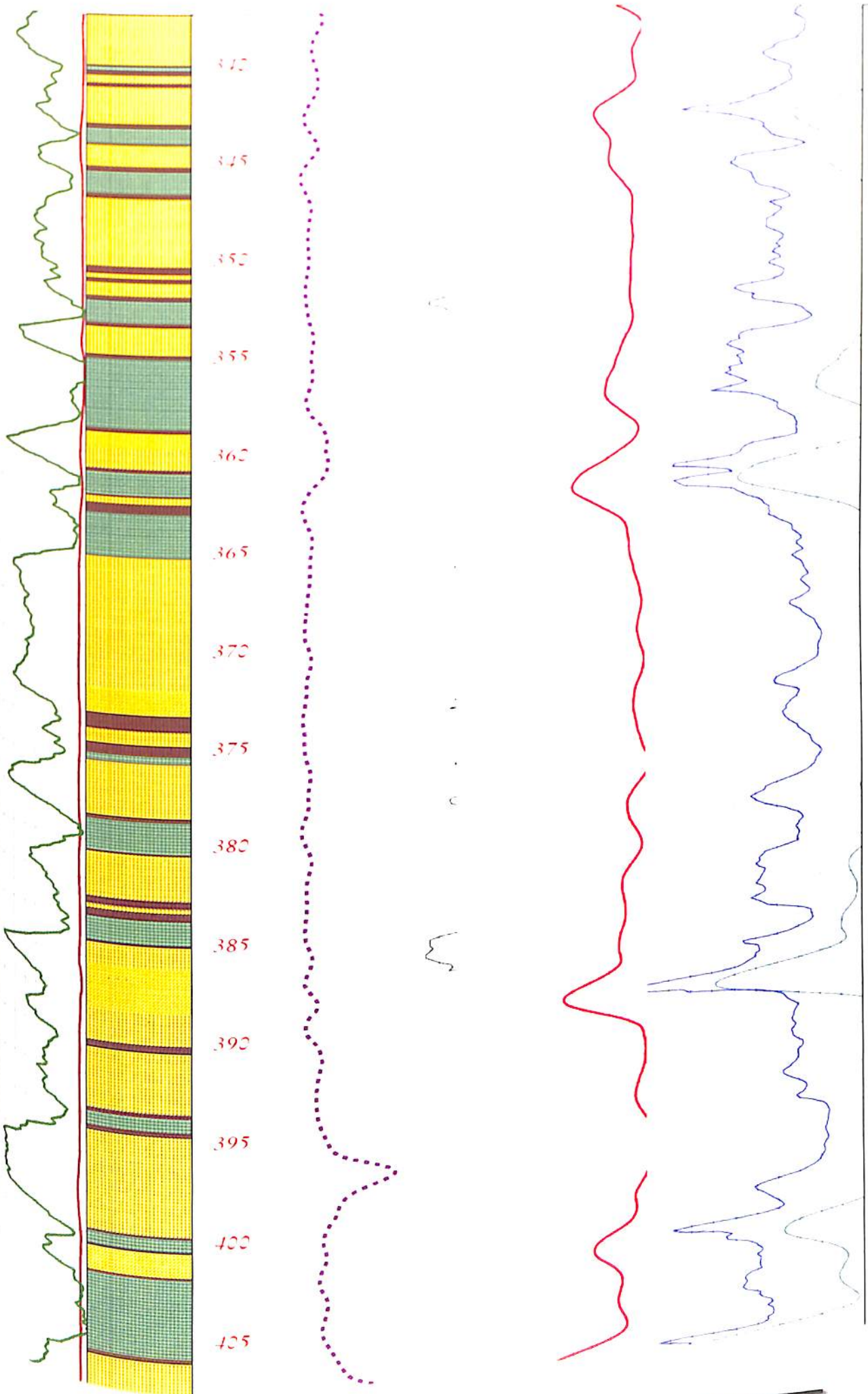
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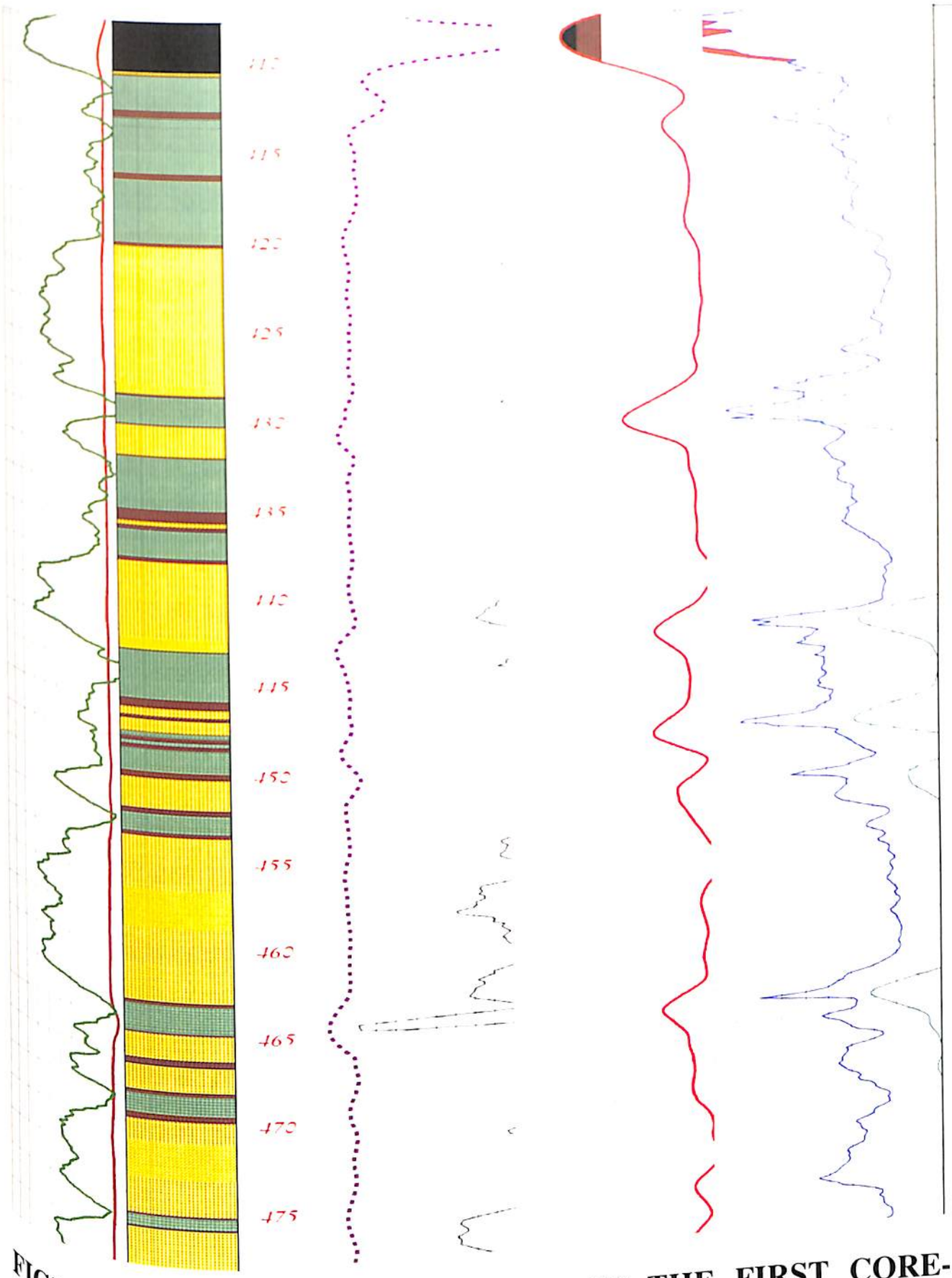
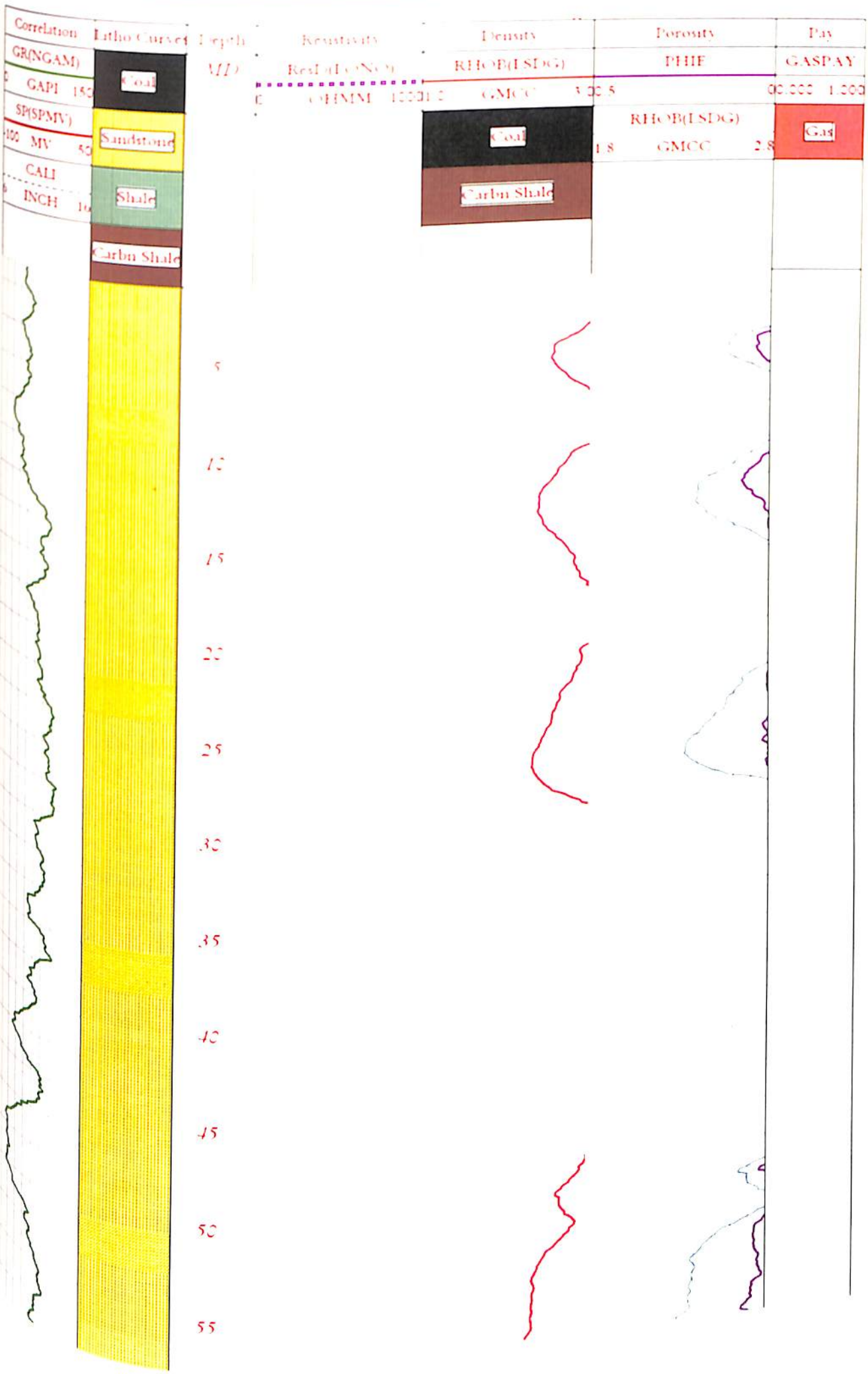


FIGURE:7.8 WELL LOG ANALYSIS OF THE FIRST CORE-WELL-1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Litho Curves
Depth
Resistivity
Density
Porosity
Pay
GR(NGAM)
MD
RHOB(LSDG)
PHIF
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OHMM
GMCC
SP(SPMV)
MV
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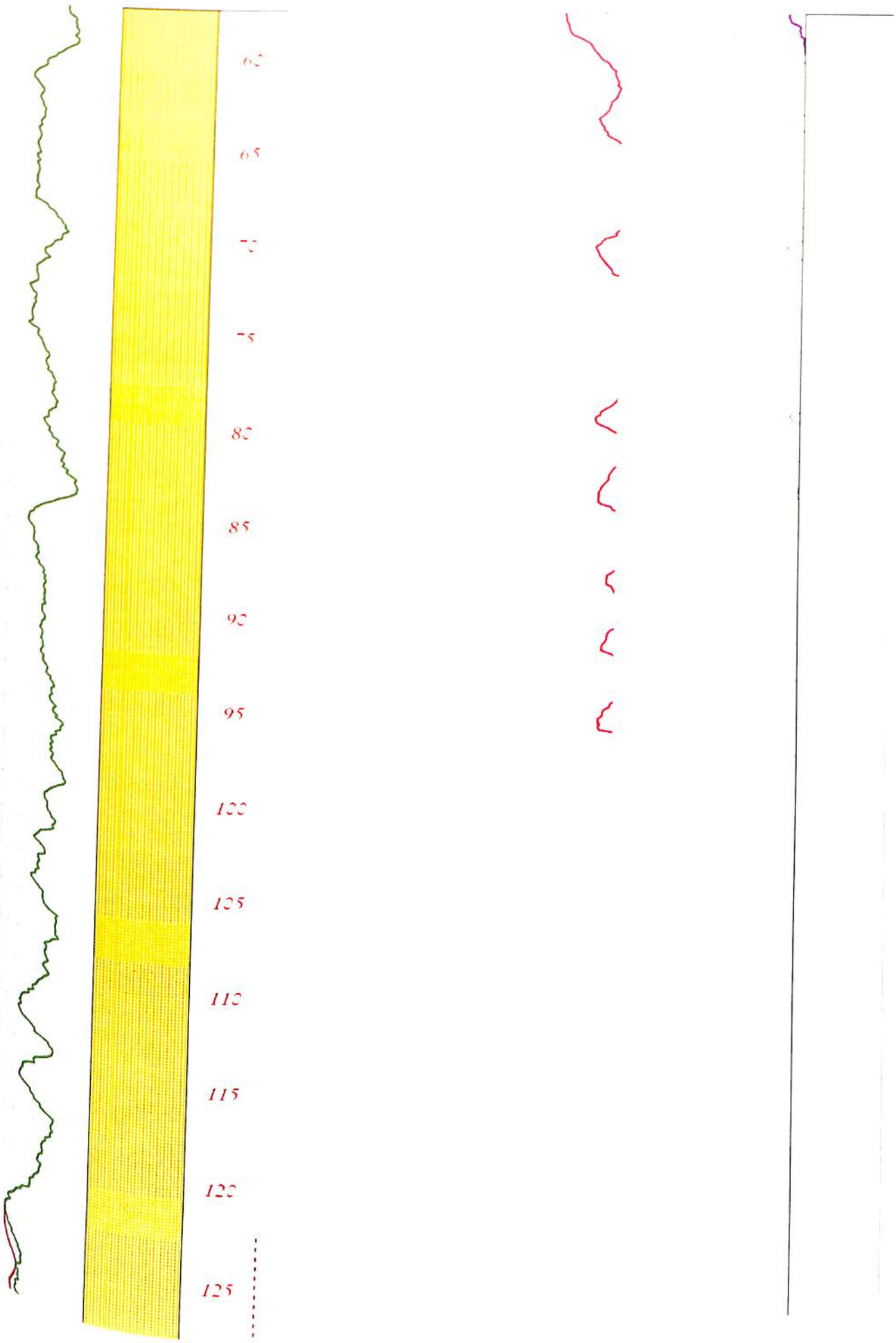
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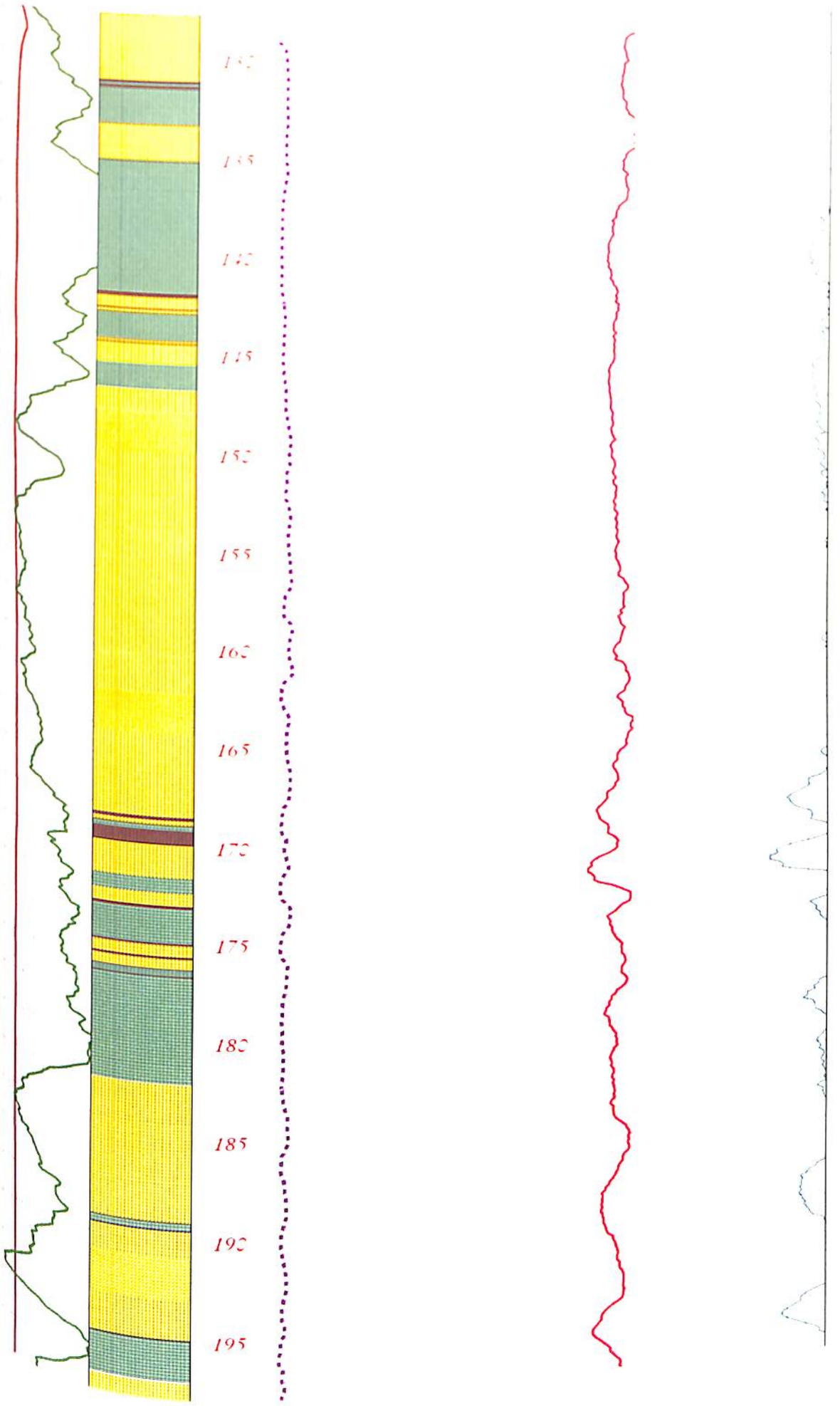
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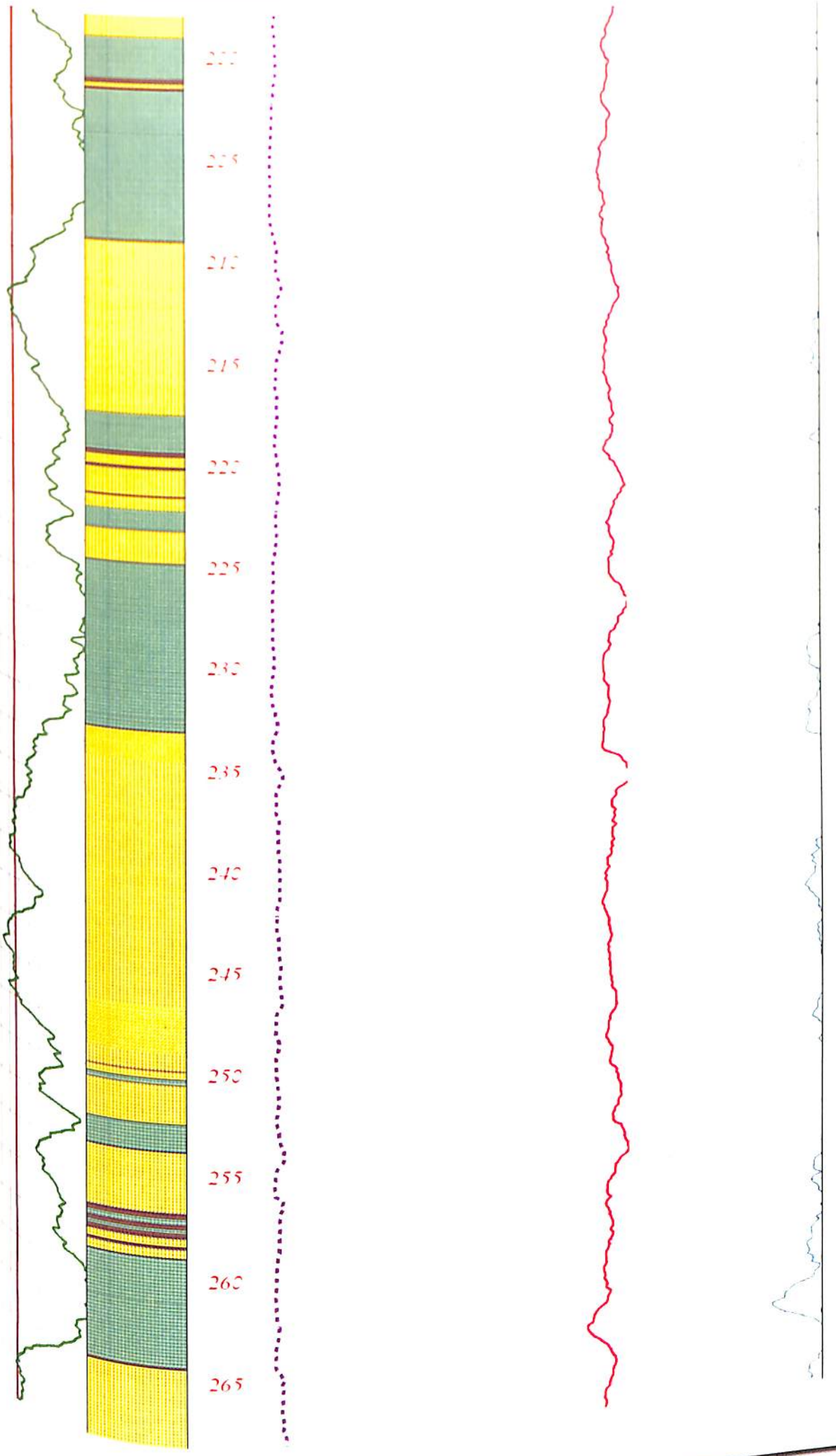
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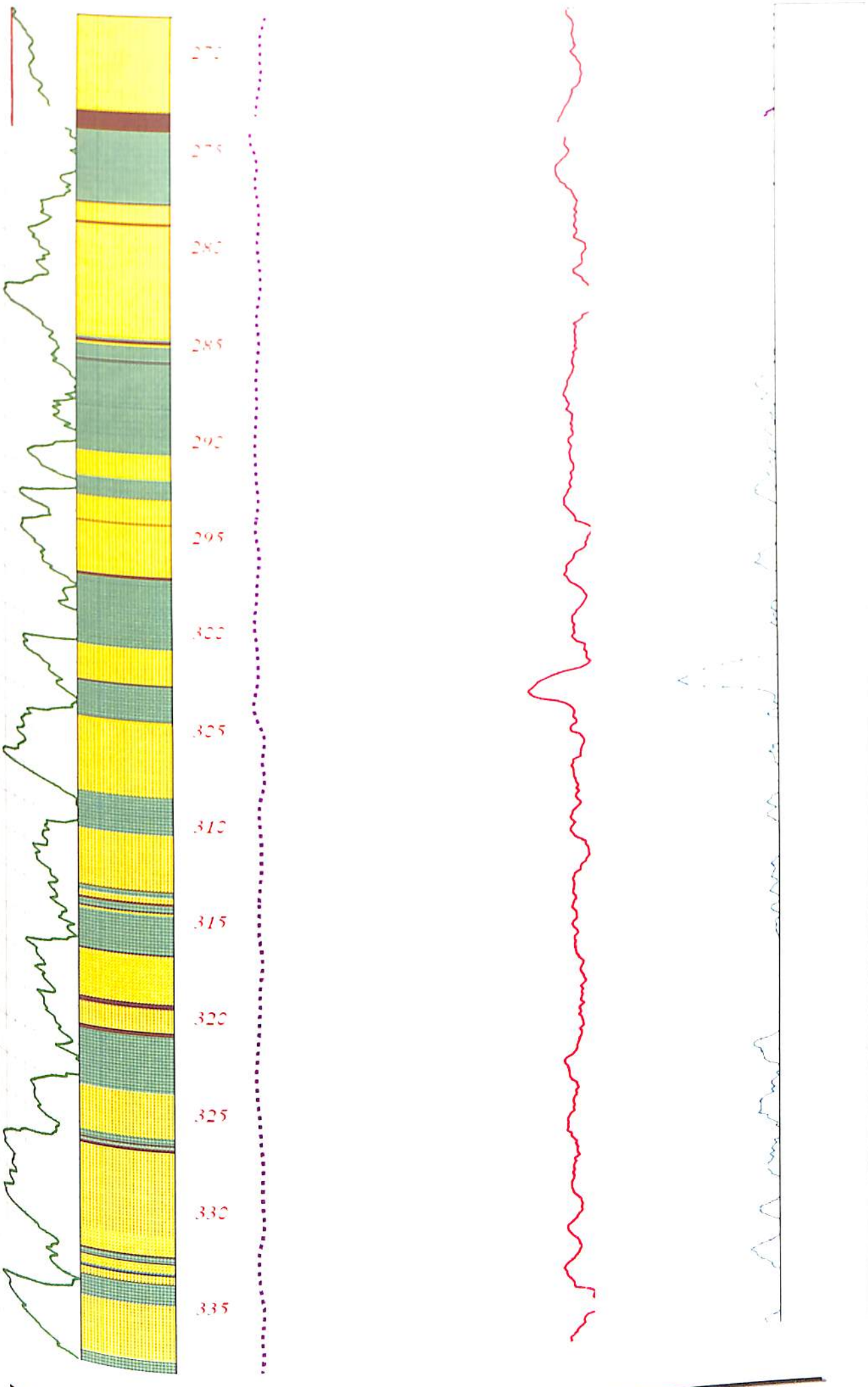
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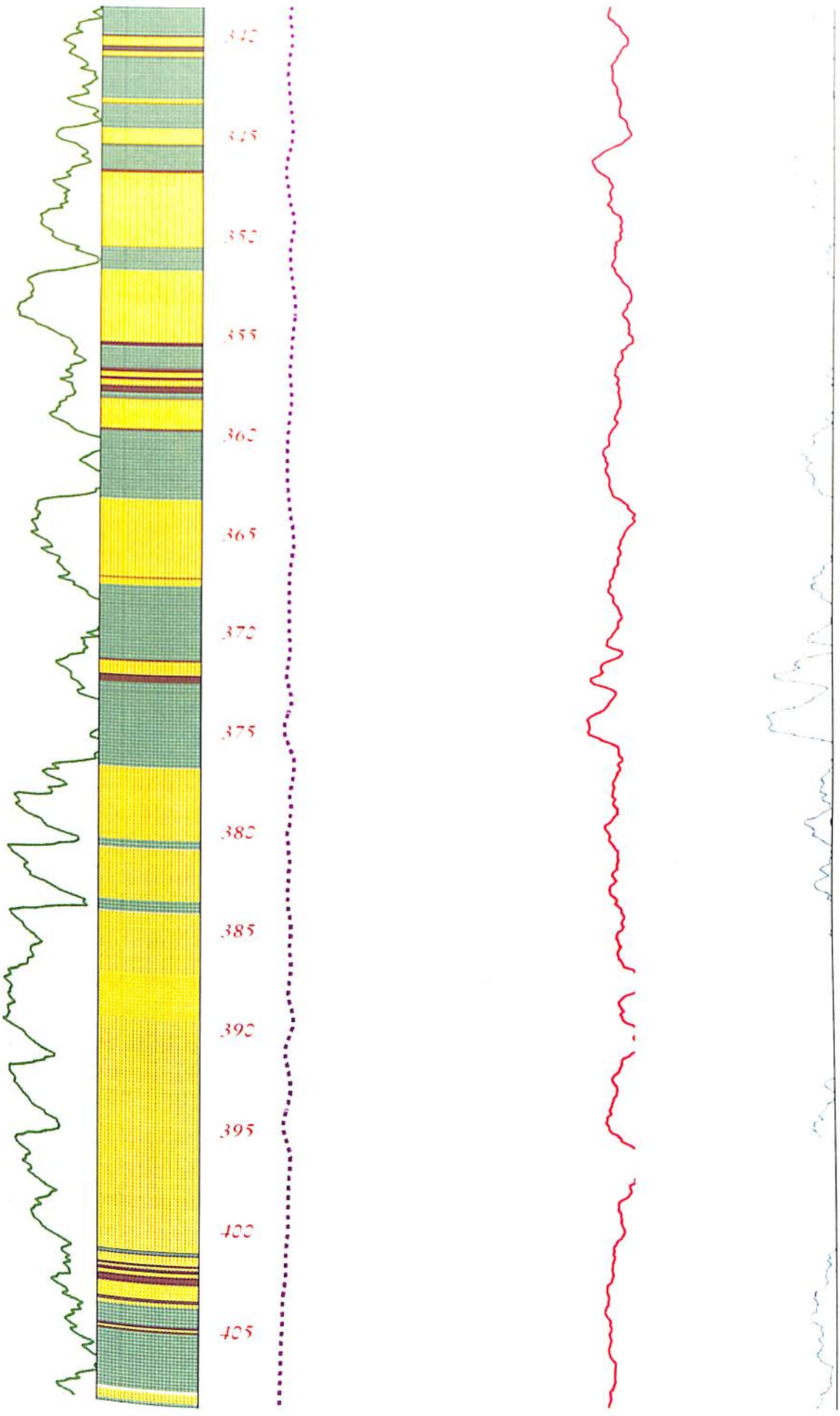
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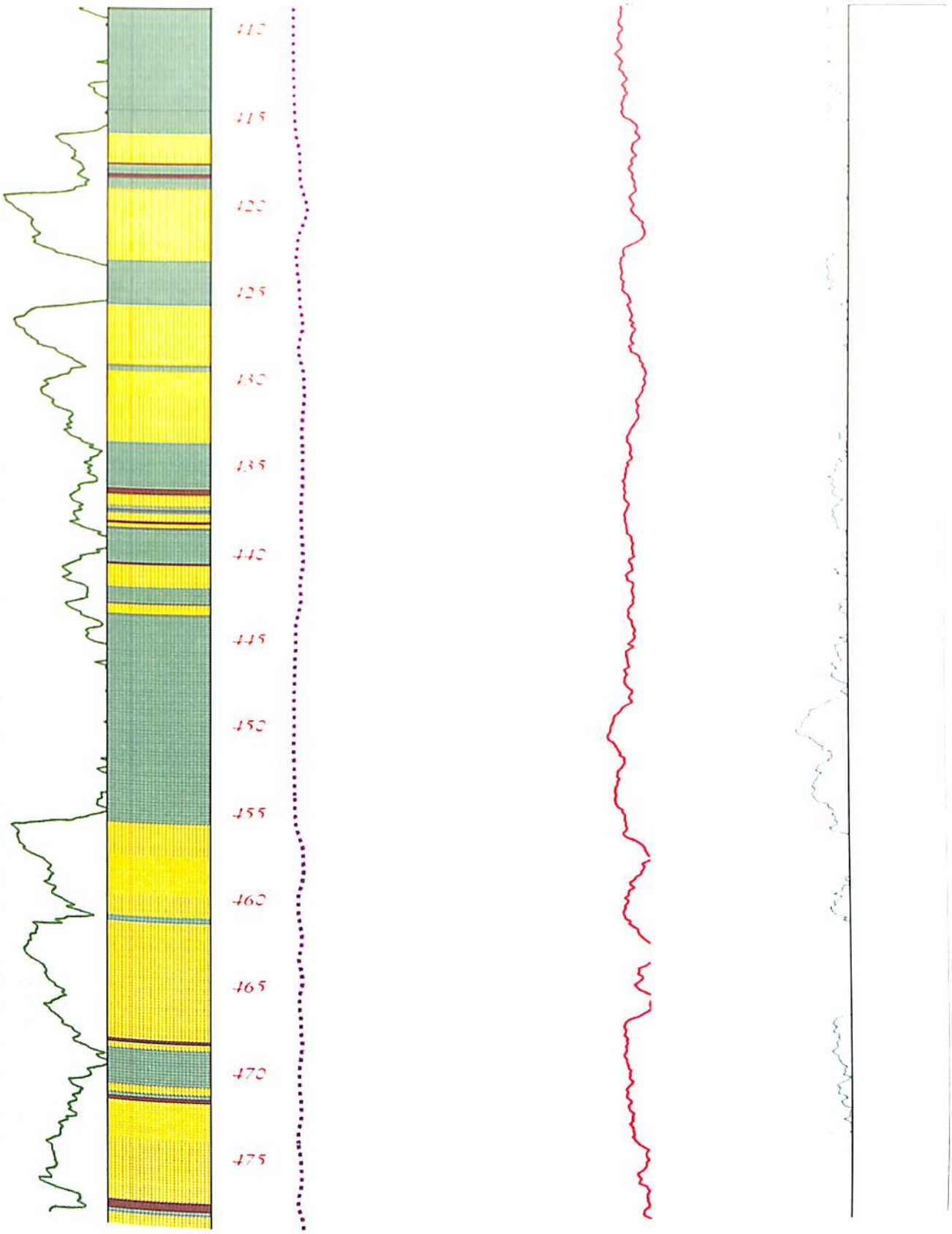
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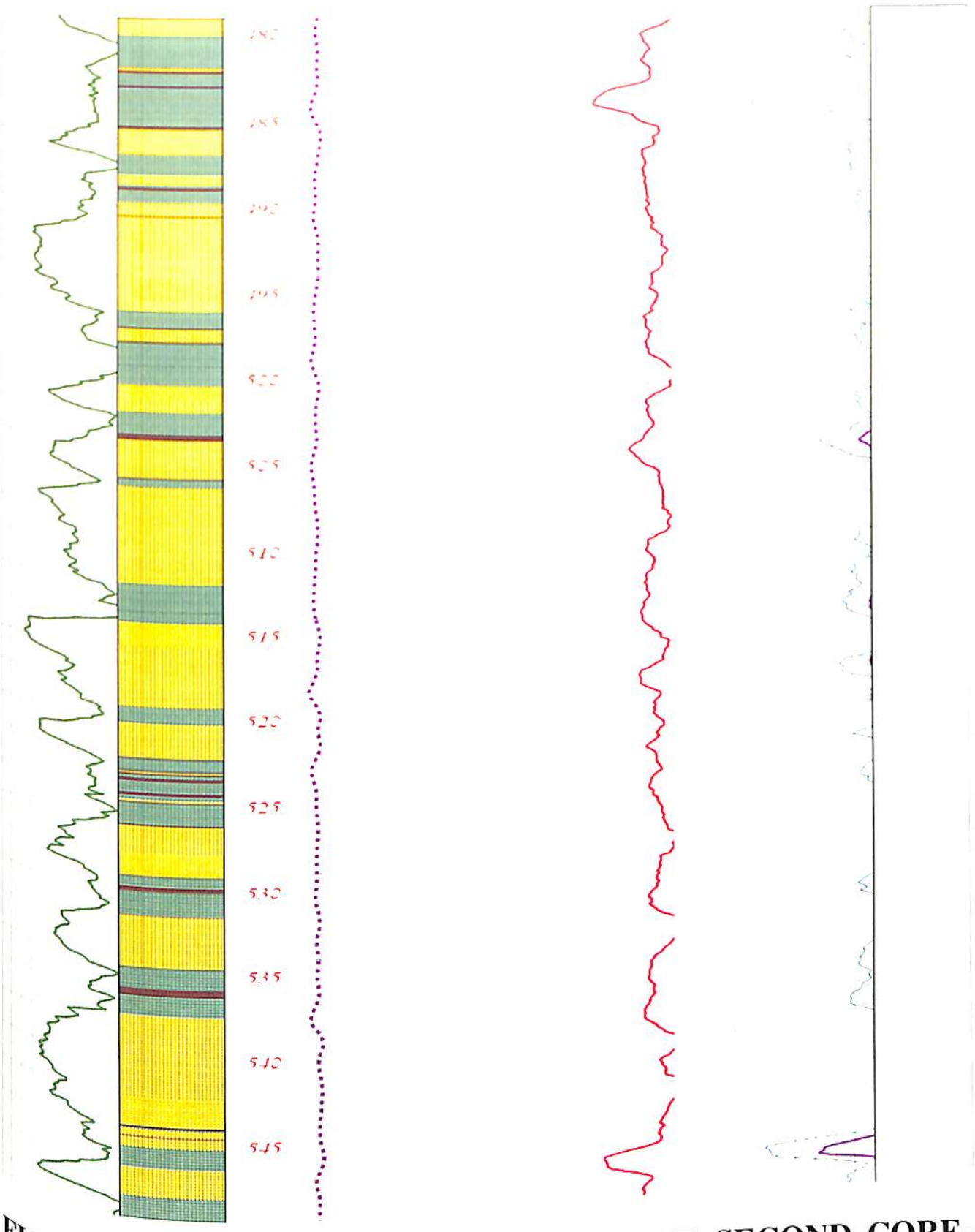
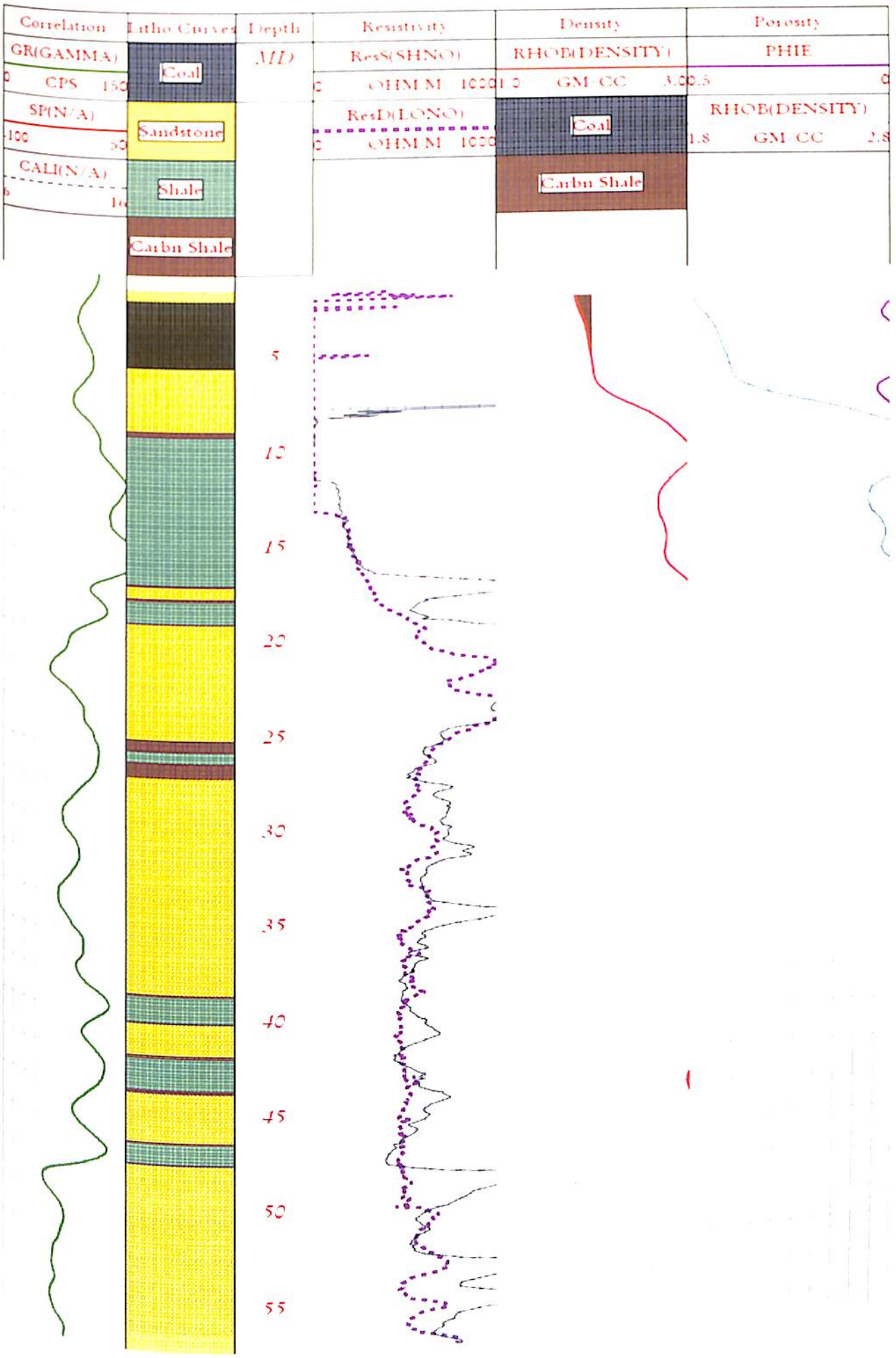


FIGURE:7.9 WELL LOG ANALYSIS OF THE SECOND CORE-WELL-2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Porosity
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-100
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CALI(N/A)
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MD
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OHM M
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ResD(LONO)
OHM M
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RHOB(DENSITY)
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GM/CC
3.0
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RHOB(DENSITY)
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GM/CC
2.8
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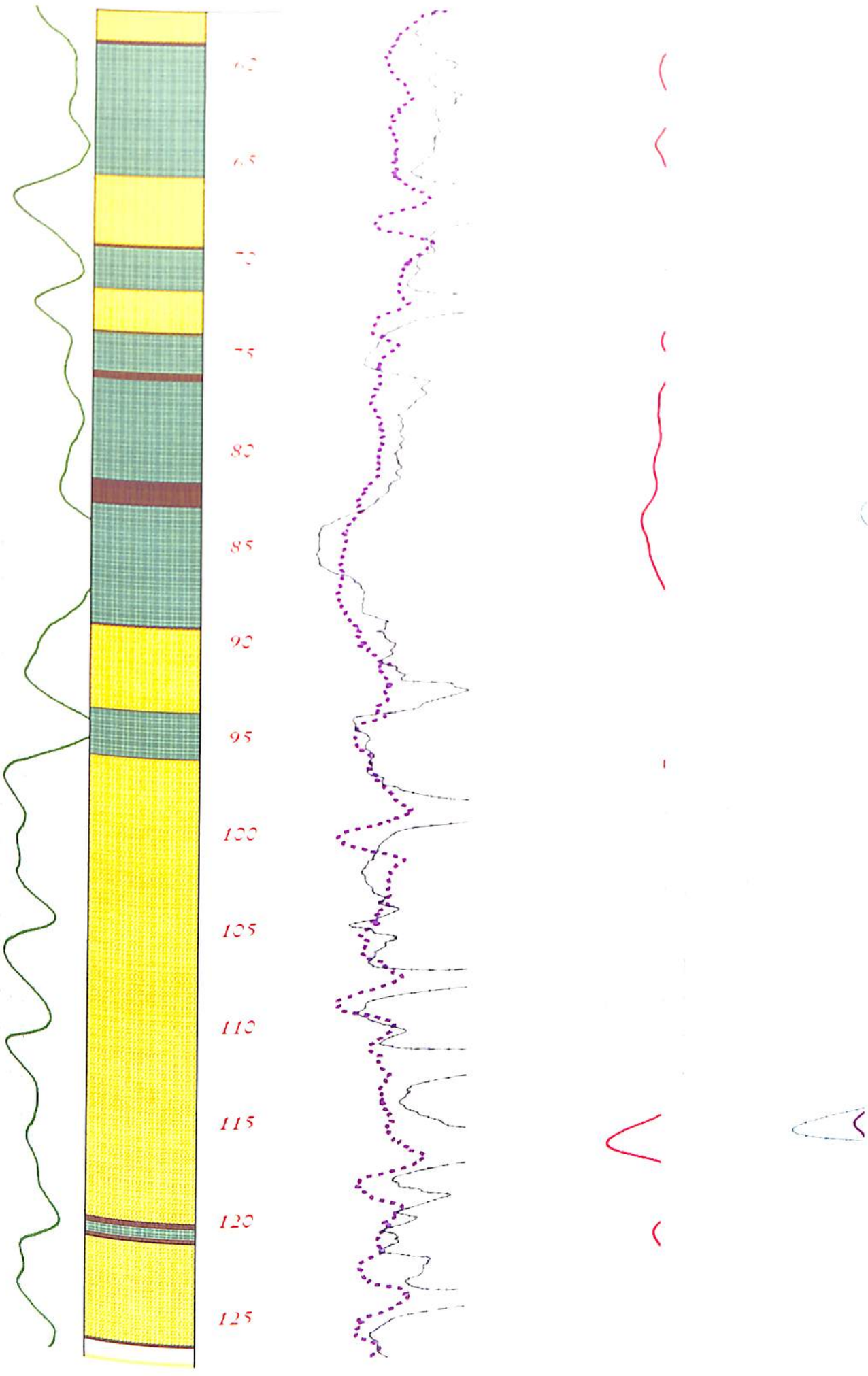
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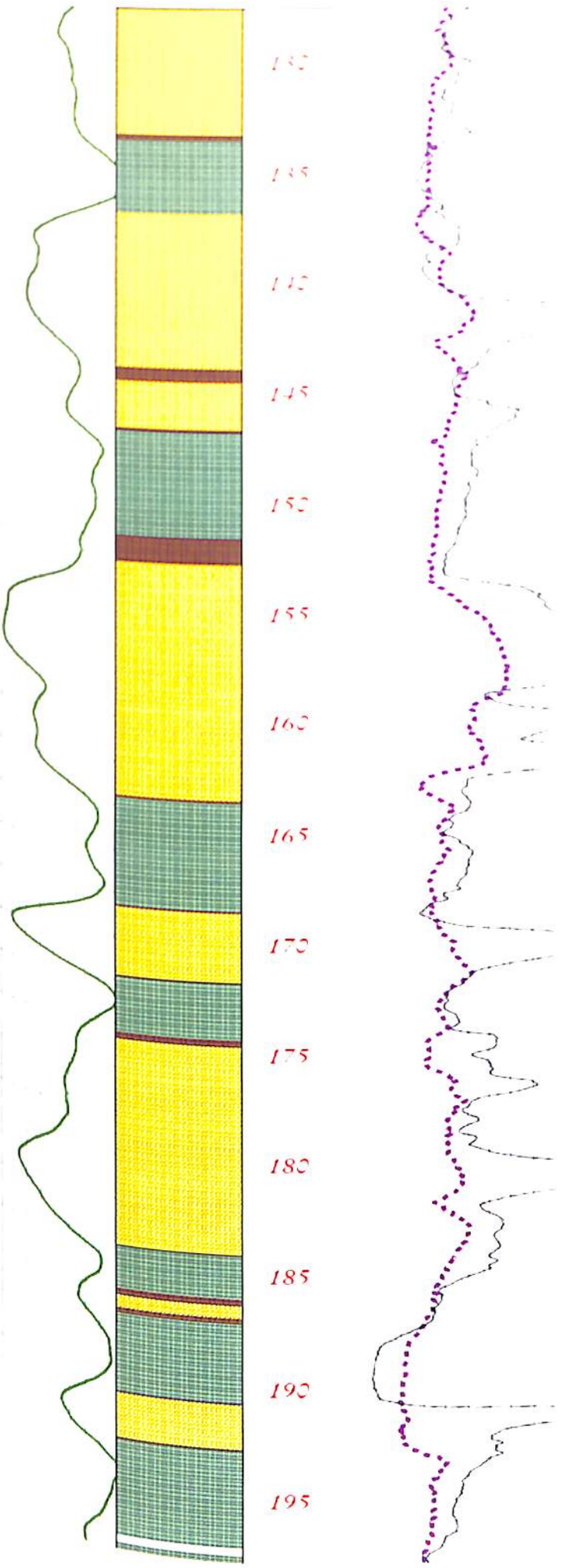
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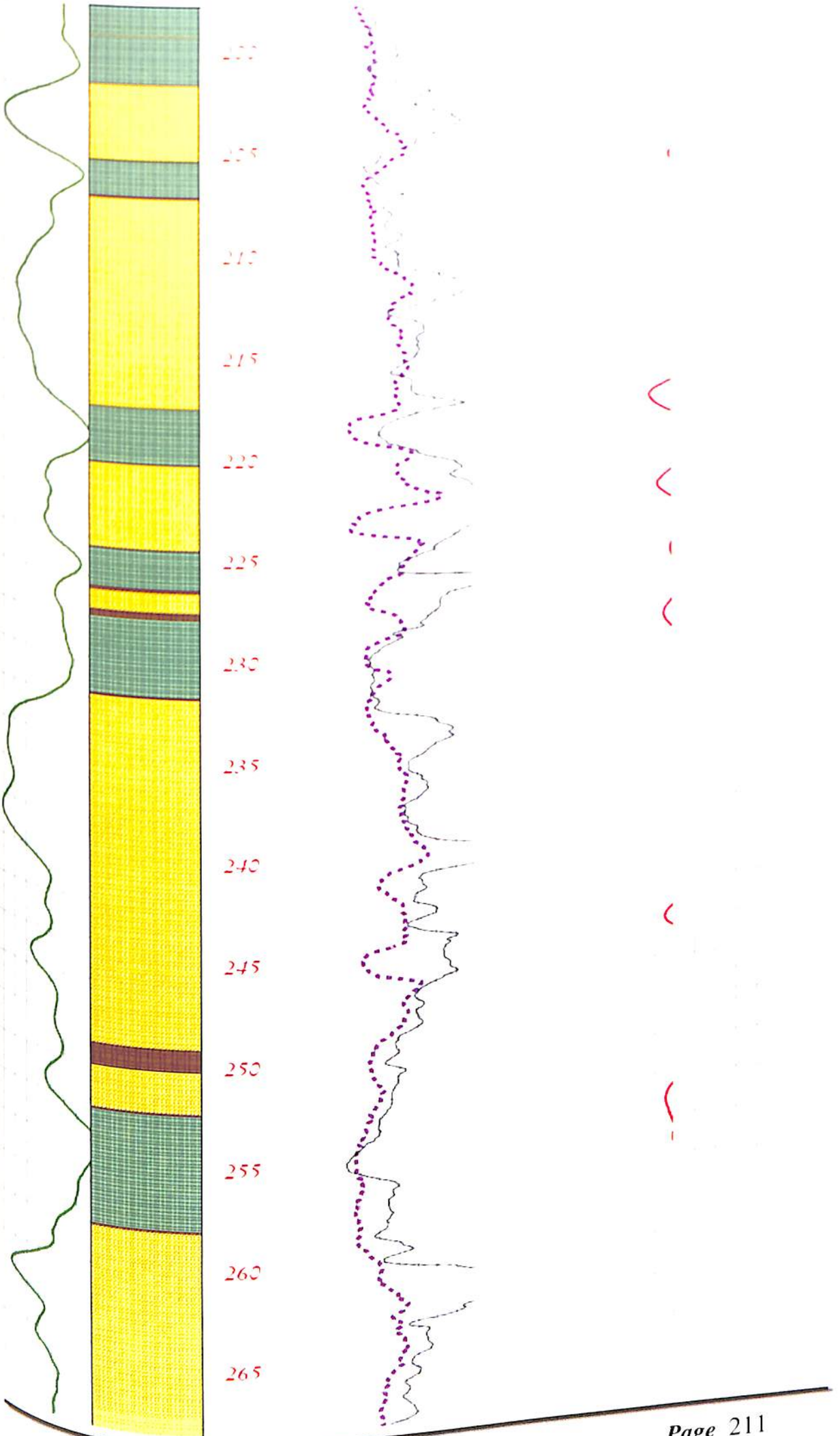
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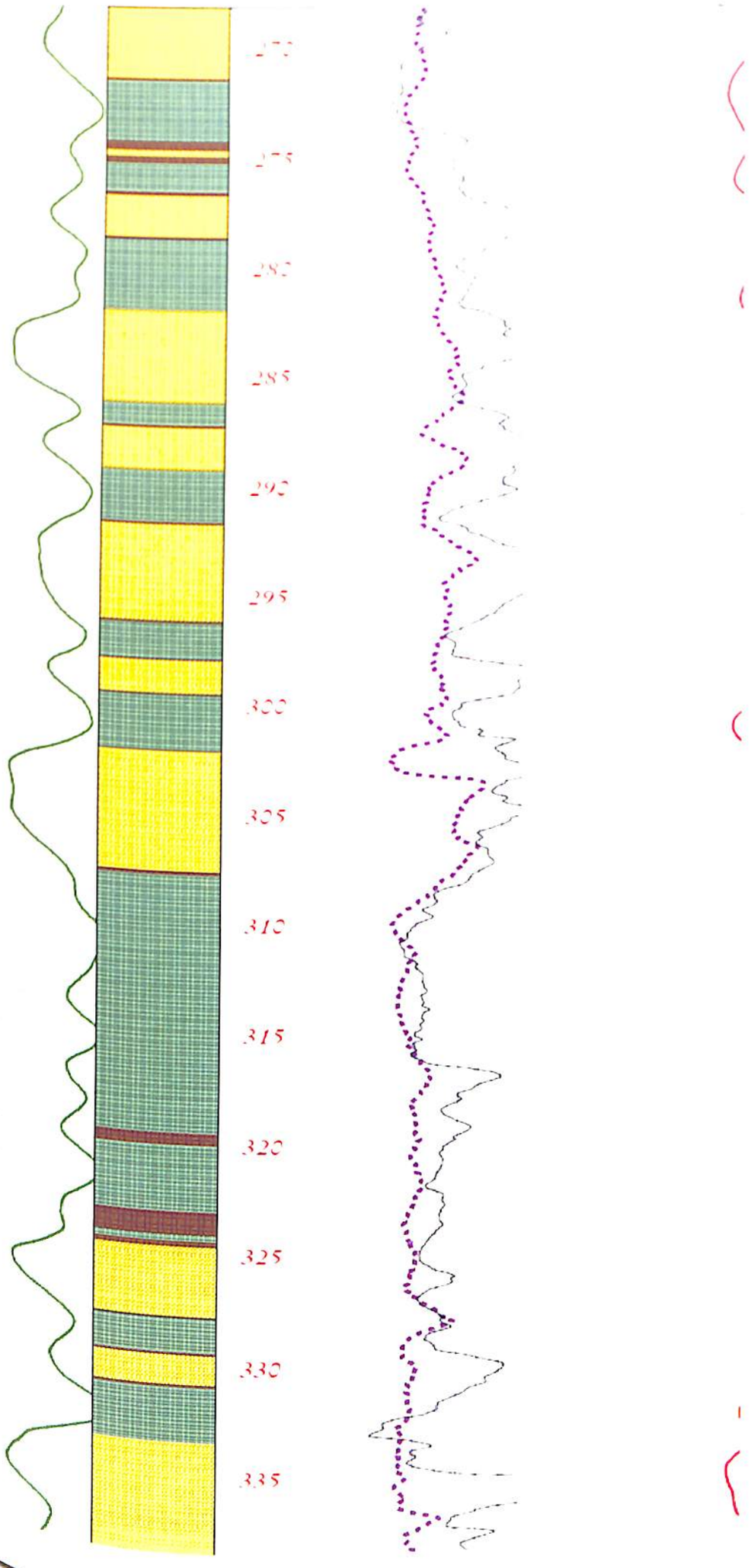
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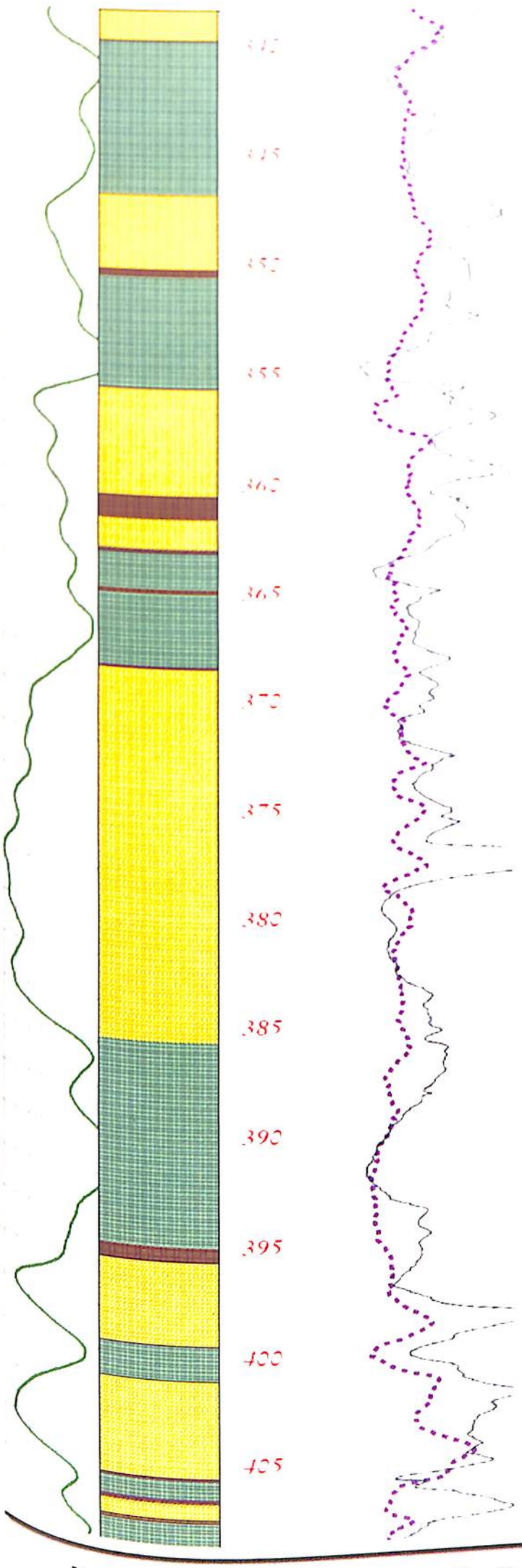
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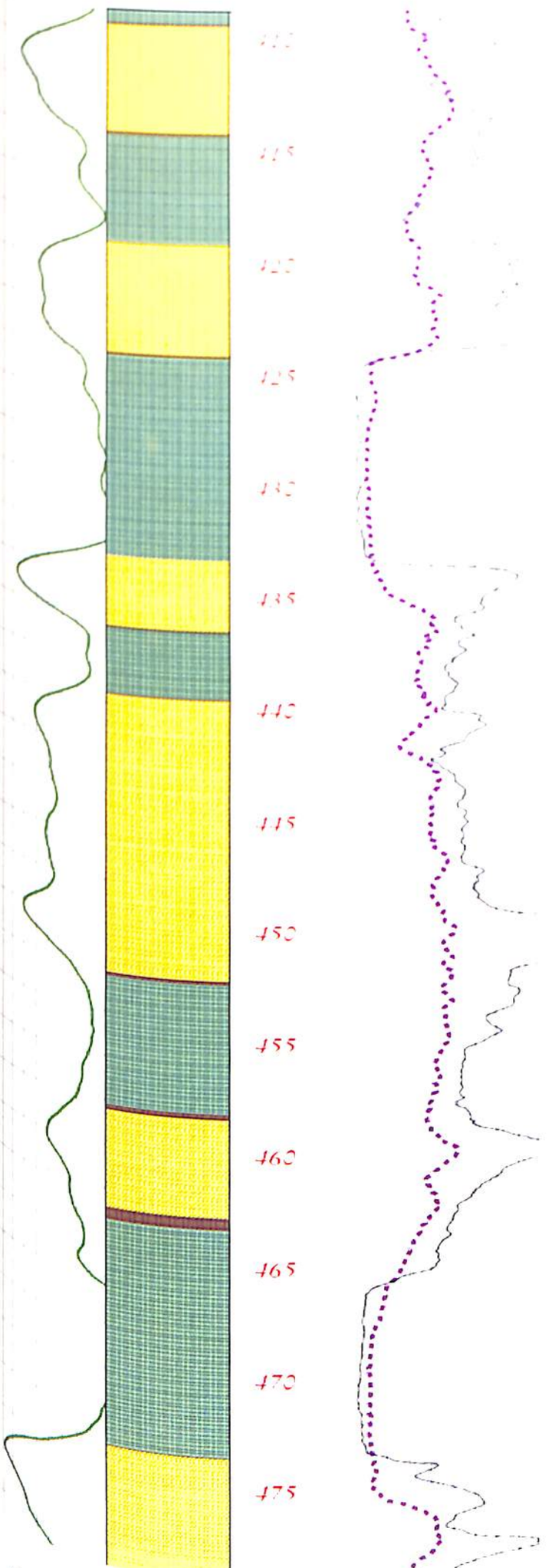
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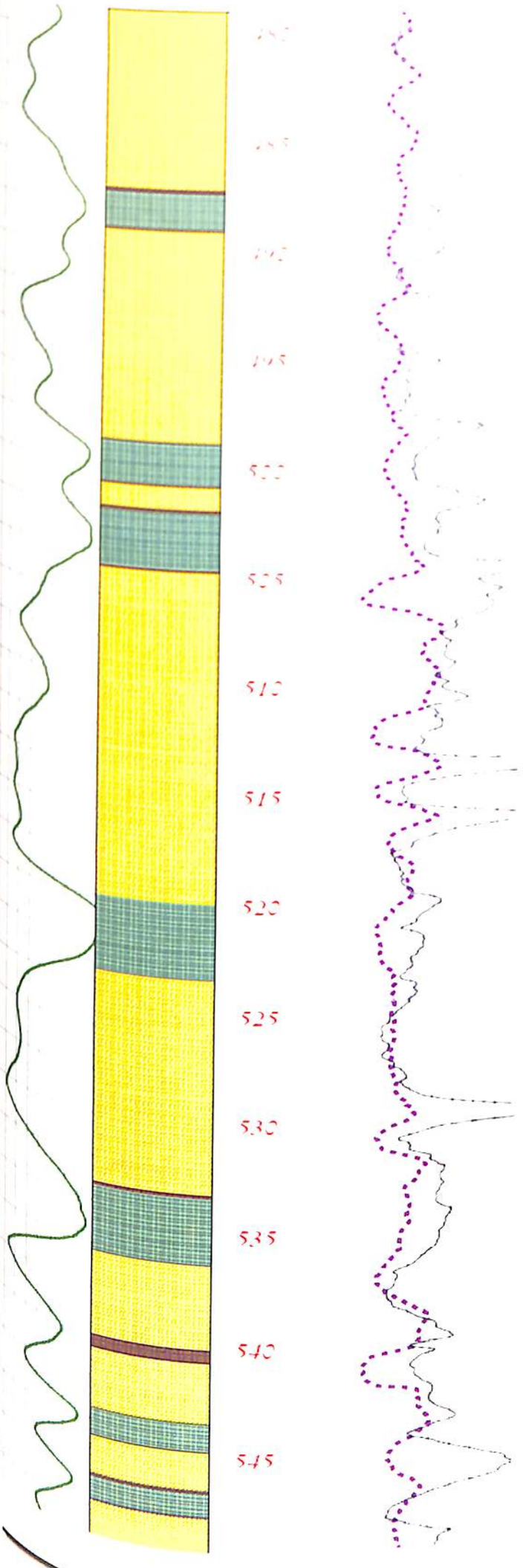
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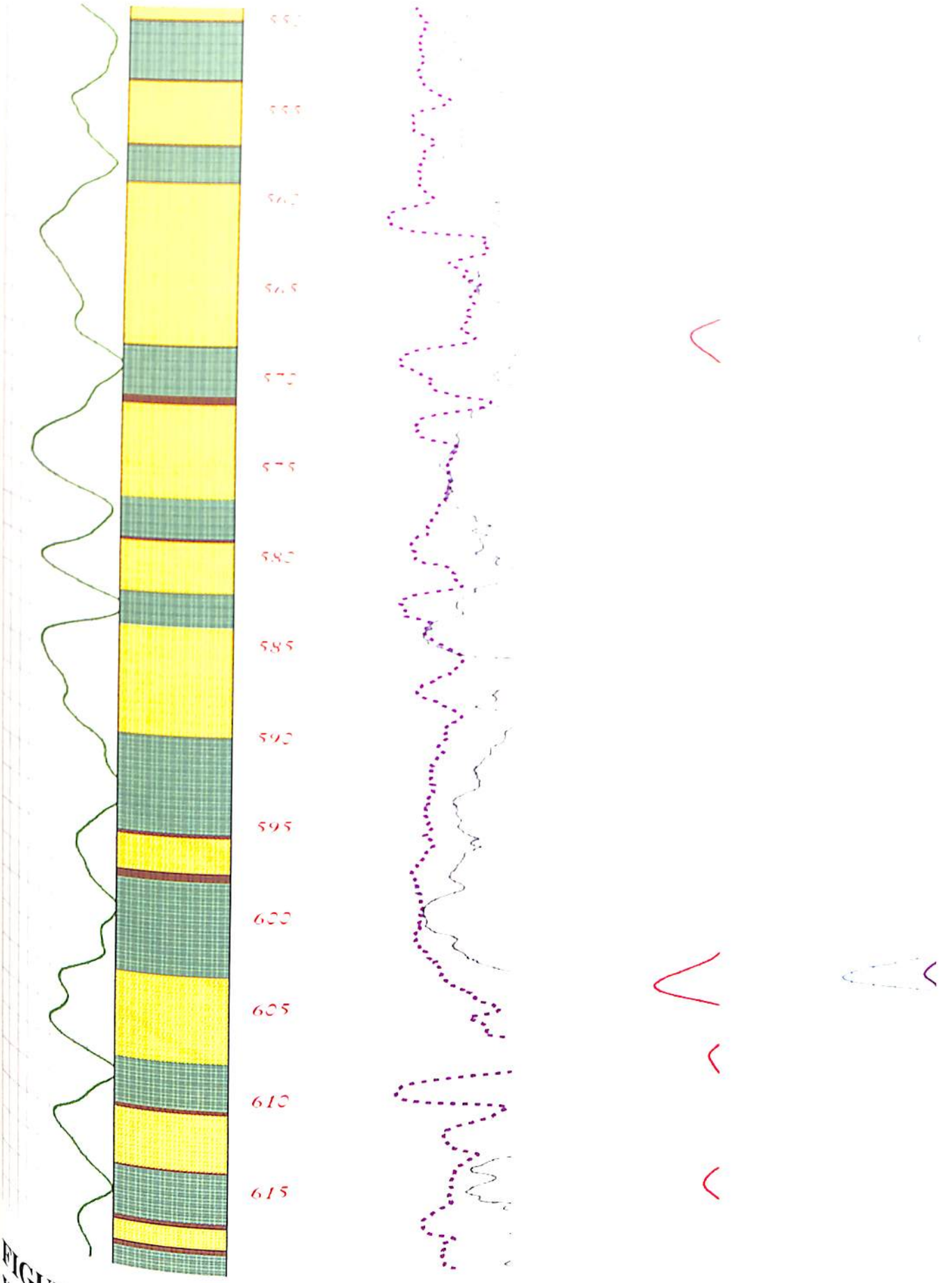

FIGURE:7.10 WELL LOG ANALYSIS OF THE THIRD CORE-WELL-3

The Log analysis is self explanatory as the entire lithology has been created for the well A(mentioned in the map of AOI) as JHRA-1.The similar attempt have been made for the rest of six other wells.

Then coal layers have been identified and all major seams have been considered for further Gas-in-place analysis. As from the well log analysis of three core-wells, no major coal seam has been detected, further cross-section have been created with all four major wells only.

The cross section of four major coal seams(the closed spaced also) have been done to find their lateral continuity that has been shown by Figure 7.11 as shown below.

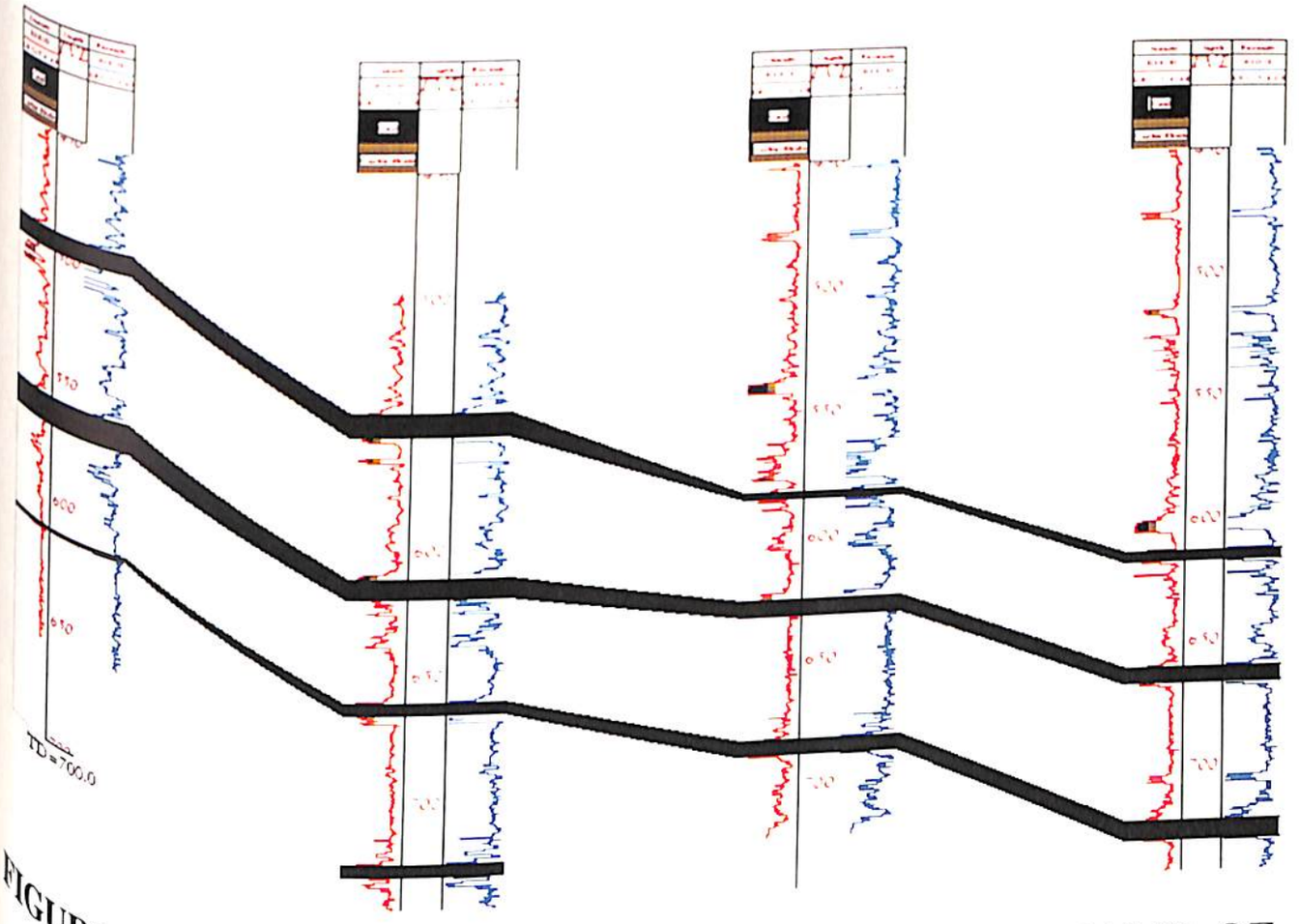

FIGURE 7.11:CROSS-SECTION OF MAJOR COAL SEAMS OF FOUR WELLS

Correlation of Coal and Sand Beds has also been depicted with the help Figure 7.12. This cross section is also helpful for not only finding the lateral continuity but also helpful to take critical decisions for ongoing drilling program .

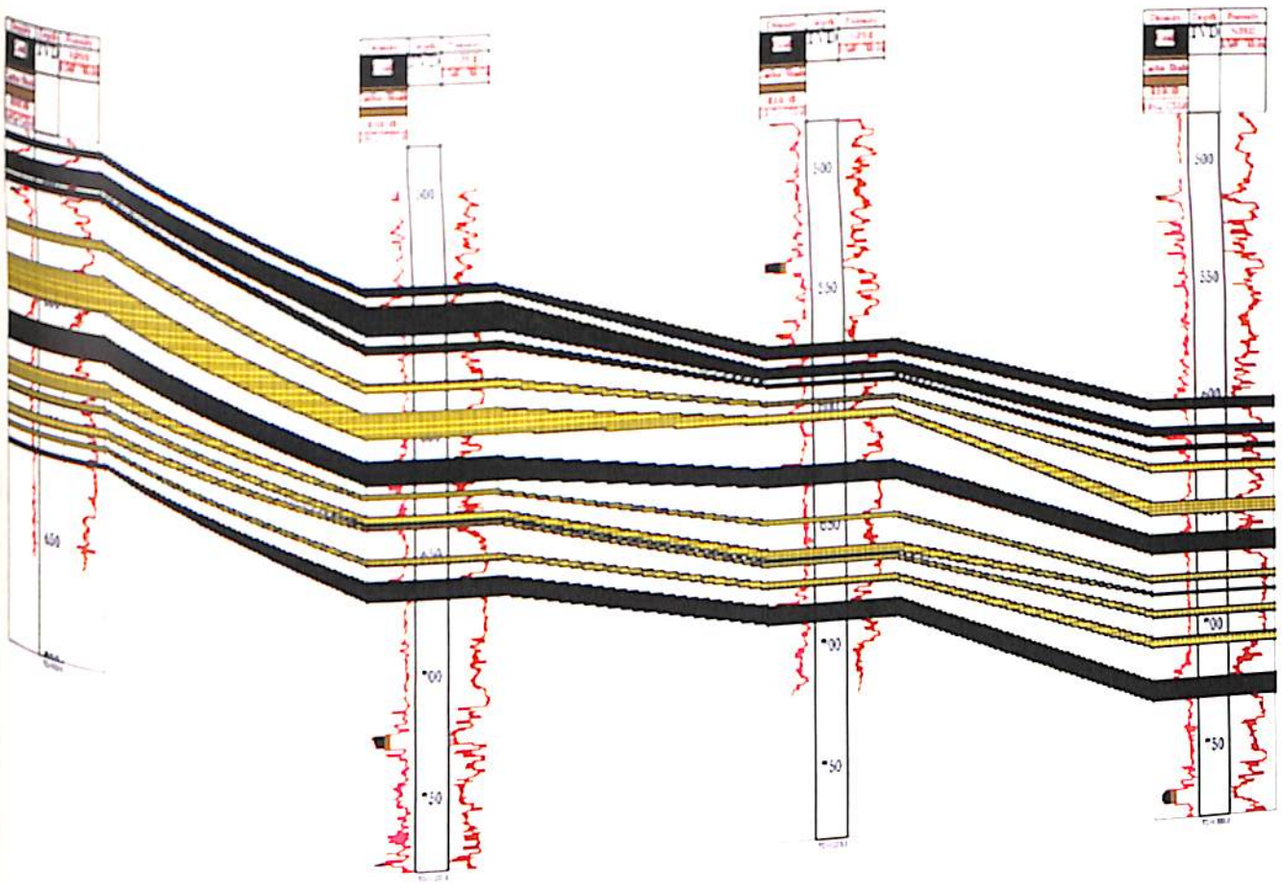

FIGURE 7.12: CROSS-SECTION FOR CORRELATION OF COAL AND SAND BEDS

In the next step we'll calculate Gas-In-Place(GIP) and then resource potential of the surrounded area(AOI) can be estimated. That study is the part of final chapter.(Chapter 8).

In the final chapter, the lay-out of the standard workflow for CBM play has been designed and process flow diagram is generated.