Schlumberger

Sonic Scanner Imaging Platform

Compressional and Shear DT Computations

100 ft to 4080 ft

COMPANY: Battelle Pacific Northwest Lab
WELL: Wallula Basalt Pilot #1
FIELD: Wildcat
County: Walla Walla
State: Washington
COUNTRY: USA

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API No: Job No.:

Other Services:

LOCATION
Field: SOUTHWEST 1/4 OF SECTION 10
Section: 10 Township: 7 Range: 31E
Latitude: 46.1049 Longitude: –118.916

Permanent Datum: GROUND LEVEL Elev: –999.25 ft
Log Measured From: DF 5.5 ft above Perm. Datum
Drilling Measured From: DF

Elevations:
K.B. 369.68 ft
D.F. 368.68 ft
G.L. 363.18 ft

Date				
Run No.		TWO		
Depth Driller		4105 ft		
Depth Logger (Schl)		4105 ft		
Btm. Log Interval		4103 ft		
Top Log Interval		1108 ft		
Casing–Driller		13.325 in @ 1108 ft		
Casing–Logger		1108 ft		
Bit Size		12.25 in		
Type fluid in hole		FRESH WATER		
Dens.	Visc.	8.4 lbm/gal	–999.25 s	
pH	Fluid Loss	–999.25	–999.25 in3	
Source of Sample				
Rm @ Meas. Temp.		23.1 ohm.m @ 64.2 deg		
Rmf @ Meas. Temp.		–999.25 ohm.m @ –999		
Rmc @ Meas. Temp.		–999.25 ohm.m @ –999		
Source: Rmf	Rmc			
Rm @ BHT		–999.25 ohm.m @ 212		
Circulation Stopped				
Logger on Bottom		10:35		
Max. Rec. Temp.		–999.25 degF		
Equip.	Location	3152	SACRAMEN	
Recorded by:		BEN GRAU		
Witnessed by:		CHARLOTTE SULLIVAN		

FOLD HERE

The well name, location and borehole reference data were furnished by the customer

Ser. Order # AZJT00051	OP Vers.: 17C0–154	Process Date: Jun–09–2009	Center: Denver	Baseline: GF4.4	Log Analyst: S.Riley,G.Martinez

Field Engineer'

TOOL STRING
BOWSPRING R
TOTAL CHLORI
MATRIX: LIMES
DENSITY: 2.71
ICV CALCULAT

DOWN

LEH-QT
LEH-QT

EDTC-B
EDTH-B 8611
EDTC-B 8620
EDTG-A/B

PPC2-B
PPC2-B 8152
PPC_CAL_STD

MAPC-B
MAPC-BA
ECH-SF 8092
MAMS-BA 8148

MAXS-B
MASS-BA 8136
MAXS-BA 8136

PPC1-B
PPC1-B 8334
PPC_CAL_STD

FBST-B
ECH-MRA 5881
FBCC-A
AH-184
AH-185 1773
FBSH-A 1730
GPIC-F
FBSC-B
FBSS-B

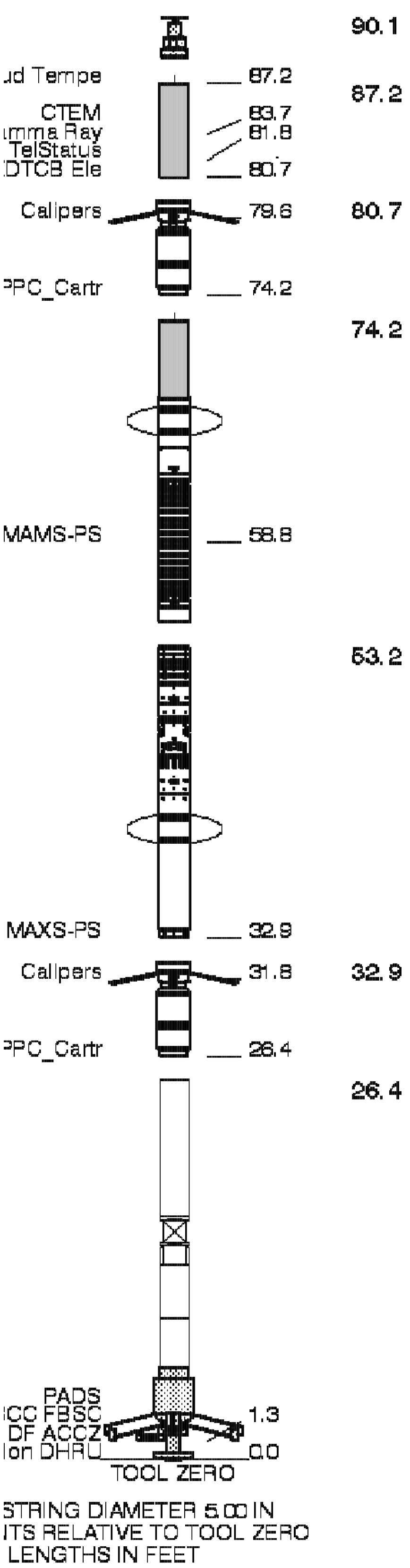
FB
HV
Tens

MAXIMUM
MEASUREMEN
ALL

s Remarks:

RAN AS PER TOOL SKETCH
AN ON NEUTRON TOOL
DES: ??? PPM
TONE
G/CC
ED USING FCD = 13.375"

HOLE EQUIPMENT



Log Analyst's Remarks:

OBJECTIVE: PROCESS OPEN H

AVAILABLE INPUT DATA:

SONIC SCANNER – Full Config
2– FOUR ARM CALIPERS run i
NPOR and RHOZ from Open H
GR
AIT Resistivity Data

DEPTH SHIFT:

PEX log used as a reference.

DATA QUALITY:

Data was of good to fair quality,

PROCESSING DETAILS:

DTCO was processed from mon
using "Best DT" program.

RESULTS:

DT–Comp.: The monopole wav
logged section, the DTCO result
for quality assessment).

DT–SHEAR : The dipole wavefo
on the log is from the X–Dipole s

INTERPRETATION SUMMARY:

The compressional and shear m

OLE SONIC SCANNER DATA FOR DT–COMP. AND DT–SHEAR

uration; All modes recorded
n combination with SONIC SCANNER
ole Neutron – Density logs.

the borehole is moderately enlarged for much of the well.

opole waveforms and DT–Shear from Dipole waveforms

veforms contain good to fair formation arrival through the
s are of corresponding quality (see coherence projection

rms also contain good to fair formation arrival. DTSM presented
shear.

easurements that are presented here are considering isotropy.

Processing Parameters: *

* Parameters are assumed to be default parameters unle

GENERAL

Shear filter was 0 to 1.6 kHz
Mud slowness was 195 us/ft

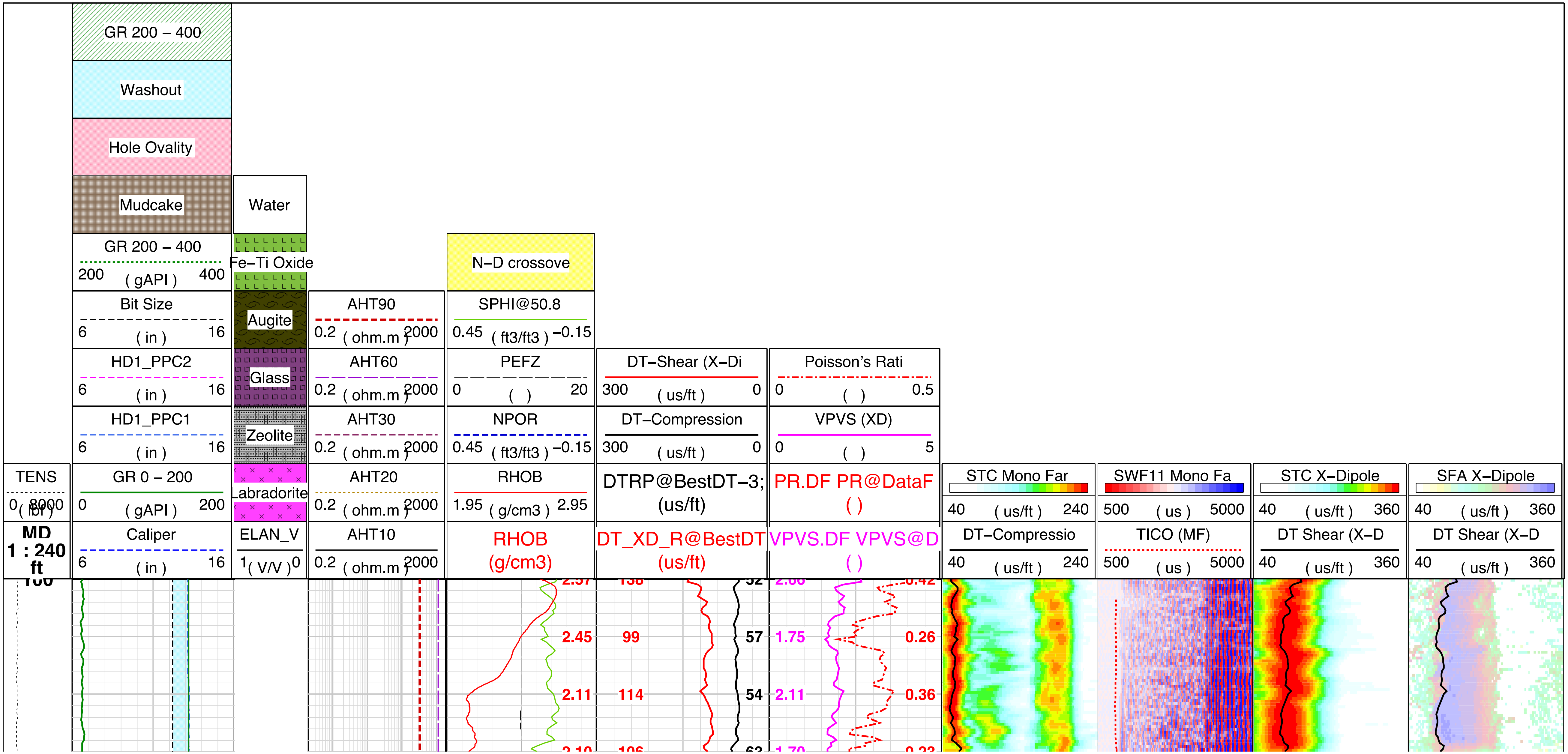
Graphic Illustration Captions:

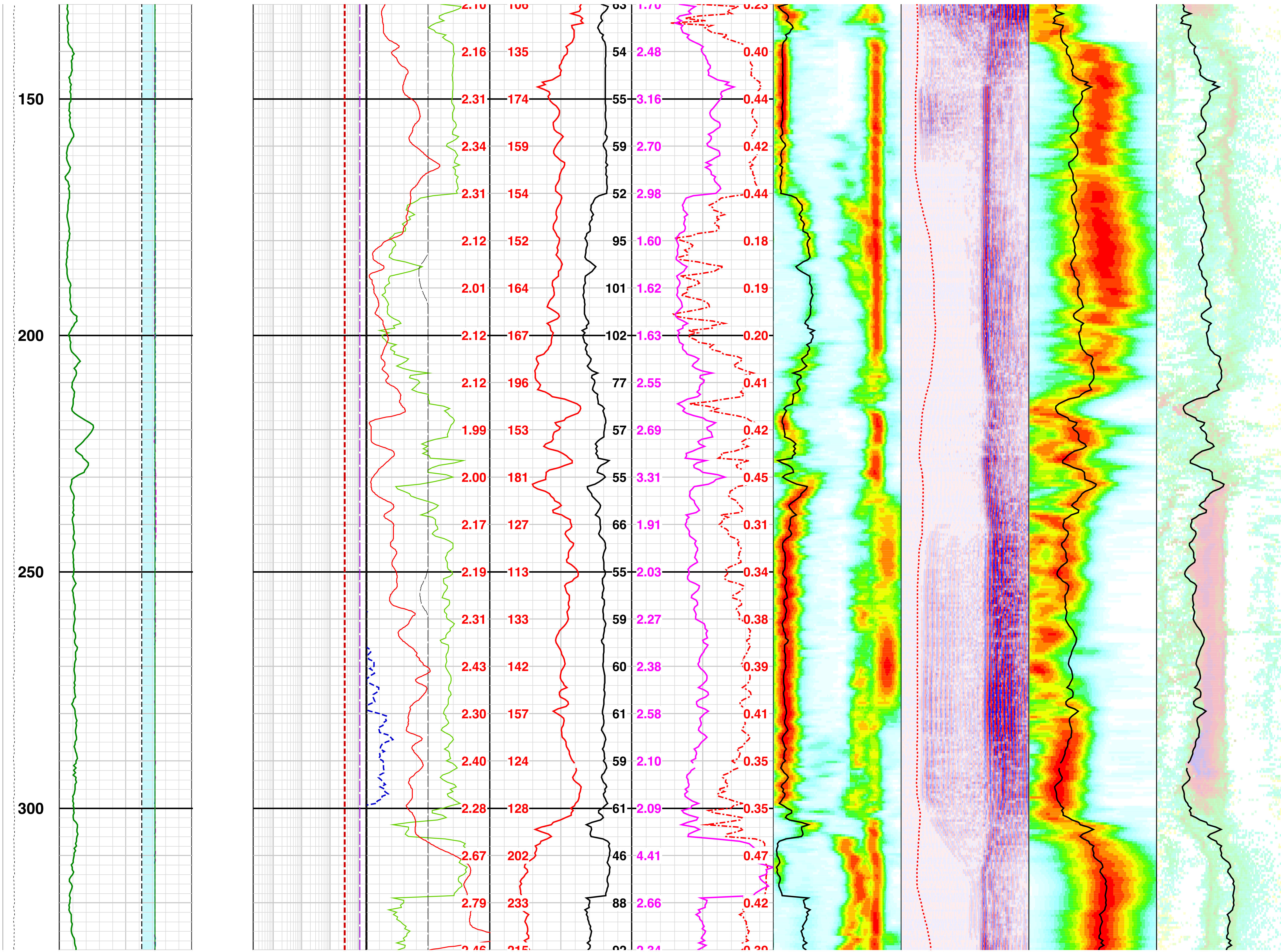
Figure 1 –
VPVS vs DTCO shows normal character.

Figure 2 –
Composite log of Compressional and Shear slowness.

Figure 3 –
Diagram explaining P and S processing.

ss otherwise specified.





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200
250
300
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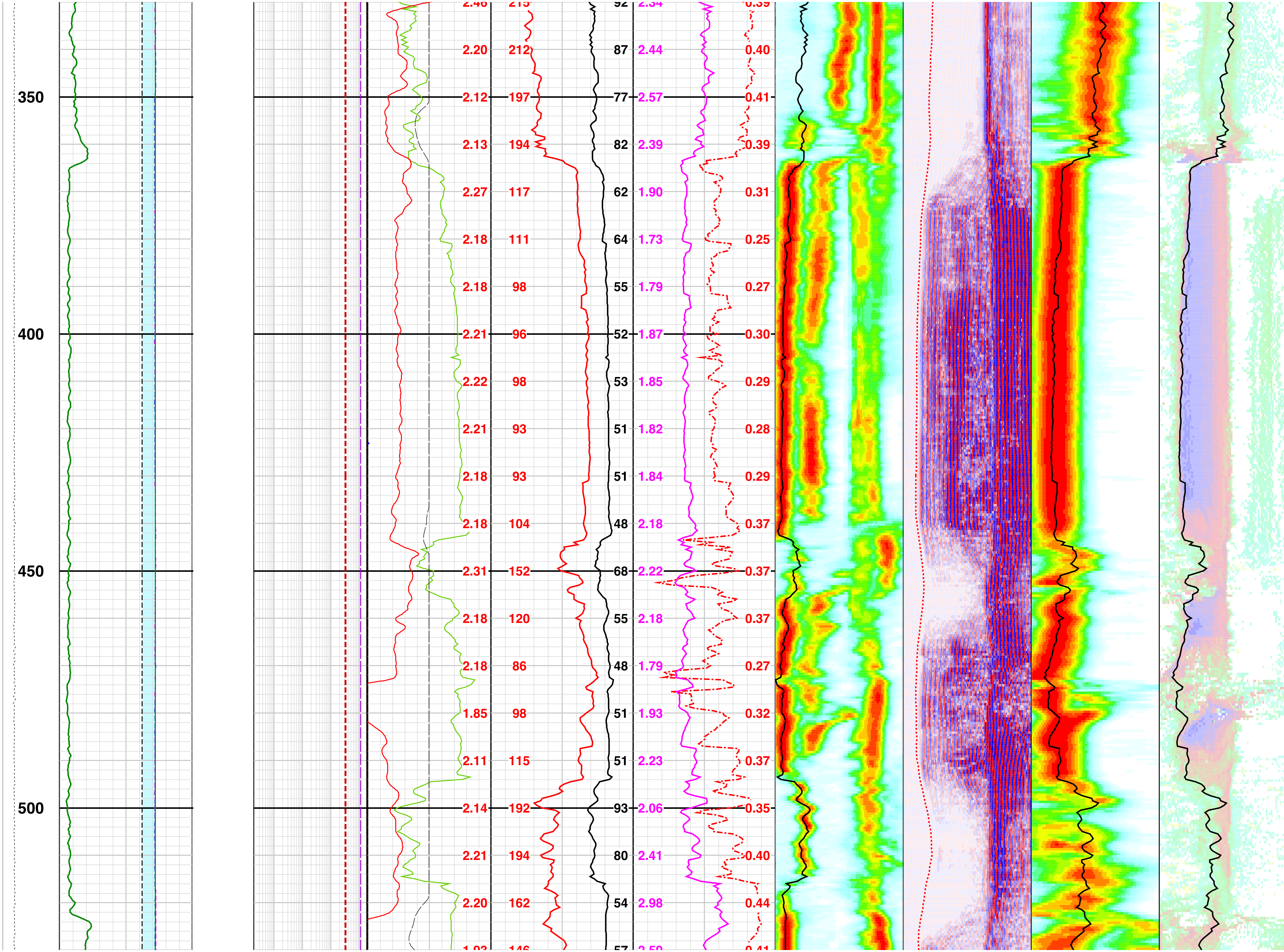
2.31 174 55 3.16 0.44
2.34 159 59 2.70 0.42
2.31 154 52 2.98 0.44
2.12 152 95 1.60 0.18
2.01 164 101 1.62 0.19
2.12 167 102 1.63 0.20
2.12 196 77 2.55 0.41
1.99 153 57 2.69 0.42
2.00 181 55 3.31 0.45
2.17 127 66 1.91 0.31
2.19 113 55 2.03 0.34
2.31 133 59 2.27 0.38
2.43 142 60 2.38 0.39
2.30 157 61 2.58 0.41
2.40 124 59 2.10 0.35
2.28 128 61 2.09 0.35
2.67 202 46 4.41 0.47
2.79 233 88 2.66 0.42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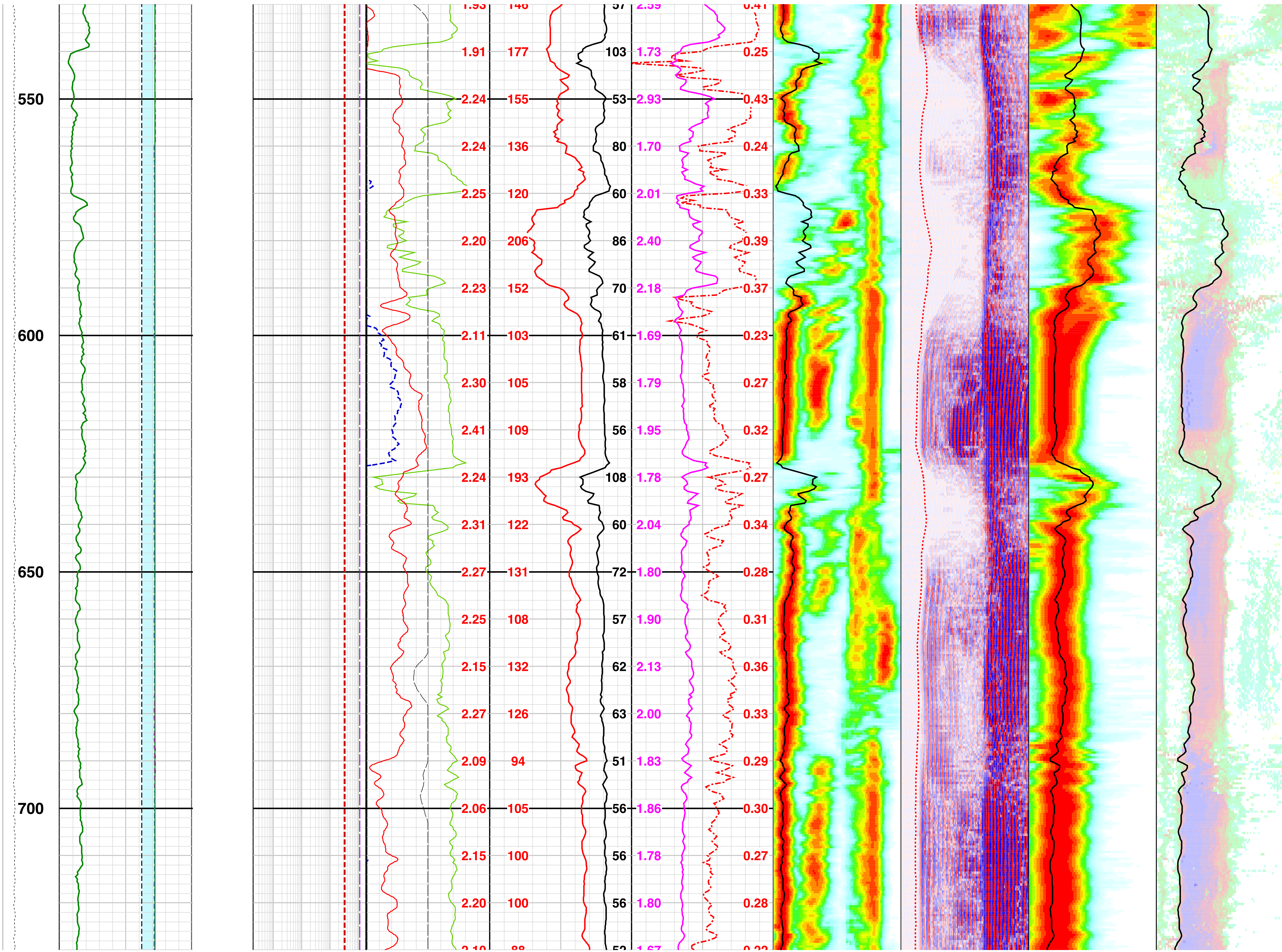
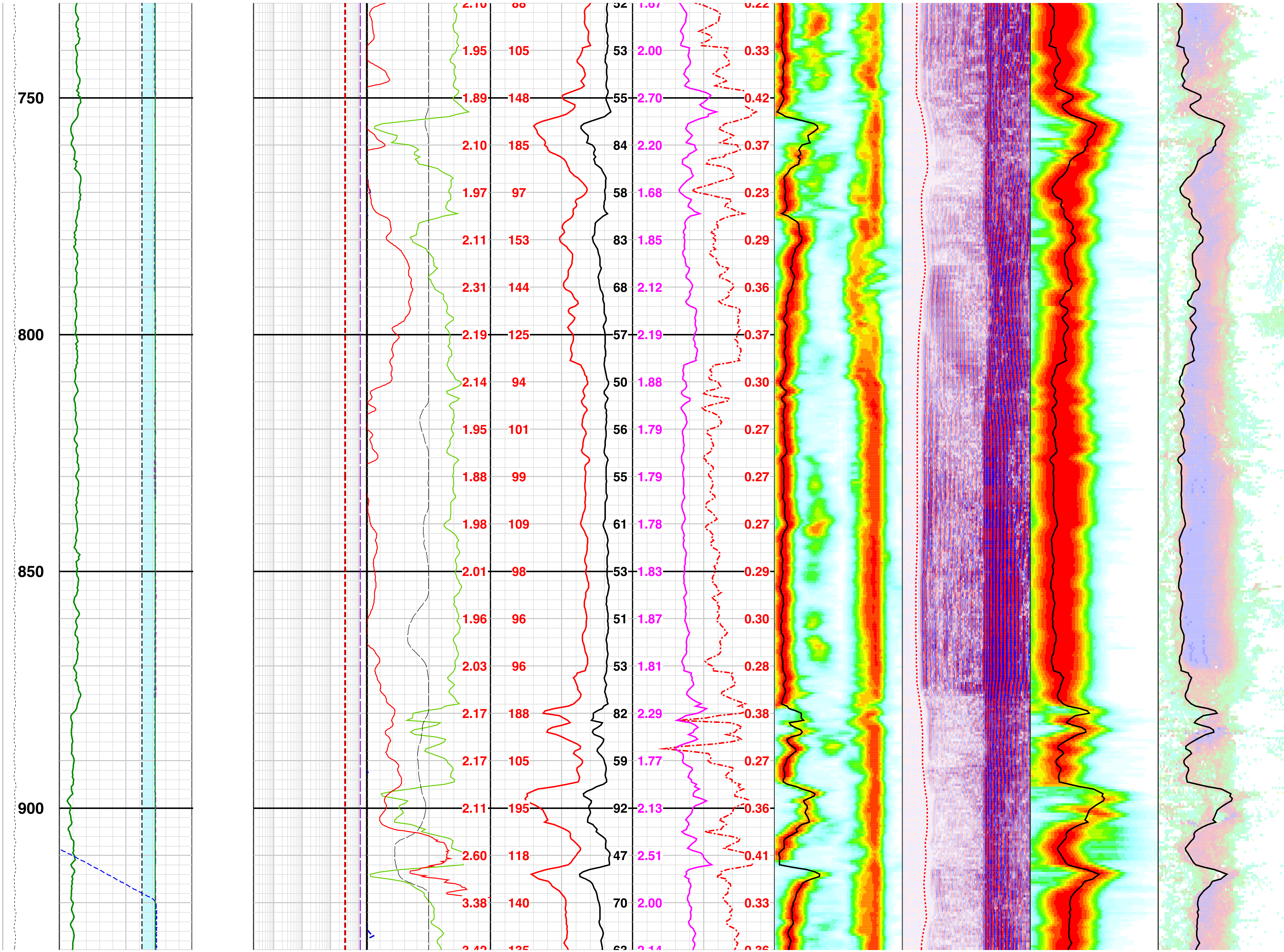
2.18 98 55 1.79 0.27
400
2.21 96 52 1.87 0.30
2.22 98 53 1.85 0.29
2.21 93 51 1.82 0.28
2.18 93 51 1.84 0.29
2.18 104 48 2.18 0.37
450
2.31 152 68 2.22 0.37
2.18 120 55 2.18 0.37
2.18 86 48 1.79 0.27
1.85 98 51 1.93 0.32
2.11 115 51 2.23 0.37
500
2.14 192 93 2.06 0.35
2.21 194 80 2.41 0.40
2.20 162 54 2.98 0.44



550
600
650
700
1.91 177 103 1.73 0.25
2.24 155 53 2.93 0.43
2.24 136 80 1.70 0.24
2.25 120 60 2.01 0.33
2.20 206 86 2.40 0.39
2.23 152 70 2.18 0.37
2.11 103 61 1.69 0.23
2.30 105 58 1.79 0.27
2.41 109 56 1.95 0.32
2.24 193 108 1.78 0.27
2.31 122 60 2.04 0.34
2.27 131 72 1.80 0.28
2.25 108 57 1.90 0.31
2.15 132 62 2.13 0.36
2.27 126 63 2.00 0.33
2.09 94 51 1.83 0.29
2.06 105 56 1.86 0.30
2.15 100 56 1.78 0.27
2.20 100 56 1.80 0.28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800
850
900
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1.89 148 55 2.70 0.42
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2.11 153 83 1.85 0.29
2.31 144 68 2.12 0.36
2.19 125 57 2.19 0.37
2.14 94 50 1.88 0.30
1.95 101 56 1.79 0.27
1.88 99 55 1.79 0.27
1.98 109 61 1.78 0.27
2.01 98 53 1.83 0.29
1.96 96 51 1.87 0.30
2.03 96 53 1.81 0.28
2.17 188 82 2.29 0.38
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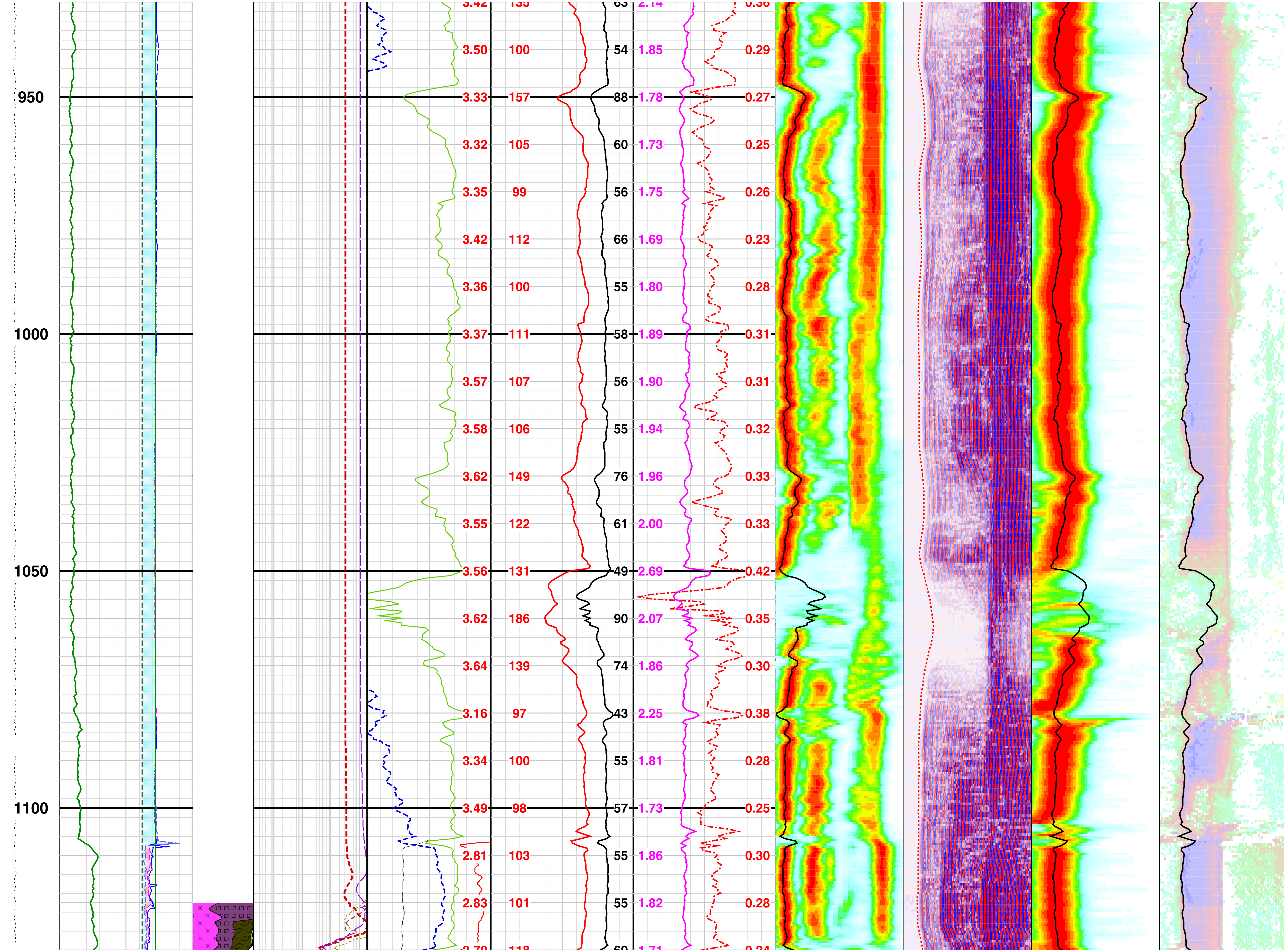
2.60 118 47 2.51 0.41
3.38 140 70 2.00 0.33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1000
1050
1100
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3.42 112 66 1.69 0.23
3.36 100 55 1.80 0.28
3.37 111 58 1.89 0.31
3.57 107 56 1.90 0.31
3.58 106 55 1.94 0.32
3.62 149 76 1.96 0.33
3.55 122 61 2.00 0.33
3.56 131 49 2.69 0.42
3.62 186 90 2.07 0.35
3.64 139 74 1.86 0.30
3.16 97 43 2.25 0.38
3.34 100 55 1.81 0.28
3.49 98 57 1.73 0.25
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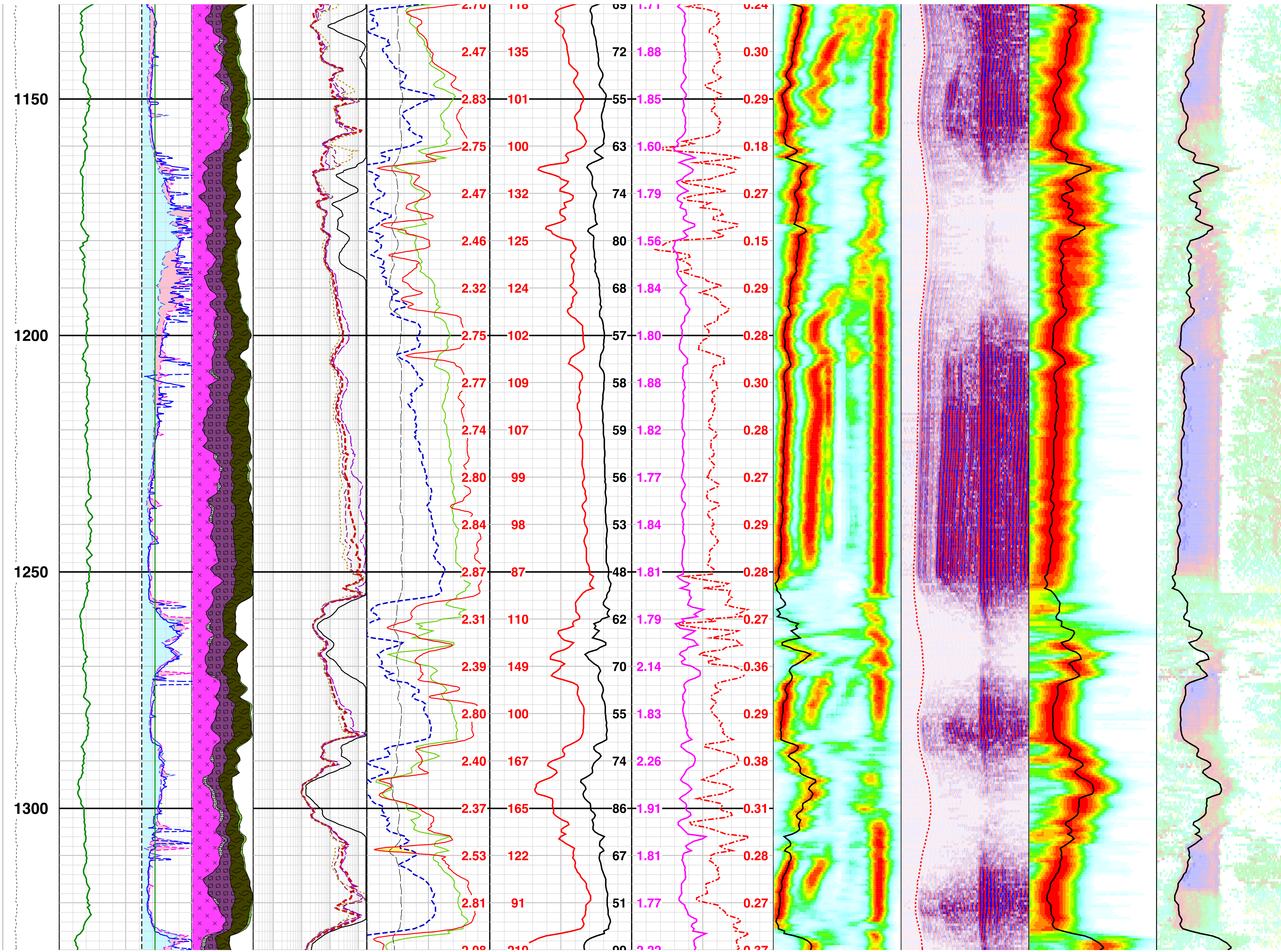
2.83 101 55 1.82 0.28



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1150 2.83 101 55 1.85 0.29
2.75 100 63 1.60 0.18
2.47 132 74 1.79 0.27
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2.32 124 68 1.84 0.29
1200 2.75 102 57 1.80 0.28
2.77 109 58 1.88 0.30
2.74 107 59 1.82 0.28
2.80 99 56 1.77 0.27
2.84 98 53 1.84 0.29
1250 2.87 87 48 1.81 0.28
2.31 110 62 1.79 0.27
2.39 149 70 2.14 0.36
2.80 100 55 1.83 0.29
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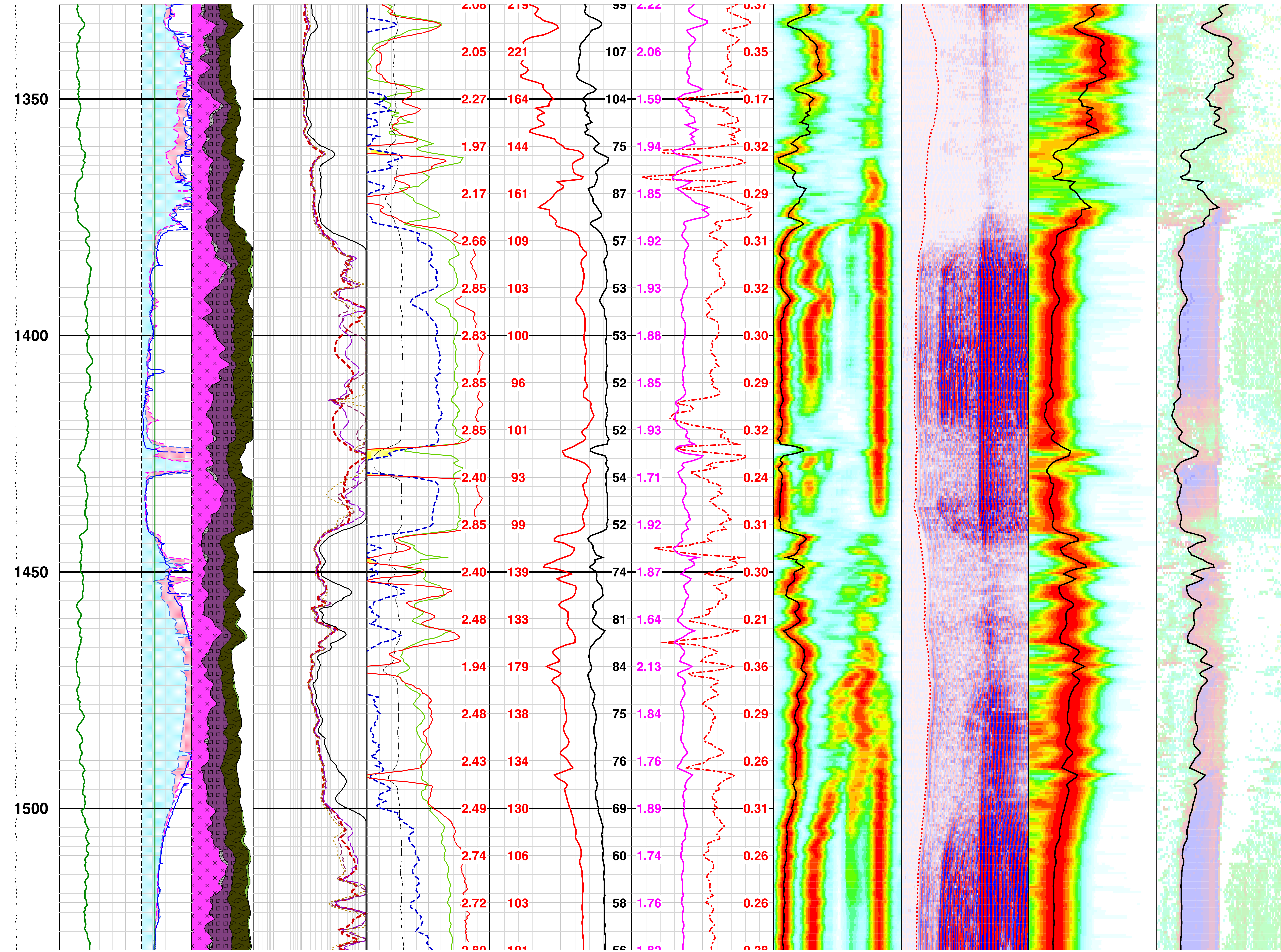
2.81 91 51 1.77 0.27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1400
1450
1500
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2.66 109 57 1.92 0.31
2.85 103 53 1.93 0.32
2.83 100 53 1.88 0.30
2.85 96 52 1.85 0.29
2.85 101 52 1.93 0.32
2.40 93 54 1.71 0.24
2.85 99 52 1.92 0.31
2.40 139 74 1.87 0.30
2.48 133 81 1.64 0.21
1.94 179 84 2.13 0.36
2.48 138 75 1.84 0.29
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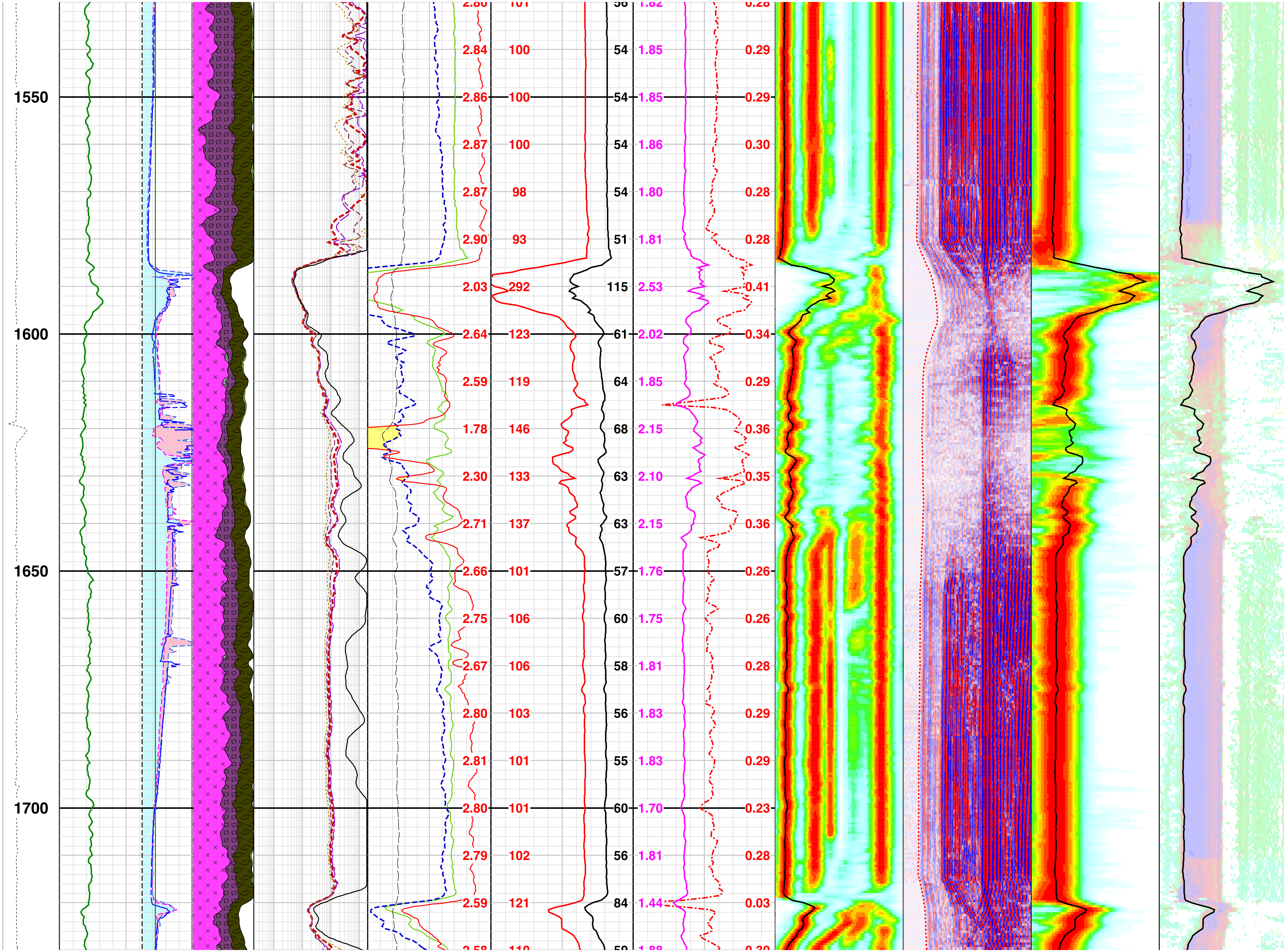

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1600
1650
1700
2.84 100 54 1.85 0.29
2.86 100 54 1.85 0.29
2.87 100 54 1.86 0.30
2.87 98 54 1.80 0.28
2.90 93 51 1.81 0.28
2.03 292 115 2.53 0.41
2.64 123 61 2.02 0.34
2.59 119 64 1.85 0.29
1.78 146 68 2.15 0.36
2.30 133 63 2.10 0.35
2.71 137 63 2.15 0.36
2.66 101 57 1.76 0.26
2.75 106 60 1.75 0.26
2.67 106 58 1.81 0.28
2.80 103 56 1.83 0.29
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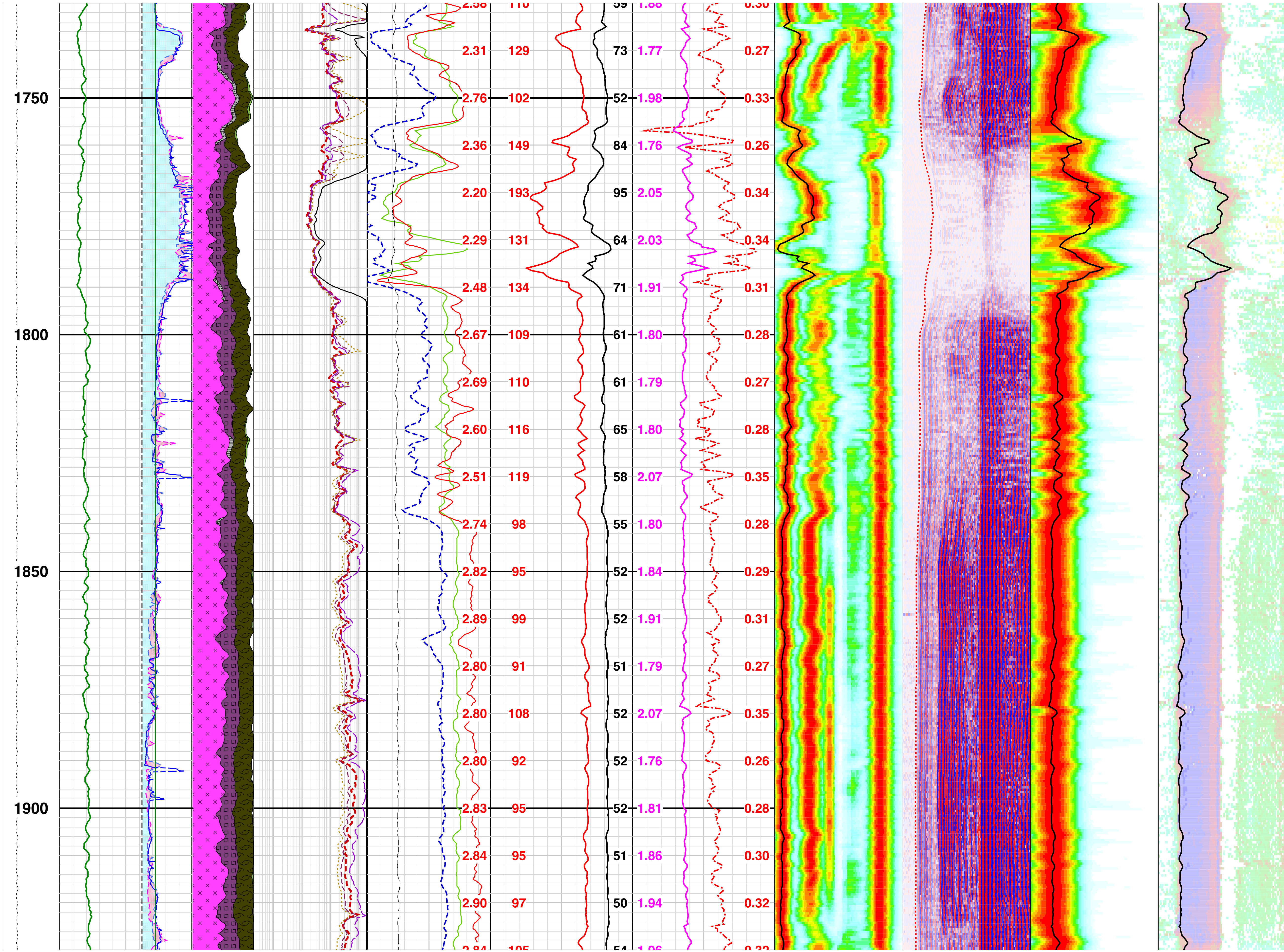
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1800
1850
1900
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2.29 131 64 2.03 0.34
2.48 134 71 1.91 0.31
2.67 109 61 1.80 0.28
2.69 110 61 1.79 0.27
2.60 116 65 1.80 0.28
2.51 119 58 2.07 0.35
2.74 98 55 1.80 0.28
2.82 95 52 1.84 0.29
2.89 99 52 1.91 0.31
2.80 91 51 1.79 0.27
2.80 108 52 2.07 0.35
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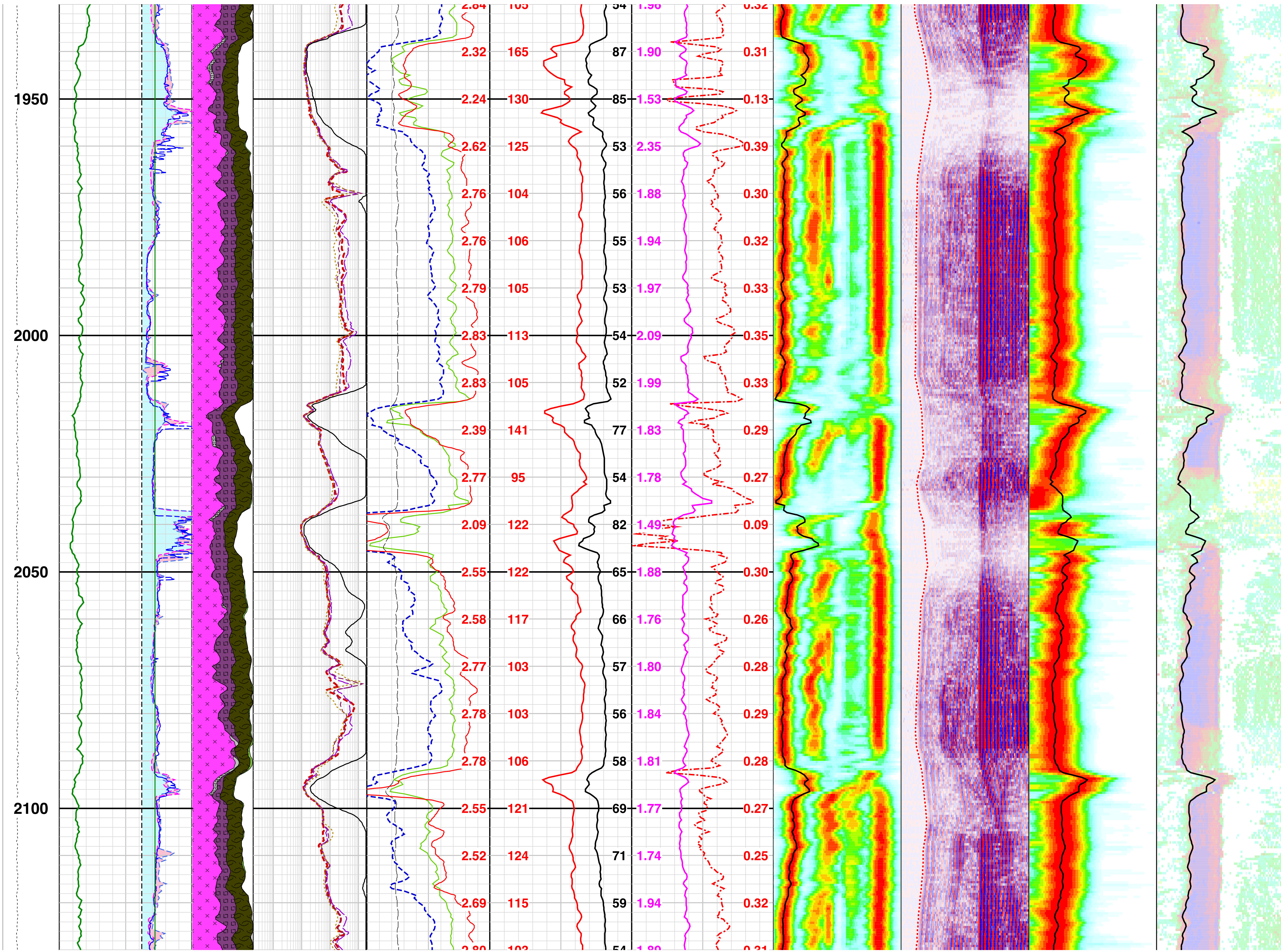
2.90 97 50 1.94 0.32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2000
2050
2100
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2.76 106 55 1.94 0.32
2.79 105 53 1.97 0.33
2.83 113 54 2.09 0.35
2.83 105 52 1.99 0.33
2.39 141 77 1.83 0.29
2.77 95 54 1.78 0.27
2.09 122 82 1.49 0.09
2.55 122 65 1.88 0.30
2.58 117 66 1.76 0.26
2.77 103 57 1.80 0.28
2.78 103 56 1.84 0.29
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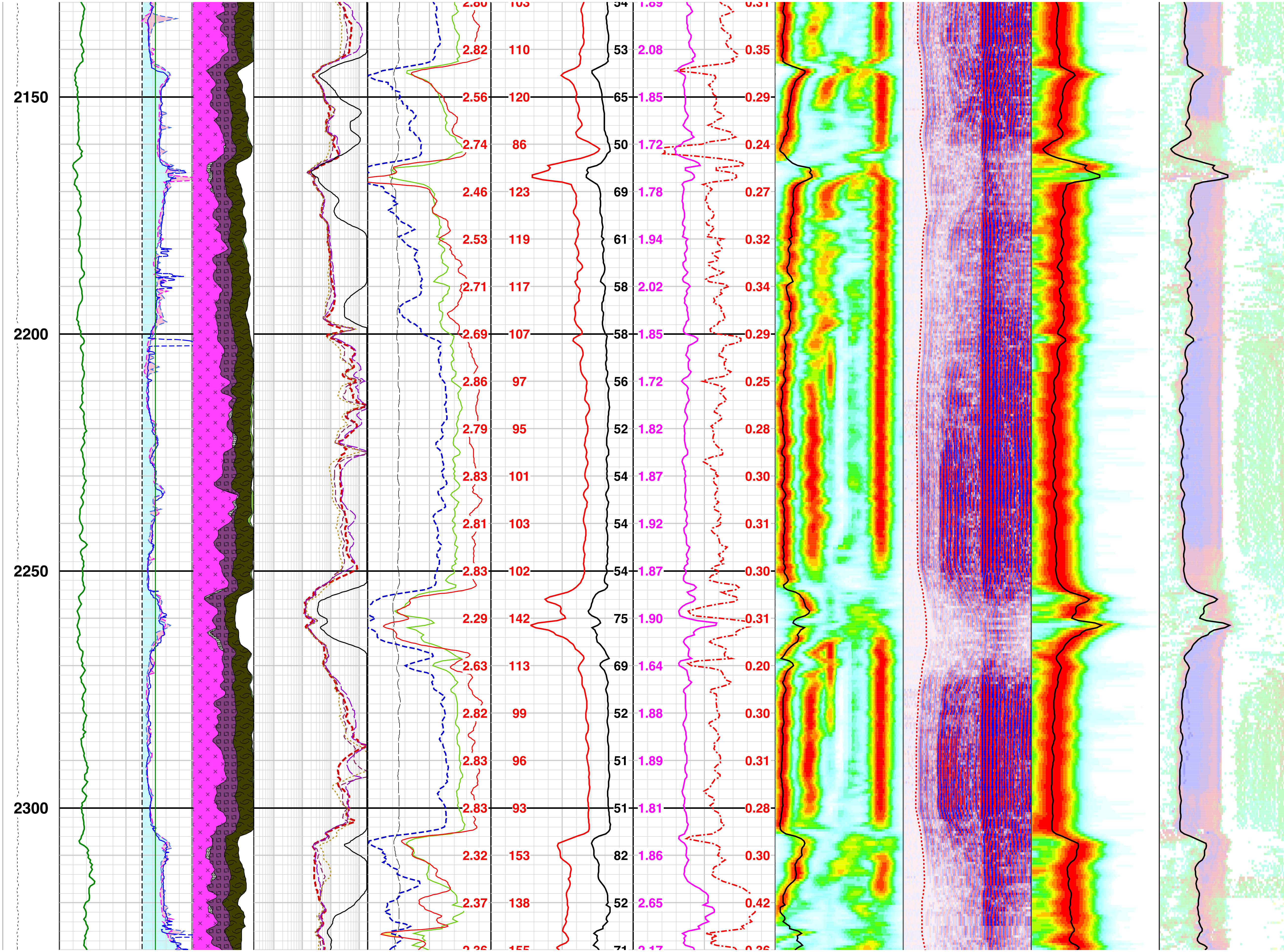
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2300
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2.53 119 61 1.94 0.32
2.71 117 58 2.02 0.34
2.69 107 58 1.85 0.29
2.86 97 56 1.72 0.25
2.79 95 52 1.82 0.28
2.83 101 54 1.87 0.30
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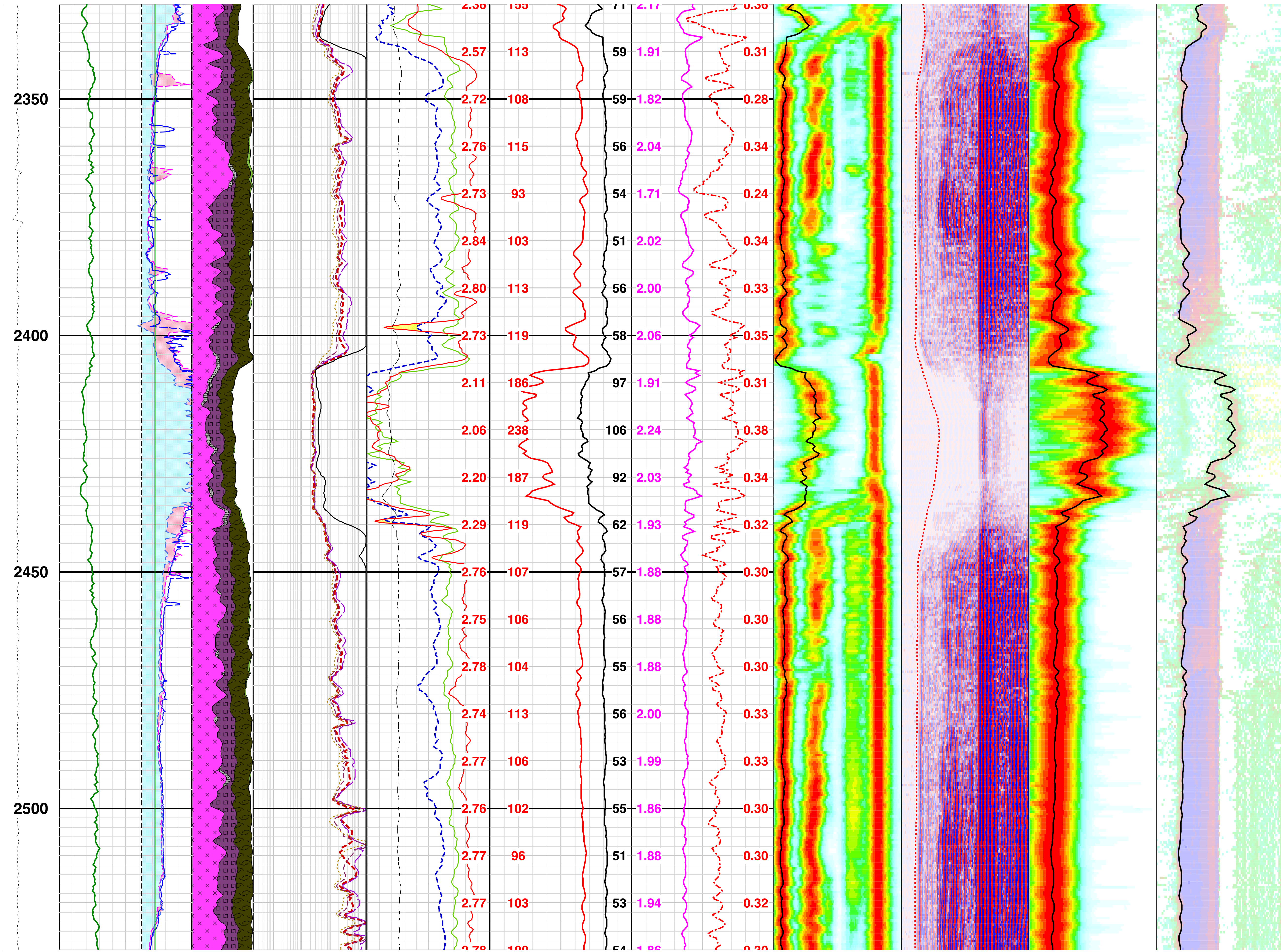
2.37 138 52 2.65 0.42



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2400
2450
2500
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2.73 93 54 1.71 0.24
2.84 103 51 2.02 0.34
2.80 113 56 2.00 0.33
2.73 119 58 2.06 0.35
2.11 186 97 1.91 0.31
2.06 238 106 2.24 0.38
2.20 187 92 2.03 0.34
2.29 119 62 1.93 0.32
2.76 107 57 1.88 0.30
2.75 106 56 1.88 0.30
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2.74 113 56 2.00 0.33
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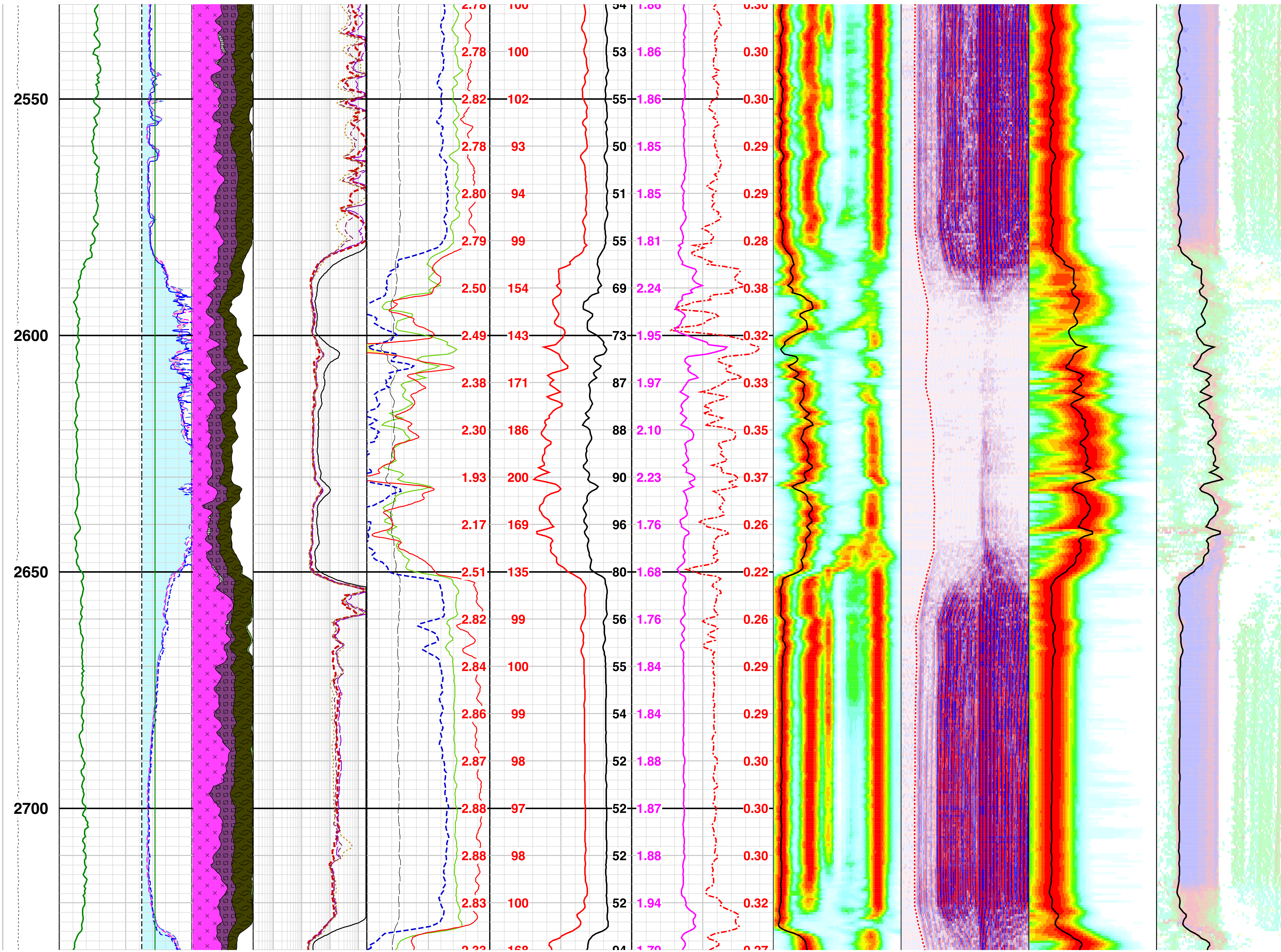
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2.38 171 87 1.97 0.33
2.30 186 88 2.10 0.35
1.93 200 90 2.23 0.37
2.17 169 96 1.76 0.26
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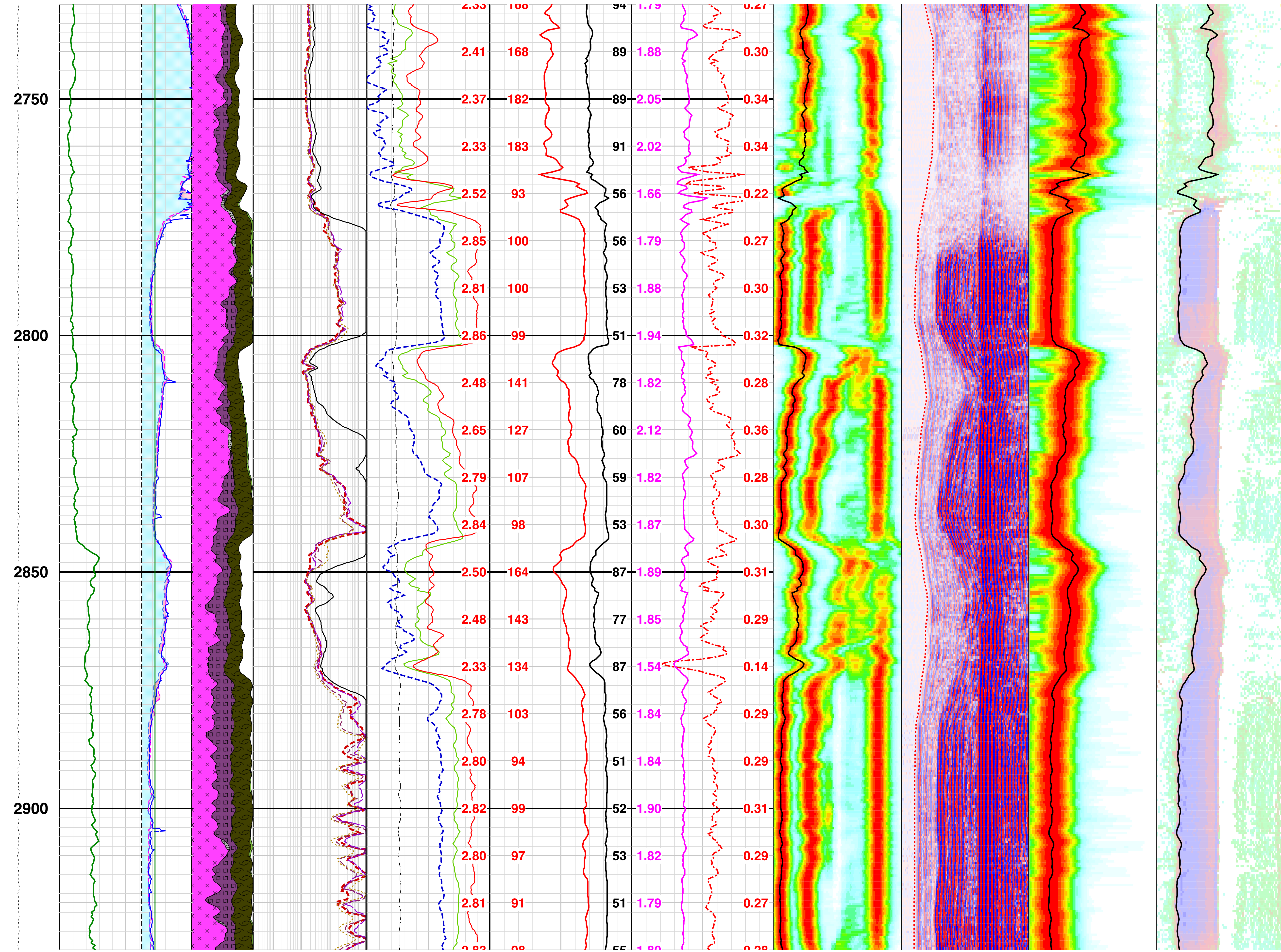
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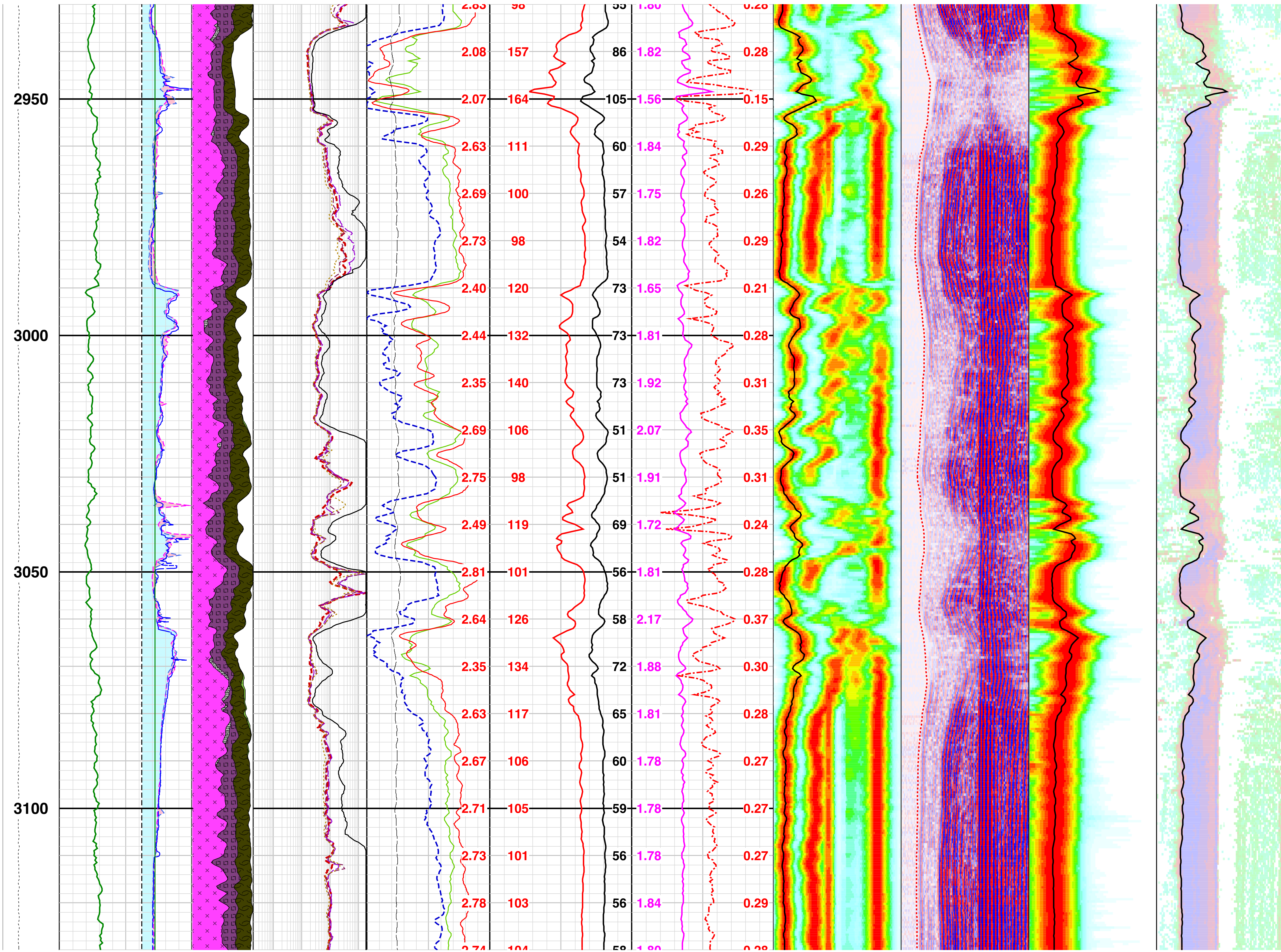
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2.35 140 73 1.92 0.31
2.69 106 51 2.07 0.35
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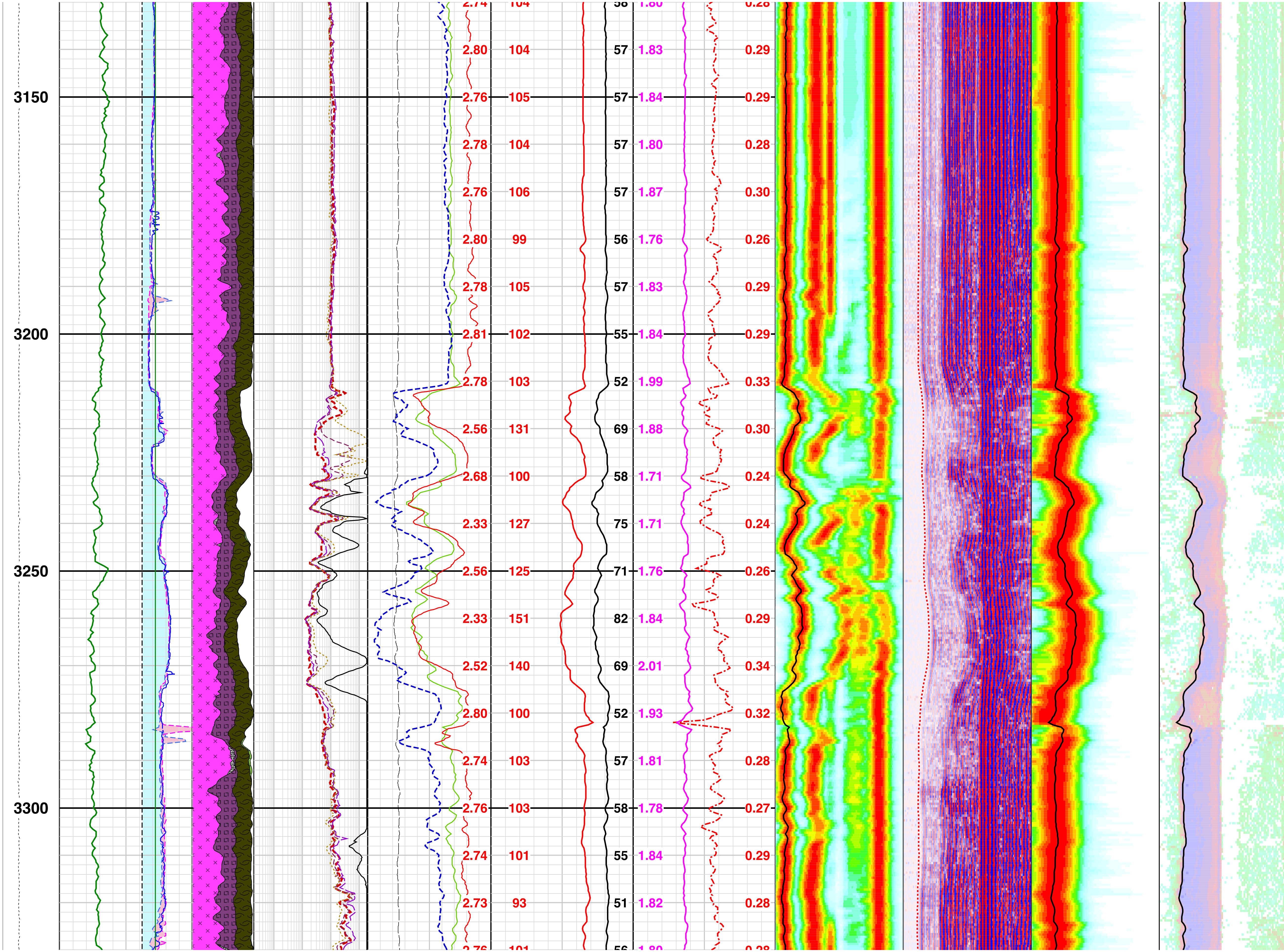
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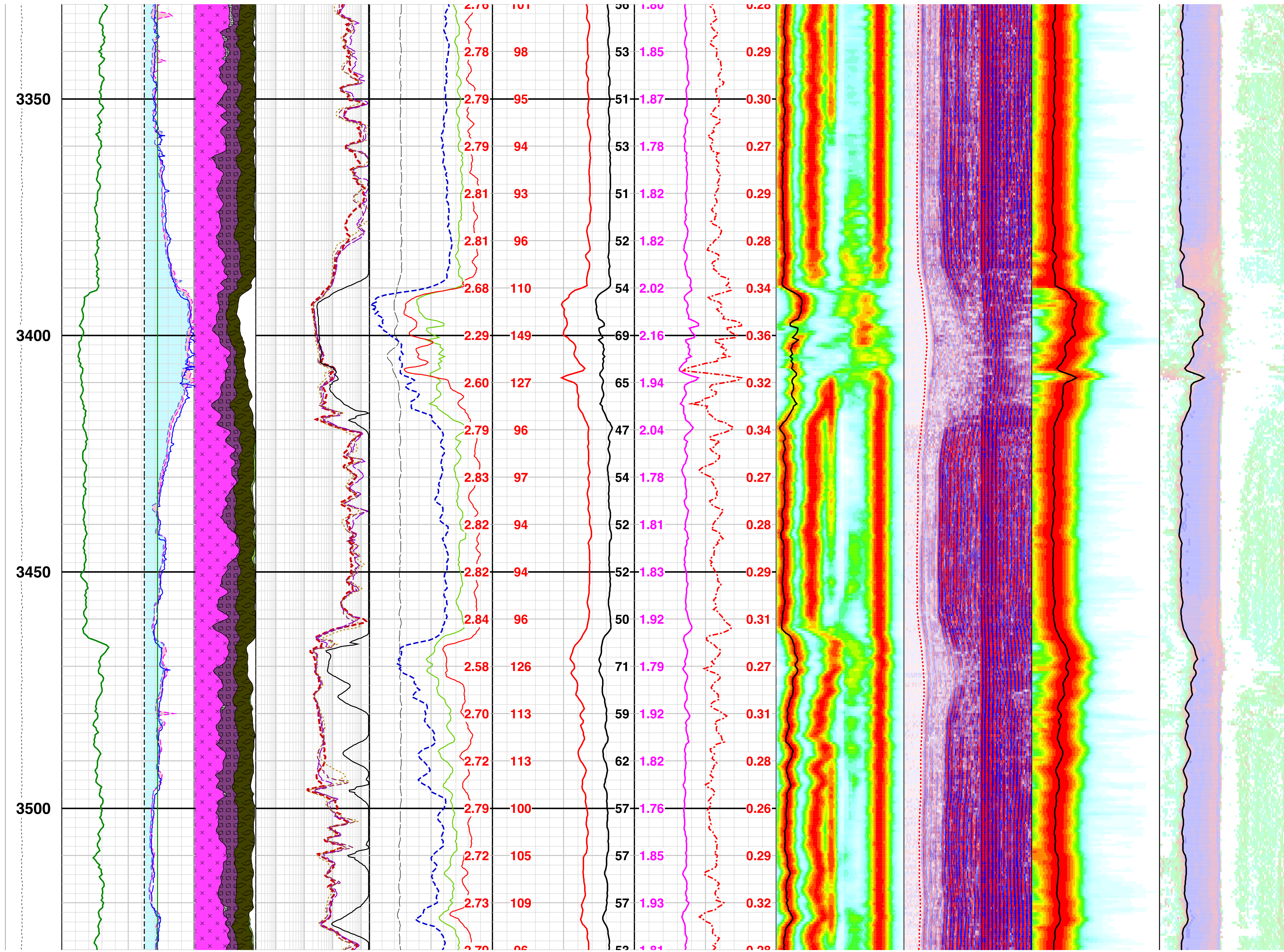
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2.68 110 54 2.02 0.34
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2.60 127 65 1.94 0.32
2.79 96 47 2.04 0.34
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2.82 94 52 1.81 0.28
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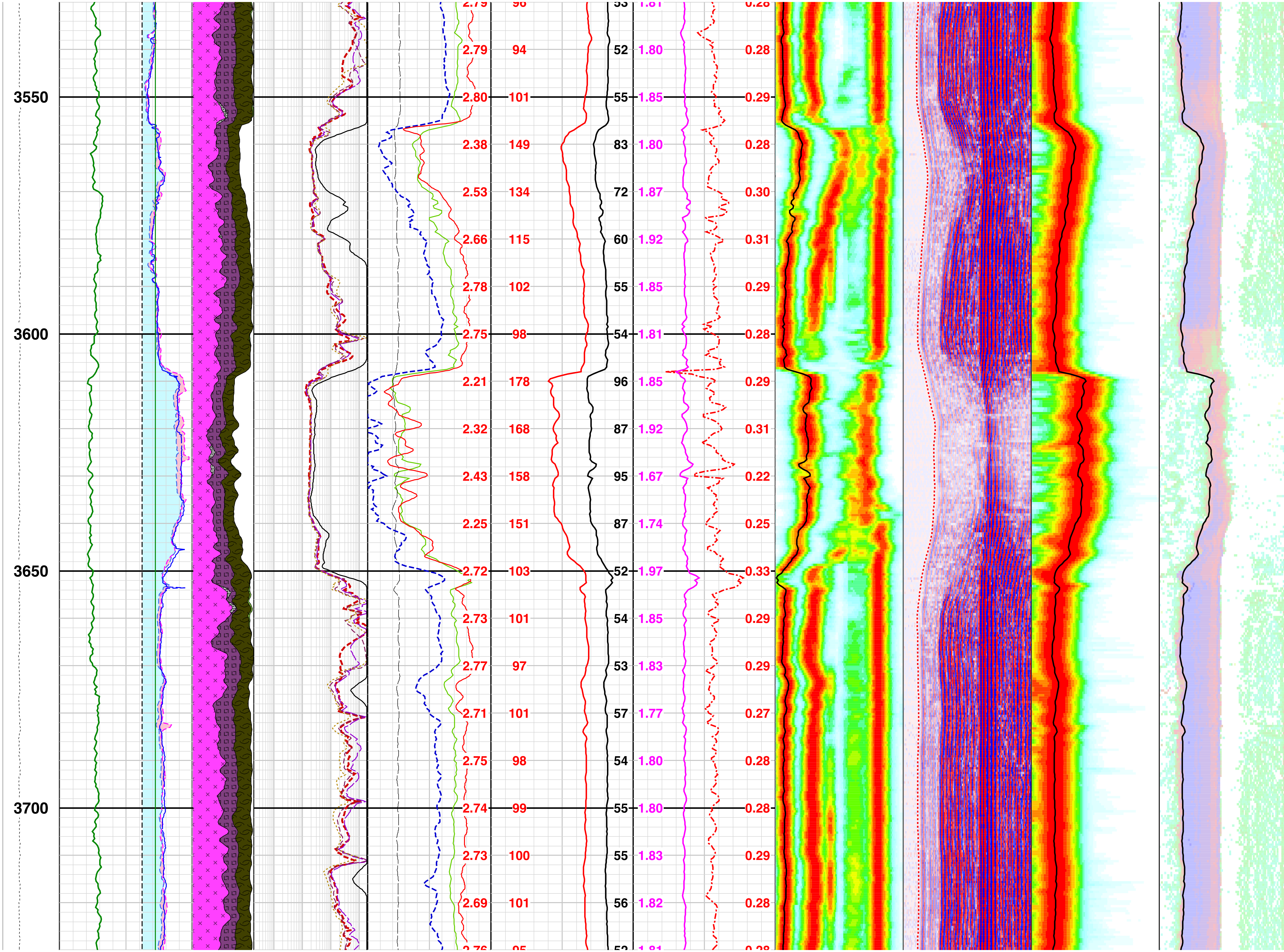
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2.32 168 87 1.92 0.31
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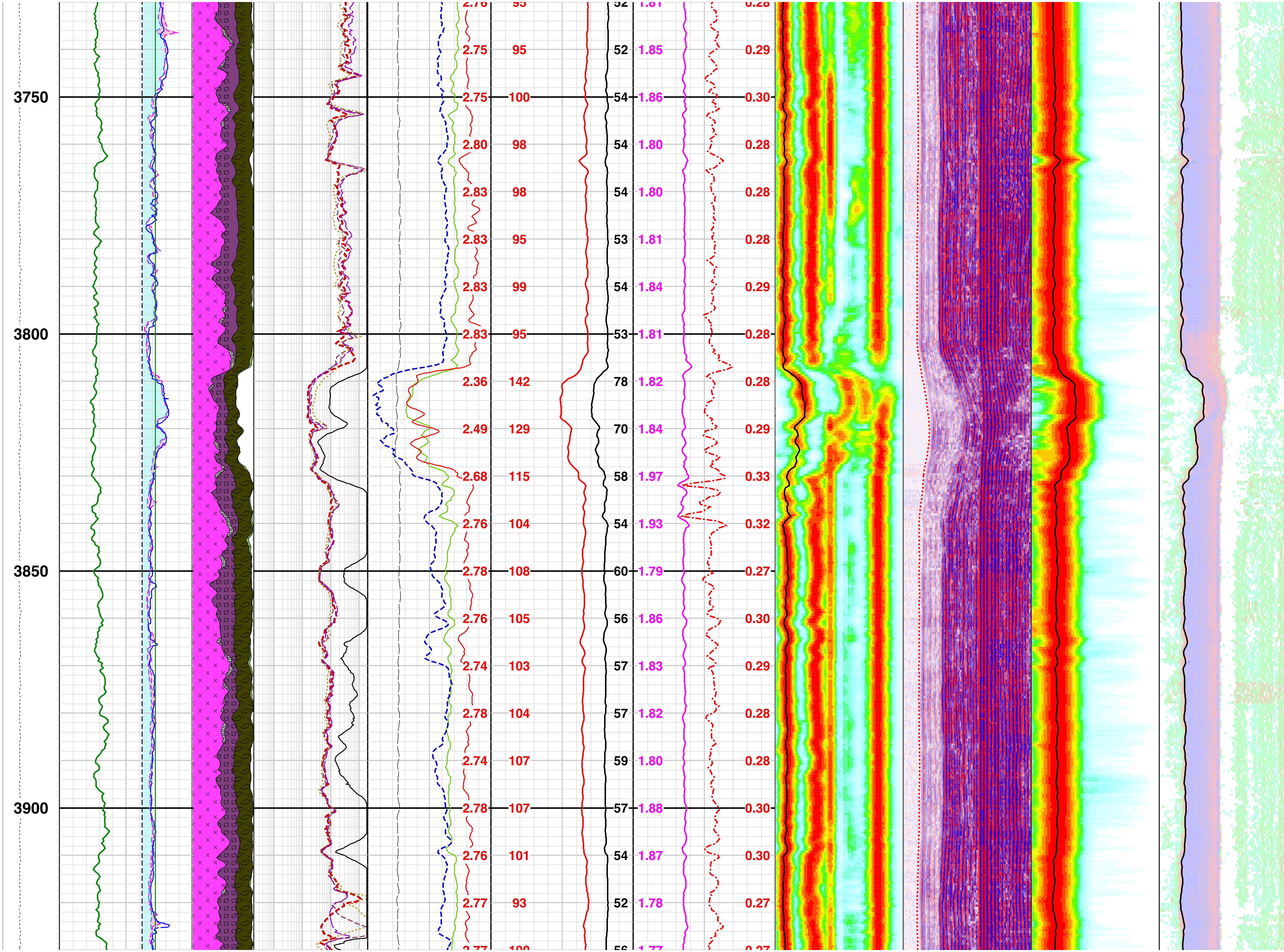
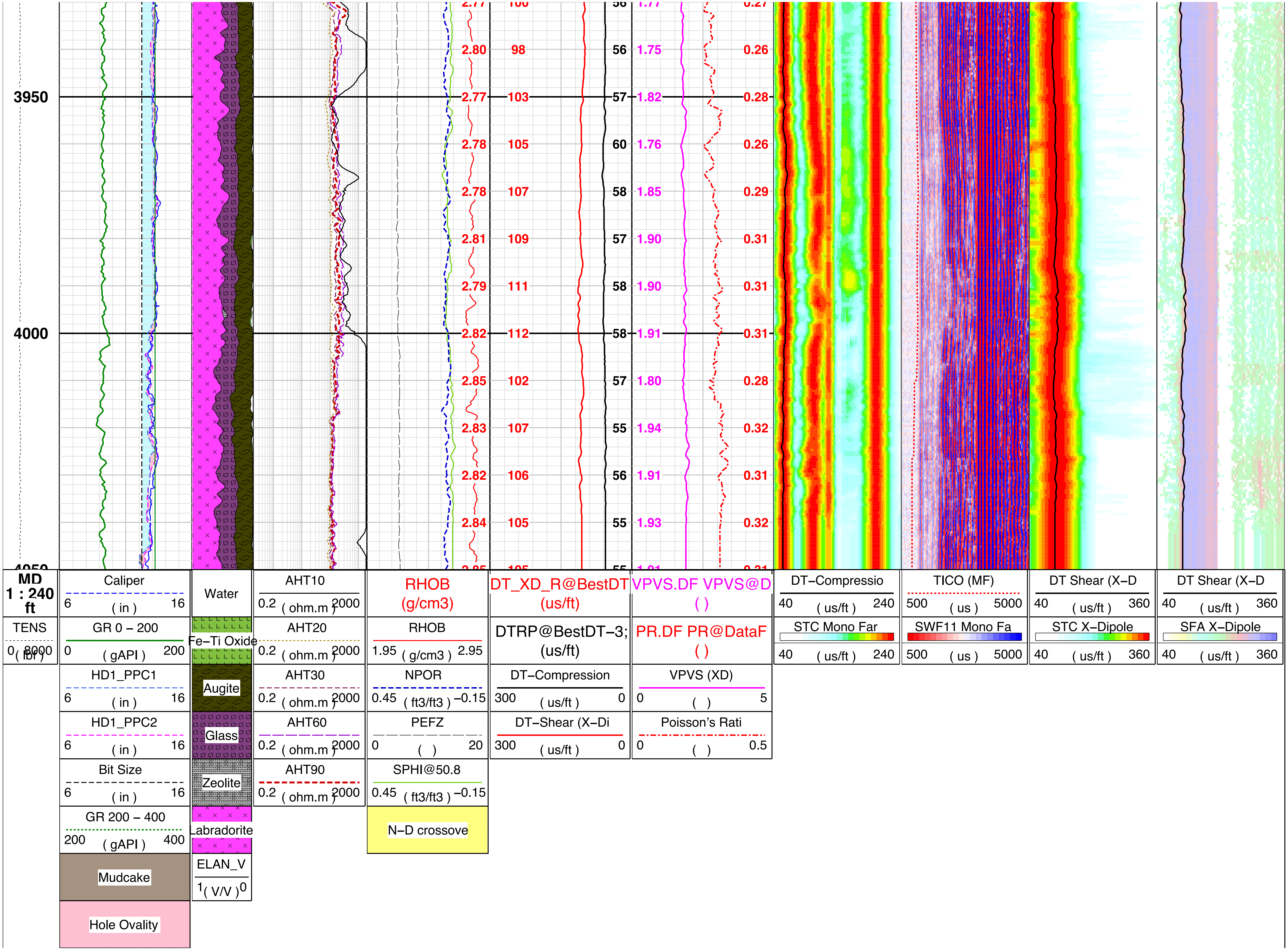
2.72 103 52 1.97 0.33
2.73 101 54 1.85 0.29
2.77 97 53 1.83 0.29
2.71 101 57 1.77 0.27
2.75 98 54 1.80 0.28
2.74 99 55 1.80 0.28
2.73 100 55 1.83 0.29
2.69 101 56 1.82 0.28

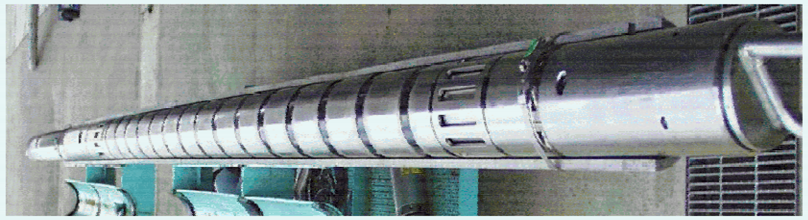


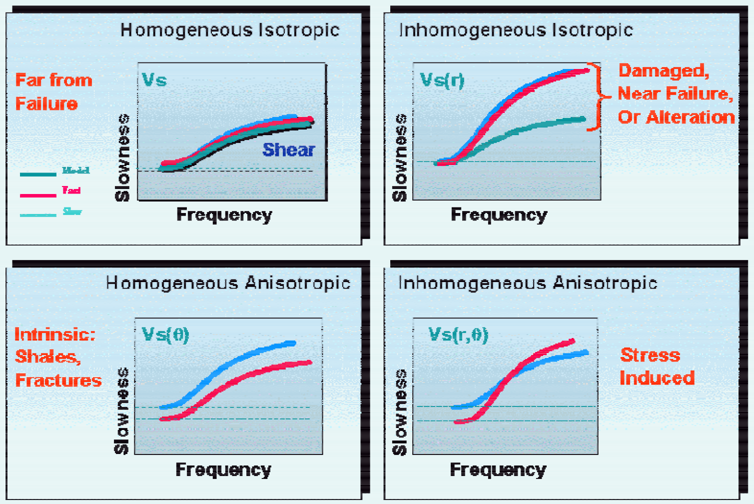
2.75 95 52 1.85 0.29
3750 2.75 100 54 1.86 0.30
2.80 98 54 1.80 0.28
2.83 98 54 1.80 0.28
2.83 95 53 1.81 0.28
2.83 99 54 1.84 0.29
3800 2.83 95 53 1.81 0.28
2.36 142 78 1.82 0.28
2.49 129 70 1.84 0.29
2.68 115 58 1.97 0.33
2.76 104 54 1.93 0.32
3850 2.78 108 60 1.79 0.27
2.76 105 56 1.86 0.30
2.74 103 57 1.83 0.29
2.78 104 57 1.82 0.28
2.74 107 59 1.80 0.28
3900 2.78 107 57 1.88 0.30
2.76 101 54 1.87 0.30
2.77 93 52 1.78 0.27



3950
4000
2.80 98 56 1.75 0.26
2.77 103 57 1.82 0.28
2.78 105 60 1.76 0.26
2.78 107 58 1.85 0.29
2.81 109 57 1.90 0.31
2.79 111 58 1.90 0.31
2.82 112 58 1.91 0.31
2.85 102 57 1.80 0.28
2.83 107 55 1.94 0.32
2.82 106 56 1.91 0.31
2.84 105 55 1.93 0.32
MD
1 : 240
ft
TENS
0 (lbf) 8000
Caliper
6 (in) 16
GR 0 – 200
0 (gAPI) 200
HD1_PPC1
6 (in) 16
HD1_PPC2
6 (in) 16
Bit Size
6 (in) 16
GR 200 – 400
200 (gAPI) 400
Mudcake
Hole Ovality
Water
Fe–Ti Oxide
Augite
Glass
Zeolite
Labradorite
ELAN_V
1 (V/V) 0
AHT10
0.2 (ohm.m) 2000
AHT20
0.2 (ohm.m) 2000
AHT30
0.2 (ohm.m) 2000
AHT60
0.2 (ohm.m) 2000
AHT90
0.2 (ohm.m) 2000
RHOB
(g/cm3)
RHOB
1.95 (g/cm3) 2.95
NPOR
0.45 (ft3/ft3) –0.15
PEFZ
0 ( ) 20
SPHI@50.8
0.45 (ft3/ft3) –0.15
N–D crossove
DT_XD_R@BestDT
(us/ft)
DTRP@BestDT–3;
(us/ft)
DT–Compression
300 (us/ft) 0
DT–Shear (X–Di
300 (us/ft) 0
VPVS.DF VPVS@D
( )
PR.DF PR@DataF
( )
VPVS (XD)
0 ( ) 5
Poisson's Rati
0 ( ) 0.5
DT–Compressio
40 (us/ft) 240
STC Mono Far
40 (us/ft) 240
TICO (MF)
500 (us) 5000
SWF11 Mono Fa
500 (us) 5000
DT Shear (X–D
40 (us/ft) 360
STC X–Dipole
40 (us/ft) 360
DT Shear (X–D
40 (us/ft) 360
SFA X–Dipole
40 (us/ft) 360

Washout
GR 200 – 400





Modular Sonic Imaging Platform

Tool Concept –

A wide–frequency–band tool that enables formation characterization as:

- **homogeneous or inhomogeneous**
- **isotropic or anisotropic**

Long and Short monopole transmitter receiver spacing

A tool that is fully characterized with predictable acoustics

Full–Serv. Tool Specifications

Makeup length	42.3 ft (12.9m)
Weight in air	844 lbm (384 kg)
Outside diameter	3 5/8 in. (entire tool)
Transmitter–Receiver offset:	11–17 ft from monopole trans. 9–15 ft from X–direction dipole trans. 10–16 ft from Y–direction diipole trans.
Number of receiver stations	13, 6–in. apart
Pressure rating	20,000 psi
Temperature rating	350 degF (–20 degC to 175 degC)
Storage temperature	Greater than –55 degC
Tensile strength	35,000 lbf (157 kN)
Max. weight below spacer	2,000 lbf (9 kN)
Max. compressional load (for tough logging conditions)	4,000 lbf (18 kN)
Shock rating	250 g at 2 ms for X/Y x 2,000 100 g at 5 ms for Z x 100

Geophysics Applications

- Improved seismic tie
- Improved time/depth relationship
- Better 3D seismic analysis
- Polar anisotropy (VTI)
- Shear synthetics

Geomechanics Applications

- Sanding prediction
- Wellbore stability
- Rock mechanics
- Selective perforating (sand control)

Petrophysics Applications

- Alteration determination
- Radial profiling
- Mechanical properties
- Gas detection

Reservoir Characterization

- Improved shallow reading device point selection (CMR* magnetic resonance tool, MDT* modular formation dynamics tester, etc.) based on formation alteration
- Improved reserves estimates
- Maximized drawdown

Features

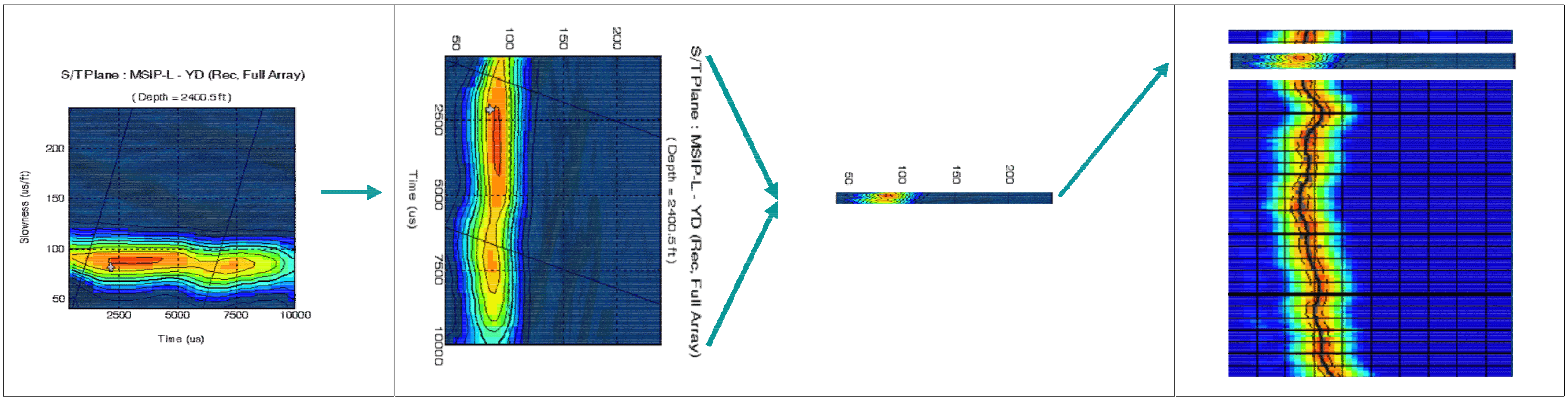
- Robust measurement of compressional and shear slowness (ΔT_C and ΔT_S)
- Increased logging speed
- Multiple monopole transmitter and receiver spacing
- High fidelity wideband waveform s and dispersion curves
- Large receiver array
- Predictable acoustics
- Cement bond log (CBL) and variable density log (VDL) measurement
- Improved behind casing measurement with CBL/VDL simultaneous acquisition
- Extremely robust electronic package

Benefits

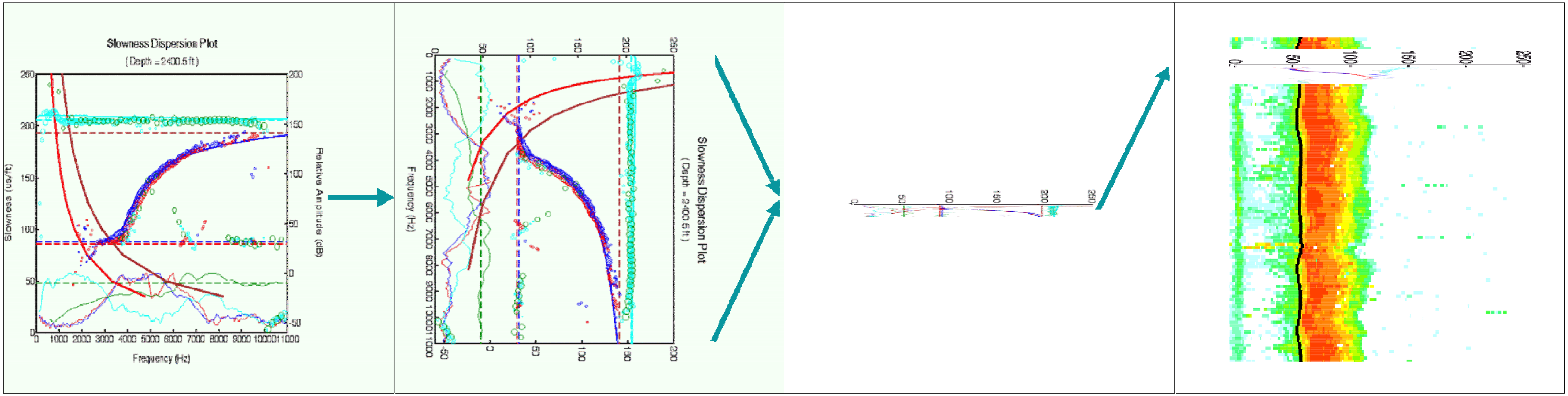
- Reduced uncertainty
- Decreased operating time
- Eliminated multiple frequency passes
- Fewer "no log" intervals
- Reduction of operating risk
- Eliminated separate run for cement evaluation
- Real-time decision making made possible with wellsite quicklook reports
- Real-time quality control

Quality Control Projection Logs

Slowness Time Coherency Log



Slowness Frequency Analysis Log



Technical Paper References:

SPWLA 1884889
"A Modular Wireline Sonic Tool for Measurements of 3D (Aimuthal, Radial, and Axial), Formation Acoustic Properties", Pistre; 46th Annual SPWLA in New Orleans, Louisiana, USA, June 26–29, 2005.

SPWLA 1534256
"Slowness–Frequency Projection Logs: A New QC Method for Accurate Sonic Slowness Evaluation"; T. Plona, M. Kane, J. Alford, T. Endo, J. Walsh, and D. Murray; 46th Annual SPWLA in New Orleans, Louisiana, USA, June 26–29, 2005.

Output Channels From This Processing:

```
                DESCRIPTION OF BASIC MSIP OUTPUT CURVES
                --------------------------------

Name                Description

DT1R---         DT-Shear from Y-Dipole - Receiver Array
DT1T---         DT-Shear from Y-Dipole - Transmitter Array
CHR1---         Peak Coherence for Y-Dipole   Receiver Array
CHT1---         Peak Coherence for Y-Dipole   Transmitter Array
SPR1---         STC Slowness Projection for Y-Dipole   Receiver Array
SPT1---         STC Slowness Projection for Y-Dipole   Transmitter Array

DT1R---         DT-Shear from X-Dipole - Receiver Array
DT1T---         DT-Shear from X-Dipole - Transmitter Array
```

```
CHR2---         Peak Coherence for X-Dipole   Receiver Array
CHT2---         Peak Coherence for X-Dipole   Transmitter Array
SPR2---         STC Slowness Projection for X-Dipole   Receiver Array
SPT2---         STC Slowness Projection for X-Dipole   Transmitter Array

DT3R---         DT-Stoneley from Monopole-Far-LF - Receiver Array
DT3T---         DT-Stoneley from Monopole-Far-LF - Transmitter Array
DTST---         DT-Stoneley from Monopole-Far-LF - Average of Receiver and Transmitter Arrays
CHR3---         Peak Coherence for Monopole-Far-LF   Receiver Array
CHT3---         Peak Coherence for Monopole-Far-LF   Transmitter Array
SPR3---         STC Slowness Projection for Monopole-Far-LF   Receiver Array
SPT3---         STC Slowness Projection for Monopole-Far-LF   Transmitter Array

DT4P---         DT-Compressional from Monopole-Far-8K - Average of Receiver and Transmitter Arrays
DT4S---         DT-Shear from Monopole-Far-8K - Average of Receiver and Transmitter Arrays
DTRP---         DT-Compressional from Monopole-Far-8K - Receiver Array
DTTP---         DT-Compressional from Monopole-Far-8K - Transmitter Array
DTRS---         DT-Shear from Monopole-Far-8K - Receiver Array
DTTS---         DT-Shear from Monopole-Far-8K - Transmitter Array
CHRP---         Peak Coherence for Monopole-Far-8K   Receiver Array
CHTP---         Peak Coherence for Monopole-Far-8K   Transmitter Array
SPR4---         STC Slowness Projection for Monopole-Far-8K   Receiver Array
SPT4---         STC Slowness Projection for Monopole-Far-8K   Transmitter Array

DTSM---         A general name for DT-Shear
DTCO---         A general name for DT-Compressional

DTEXR---         DT-Shear from Fast or Slow dipole waveforms processing in BestDt - Receiver Array
DTEXT---         DT-Shear from Fast or Slow dipole waveforms processing in BestDt - Transmitter Array
DTSM_FAST---         Fast DT-Shear from "Post-Anisotropy" processing
DTSM_SLOW---         Slow DT-Shear from "Post-Anisotropy" processing
CHREX---         Peak Coherence for Fast or Slow dipole waveforms processing in BestDt -  Receiver Array
CHTEX---         Peak Coherence for Fast or Slow dipole waveforms processing in BestDt - Transmitter Array
SPREX---         STC Slowness Projection for Fast or Slow dipole waveforms processing in BestDt -  Receiver Array
SPTEX---         STC Slowness Projection for  Fast or Slow dipole waveforms processing in BestDt - Transmitter Array

TISH----         Shear Total Travel Time
TICO----         Compressional Total Travel Time

VPVS----         (DT-Shear/Dt-Compressional ratio)
PR------         (POISSON RATIO =((0.5*VPVS*VPVS)-1)/((VPVS*VPVS) -1))


>>>>>>LOGGING MODES>>>>>>

BASIC CONFIGURATION / CONCISE MODE:
        MU -- Monopole Upper
        ML -- Monopole Lower

FULL CONFIGURATION / ALL MODE:
        MU -- Monopole Upper
        ML -- Monopole Lower
        MF -- Monopole Far
        XD_DIIN -- X-Dipole In-Line
        XD_DIOF -- X-Dipole Off-Line
        YD_DIIN -- Y-Dipole In-Line
        YD_DIOF -- Y-Dipole Off-Line

(Note: Availability of XDIN, XDOF, YDIN and YDOF waveforms are necessary for Anisotropy analysis).
```