Schlumberger

Shear Anisotropic Advisor

Anisotropic DT Computations
Deviated Wellbore

COMPANY: Crestone Peak Resources Operating LLC
WELL: COSSLETT 1F-22H-B168
FIELD: Wattenberg
COUNTY: Weld
STATE: Colorado
COUNTRY: USA

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WELL:	COSSLETT 1F-22H-B168
FIELD:	Wattenberg
COUNTY:	Weld
STATE:	Colorado
COUNTRY:	USA

API:05-123-47675

Location: Township:1N Range:68W

Other Services:

Permanent Datum:Ground Level — Elevation:5174
Log Measured From:Kelly Bushing — 23ft above the permanent datum
Drilling Measured from:Kelly Bushing

Elevations:
K.B. 23 ft
D.F. 22 ft
G.L. 5174 ft

Date	08-Jan-2019	
Run No.	1	
Depth Driller	17796 ft	
Depth Logger (Schl)	8706.8 ft	
Btm. Log Interval	8706 ft	
Top Log Interval	2535 ft	
Casing-Driller	9.625 in @ 2525 ft	
Casing-Logger	2535 ft	
Bit Size	8.75 in	
Type Fluid in Hole	OBM	
Dens. | Visc.	10.5 lbm/gal | 53 s	
pH | Fluid loss	NA 9.00 cm3	
Source of Sample	Sample	
Rm @ Meas.Temp.	0.0001 ohm.m @ 75 degF	
Rmf @ Meas.Temp.	0 ohm.m @ 75 degF	
Rmc @ Meas.Temp.	N/A 75 degF	
Source: Rmf | Rmc	Calculated	
Rm @ BHT	3.903661e-05 ohm m 202.7 degF	
Circulation Stopped	23:30	
Logger on Bottom	3:00	
Max Rec.Temp.	202.7 deg F	
Equipment | Location	9102 |Fort Morgan	
Recorded by:	Stephen Tang	
Witnessed by:	Jason Burris	

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

PTS Software:Techlog 2018.1	Process Date:January 2019	PTS Center: Denver	Log Analyst:G.A. Martinez	

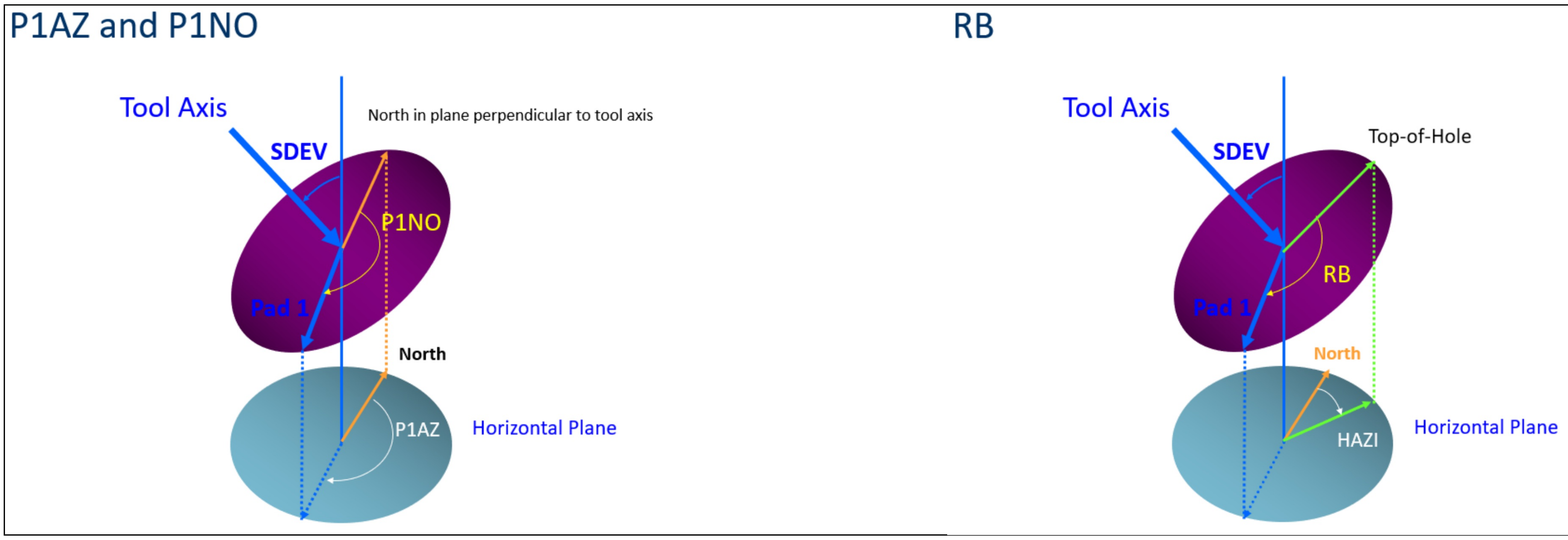
Log Analyst Remarks:

AVAILABLE INPUT DATA:
ThruBit Dipole Full Configuration
DTCO: DT-Compressional from Monopole waveforms.
DTSM: DT-Shear from Dipole Source Including the X and Y Dipole
CALIPER: 1 Caliper CALI
NEUTRON/DENSITY: NPHI or TNPH and RHOZ from Triple Combo.
DIRECTIONAL DATA: GPIT was recorded on this logging run WITH A GYRO.

PROCESSING DETAILS:
DT-Compressional was processed using the Monopole waveforms. DT-Shear was processed using Dipole in Techlog.
This log uses the Fast and Slow shears to compute TIMANI and SLOANI.
INTERPRETATION METHOD:
To compute anisotropy SLOANI cutoff has been considered with SLOANI>2.3 for all the anisotropic intervals

Anisotropic Interpretation and Fast Shear Azimuth Rose Plot

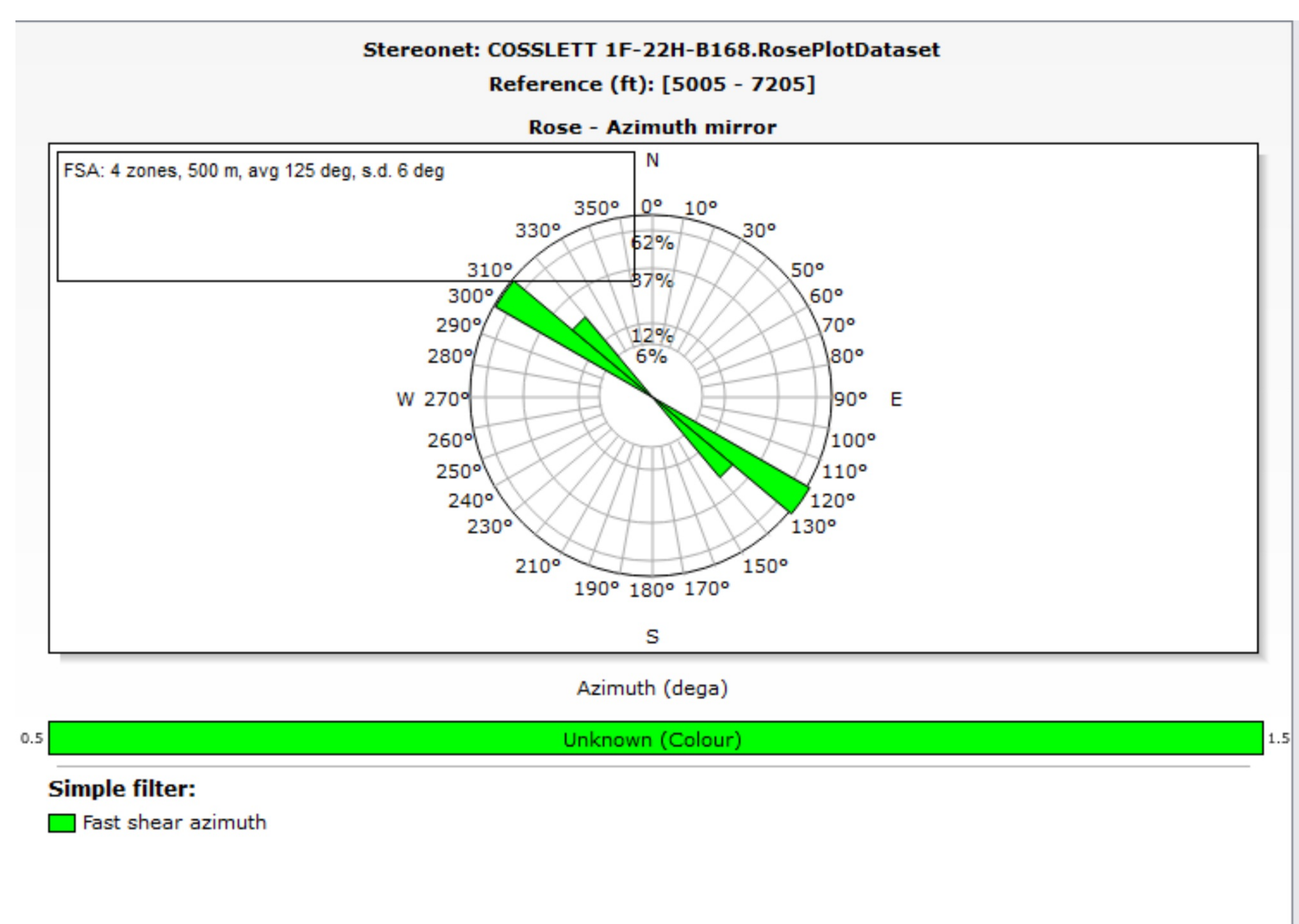
To provide a Fast Shear Orientation in the **Earth frame** an application had to be run because the Fast Shear Azimuth provided by the Anisotropy Processing has the tool as a reference irrespectively of the gyro measurements as in the figure below.



The **Stress regime and direction** application processing assumes that the source of anisotropy is due to stress induced anisotropy, for that reason a cluster analysis was run to be able to select the clean and porous portions of the well that would be more sensitive to present day stresses. The zones are represented by the light green, light blue and blue colors in the 7th track of the composite log.

Once the clean and porous sections were selected the obtained fast shear azimuth from the anisotropy processing was filtered to work only in the zones that presented at slowness-based anisotropy greater than 2.3 %. All the resulting 6 zones characterized certain portions of the well borehole as in the table below

This procedure provided a Fast Shear Azimuth in the Earth frame which indicated and orientation of N 50 W



☐	Well name	Feature type	MD top [ft]	MD bottom [ft]	Borehole deviation [deg]	Borehole azimuth [deg]	Reference frame	Feature azimuth [deg]
☑	COSSLETT 1F-...	Fast shear azimuth	4810.0	5200.0	11.4	36.1	Top of hole	120.6
☑	COSSLETT 1F-...	Fast shear azimuth	5220.0	6090.0	10.4	35.9	Top of hole	121.4
☑	COSSLETT 1F-...	Fast shear azimuth	6110.0	6420.0	9.7	28.7	Top of hole	121.5
☑	COSSLETT 1F-...	Fast shear azimuth	7170.0	7240.0	10.1	58.6	Top of hole	135.0
☑	COSSLETT 1F-...	Fast shear azimuth	7860.0	7930.0	46.4	178.8	Top of hole	80.8
☑	COSSLETT 1F-...	Fast shear azimuth	8100.0	8670.0	81.3	179.1	Top of hole	92.3

Track Descriptions

Track 1: Depth
Depth numbers - depth scale
MinEne - overall minimum cross energy
MaxEne - overall maximum cross energy
X - Ene area shading - indicates the difference betw een MinEne and MaxEne
FSA_FLAG - Flag denoting Anisotropic intervals

Track 2: TVD
TVD True Vertical Depth

Track 3: GAMMA RAY
GR - standard gamma ray
BS - bit size
CALI - ThruBit Caliper
BOREHOLE DEVIATION - borehole deviation from drilling survey
BOREHOLE AZIMUTH - borehole azimuth from drilling survey
RB_TBDS - Relative Bearing from the Thrubit tool

Track 4: Porosity
DPHZ - density porosity
TNPH - neutron porosity
SPHI - sonic porosity

Track 5: Fast Shear Orientation
FSA_RB (red) - overall fast shear azimuth with Relative Bearing as a reference in the tool frame.
FSA_ERRPLUS - Fast shear azimuth uncertainty
FSA_ERRMINUS - Fast shear azimuth uncertainty minus
Orientation Uncertainty area shading - indicates uncertainty of fast shear azimuth direction

Track 6: Delta-T/ Anisotropy Indicators
DTCO - delta-t compressional
DTCO values - delta-t compressional at that depth
DTSM_FAST - delta-t FAST shear
DTSM_FAST values - delta-t FAST shear at that depth
DTSM_SLOW - delta-t SLOW shear
DTSM_SLOW values - delta-t SLOW shear at that depth
DT-based Aniso - indicates slowness based anisotropy (FAST < SLOW)
Time-based Aniso - indicates arrival time based anisotropy (FAST < SLOW)
Purple->Red area shading - indicates a percentage difference for both slowness based and time based anisotropy
purple =low percentage red = high percentage

Track 7: Cluster Analysis
Cluster analysis results of the GR, RHOB, and TNPH arrays

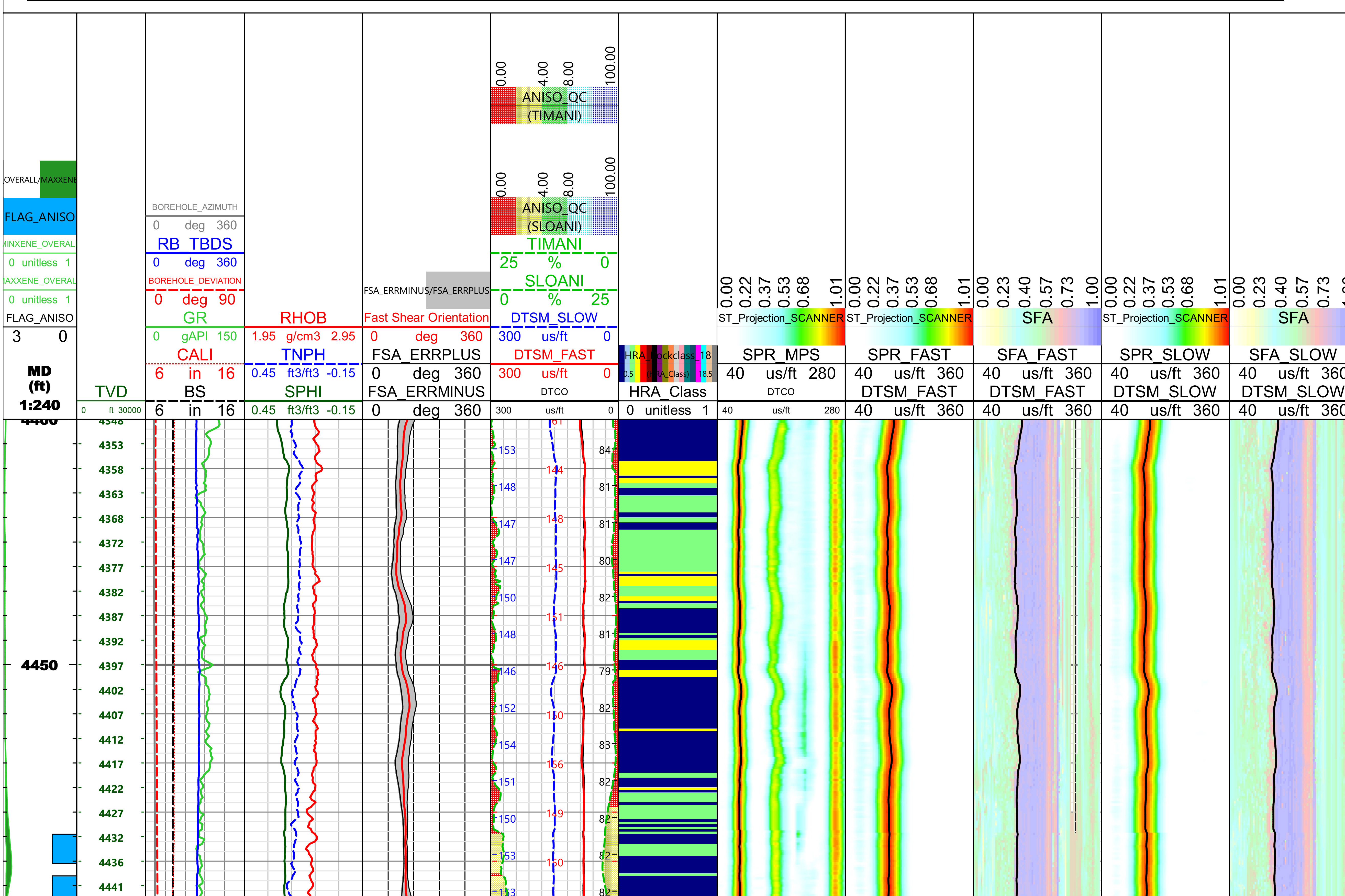
Track 8: Monopole Sonic Coherence
SPR_MF - monopole sonic coherence projection
DTCO - delta-t compressional

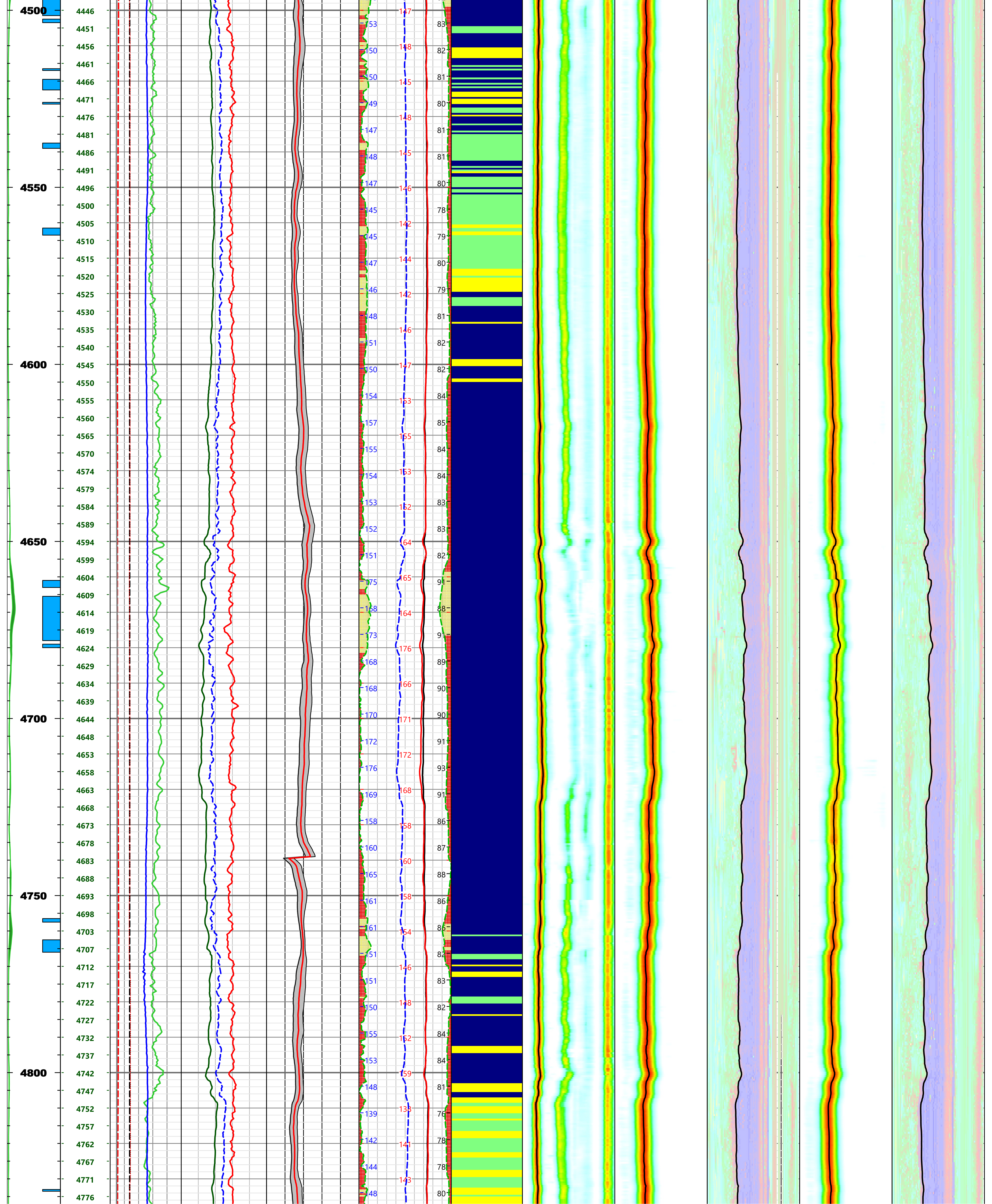
Track 9: FAST Shear Sonic Coherency
SPR_FAST - FAST shear sonic coherence projection
DTSM_FAST - delta-t FAST shear

Track 10: FAST Shear Frequency Analysis
SFA_FAST - FAST shear sonic frequency analysis projection
DTSM_FAST - delta-t FAST shear

Track 11: SLOW Shear Sonic Coherency
SPR_SLOW - SLOW shear sonic coherence projection
DTSM_SLOW - delta-t SLOW shear

Track 12: SLOW Shear Frequency Analysis
SFA_SLOW - SLOW shear sonic frequency analysis projection
DTSM_SLOW - delta-t SLOW shear

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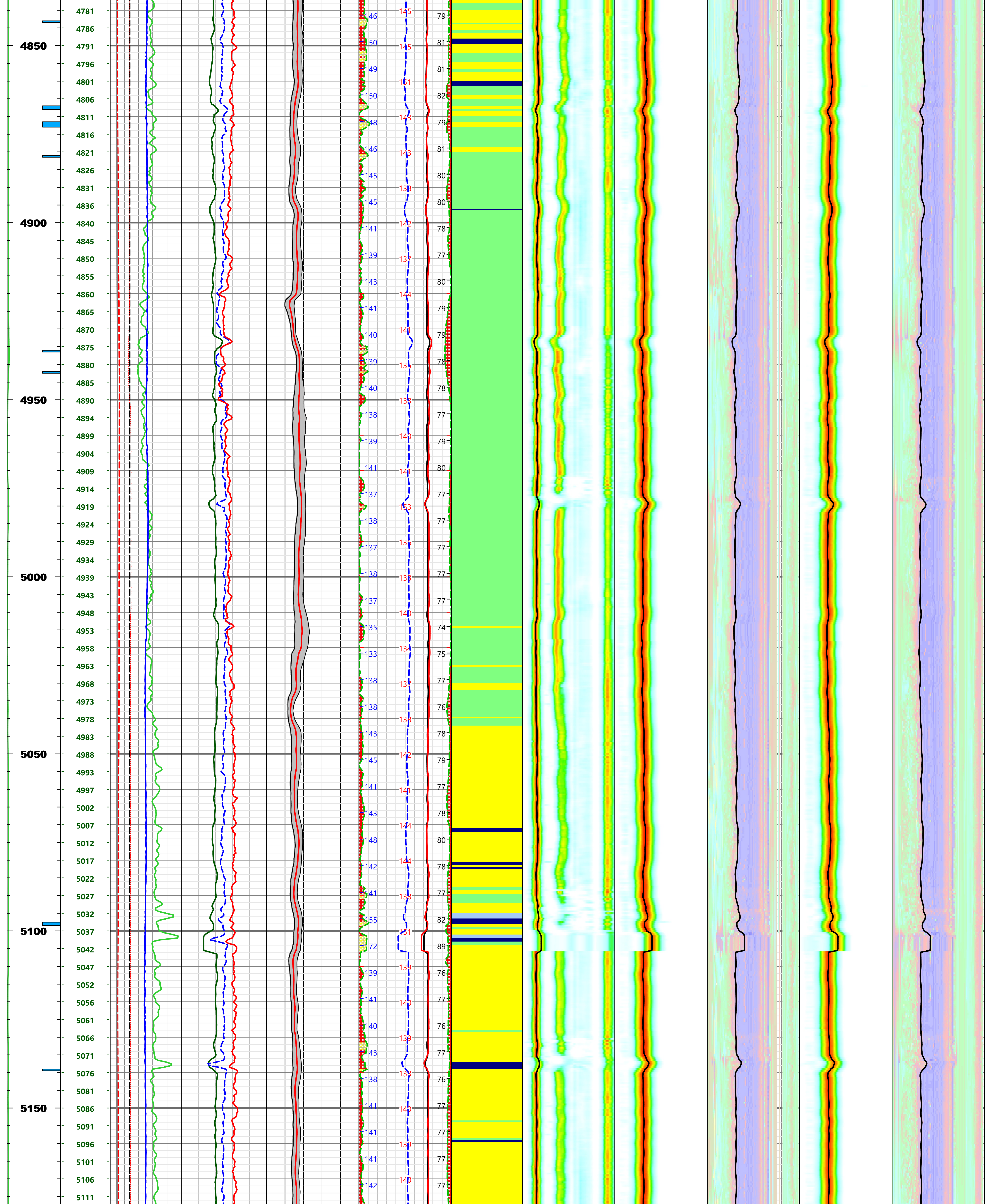
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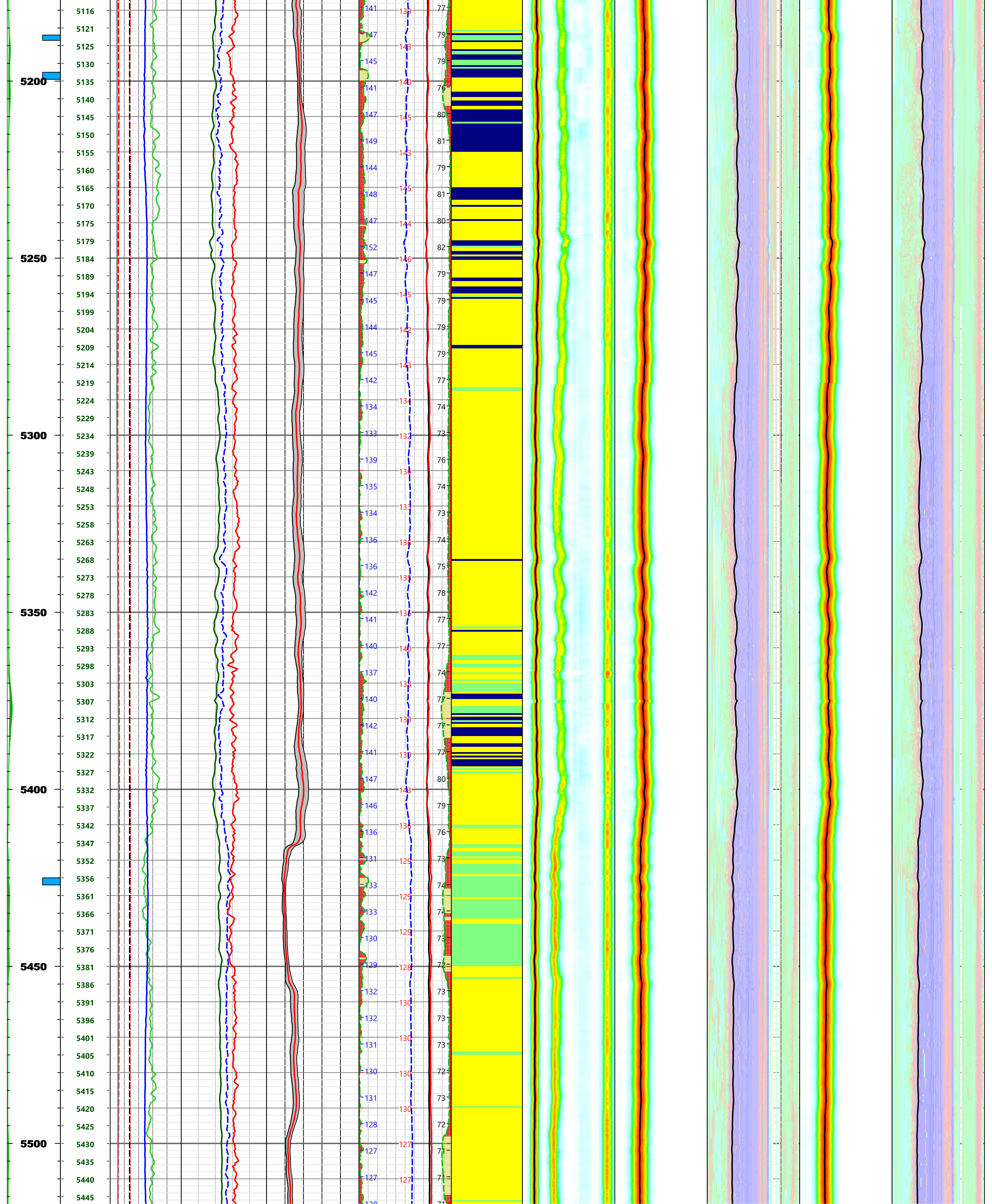

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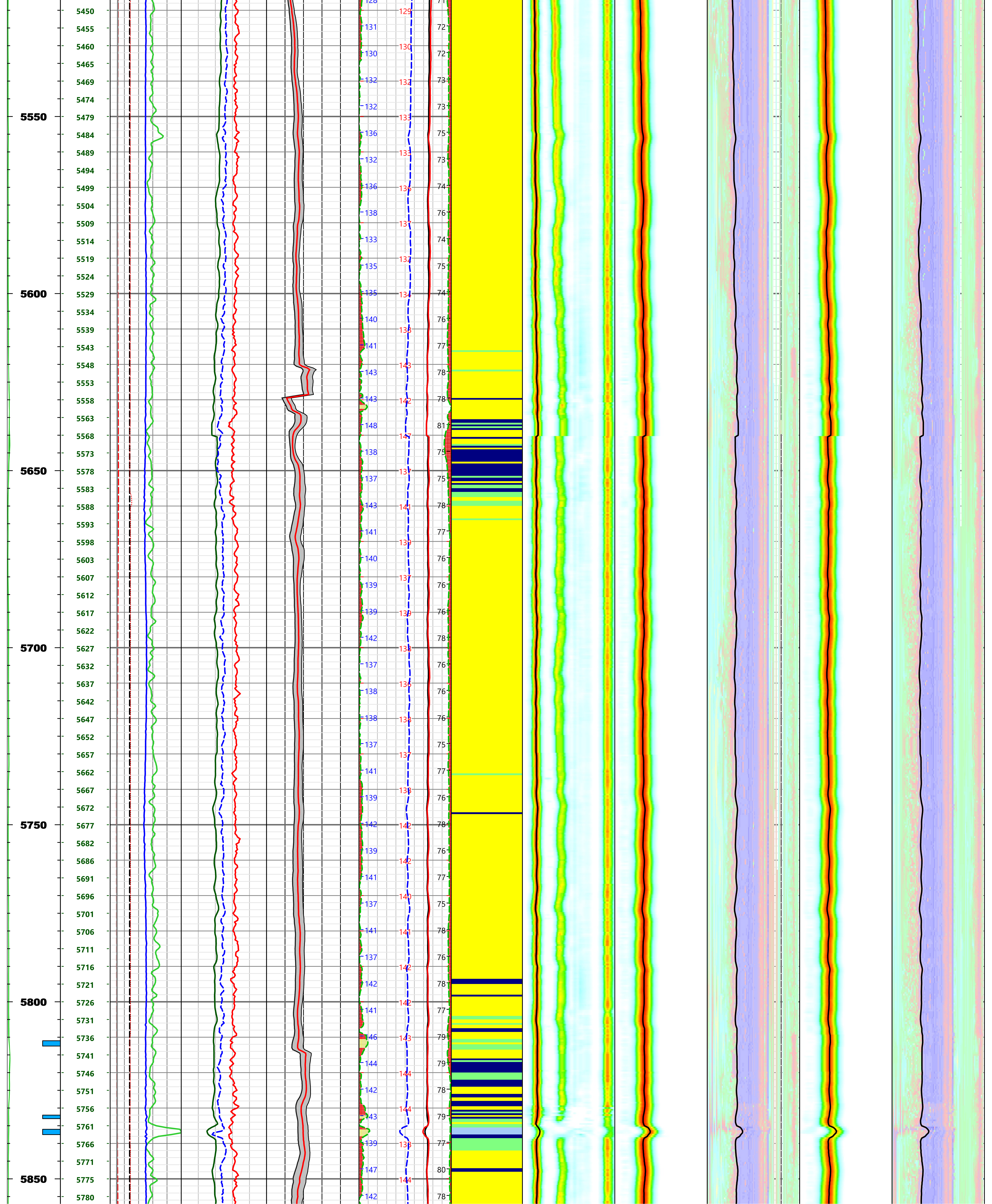
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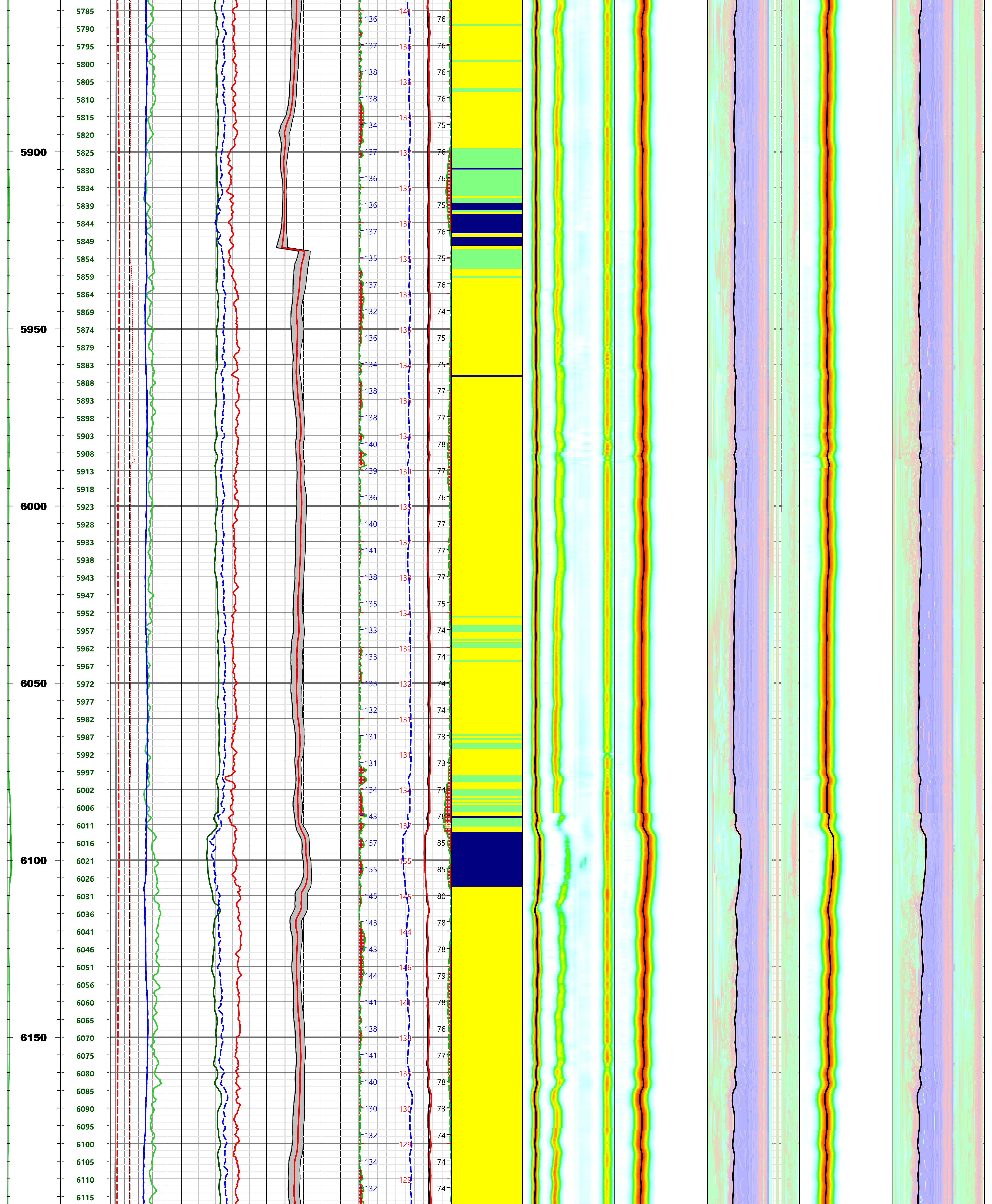
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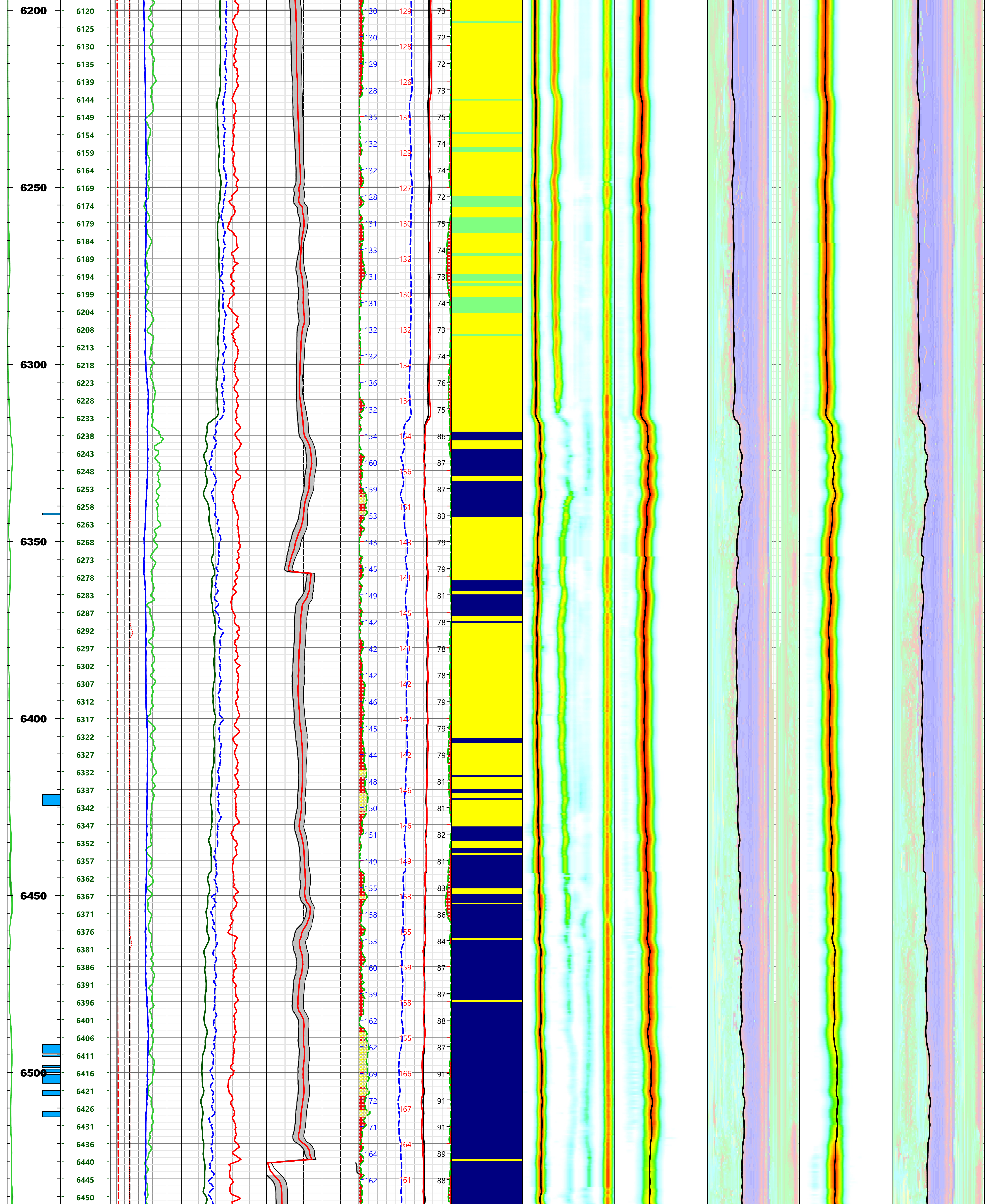

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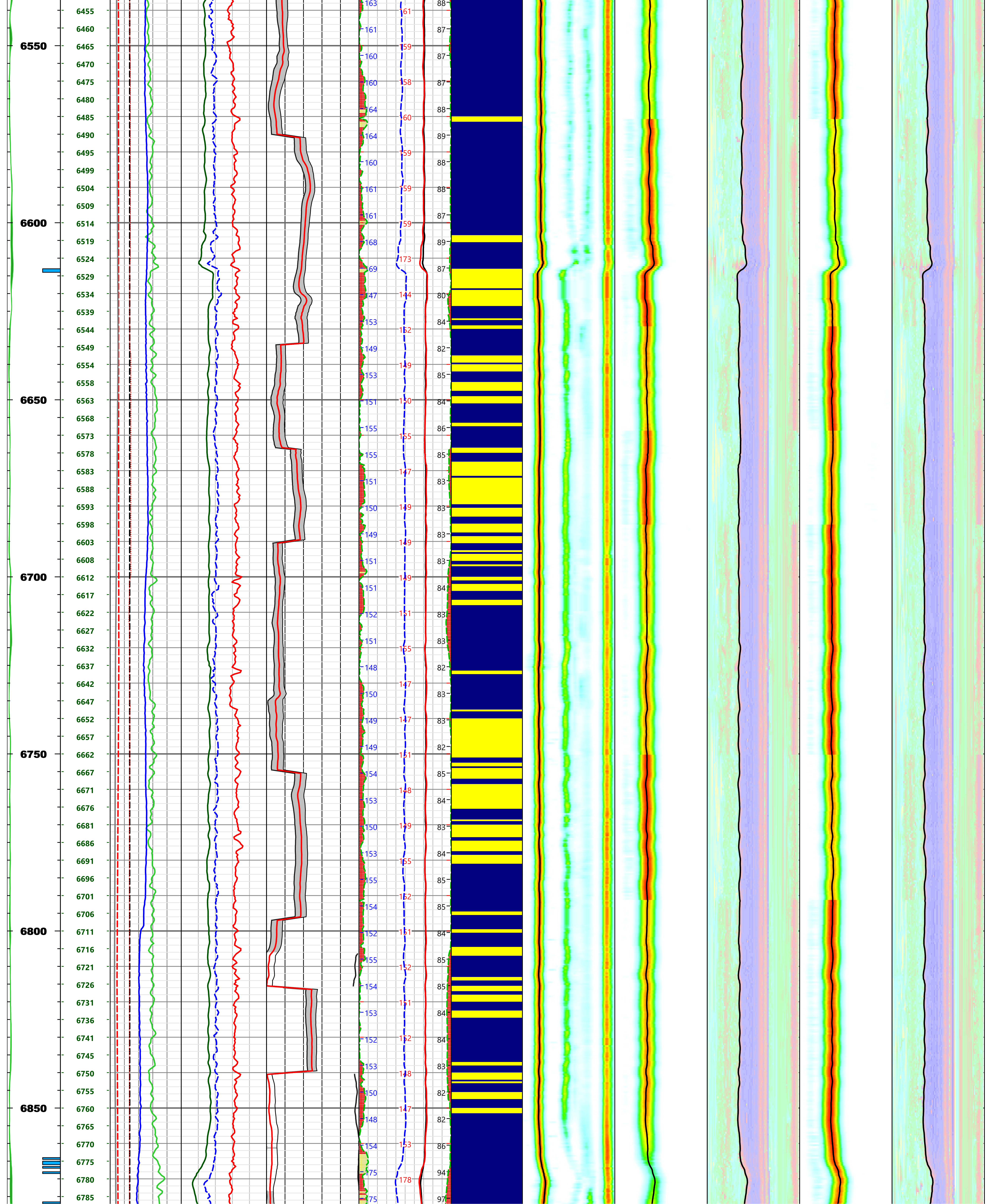
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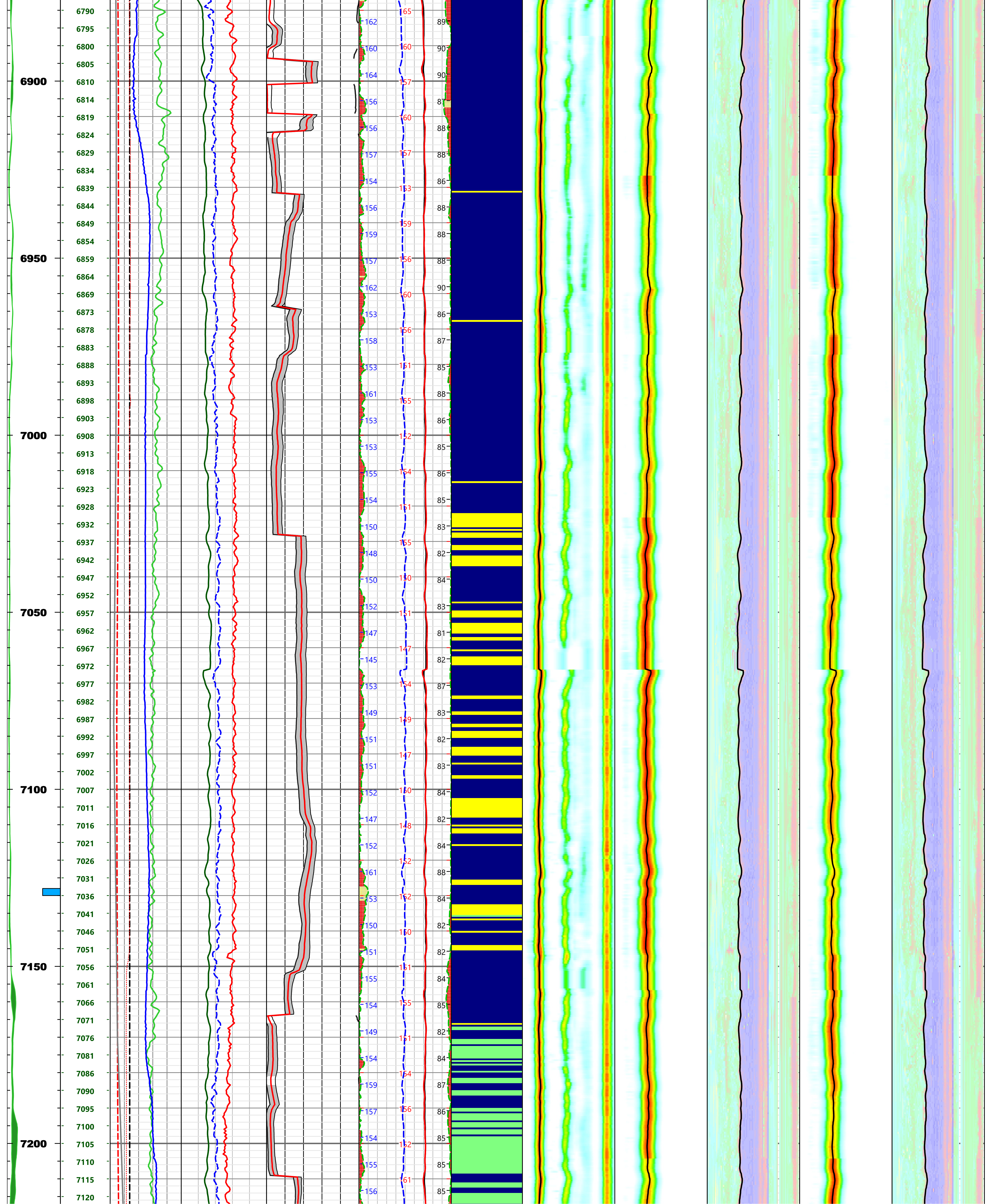
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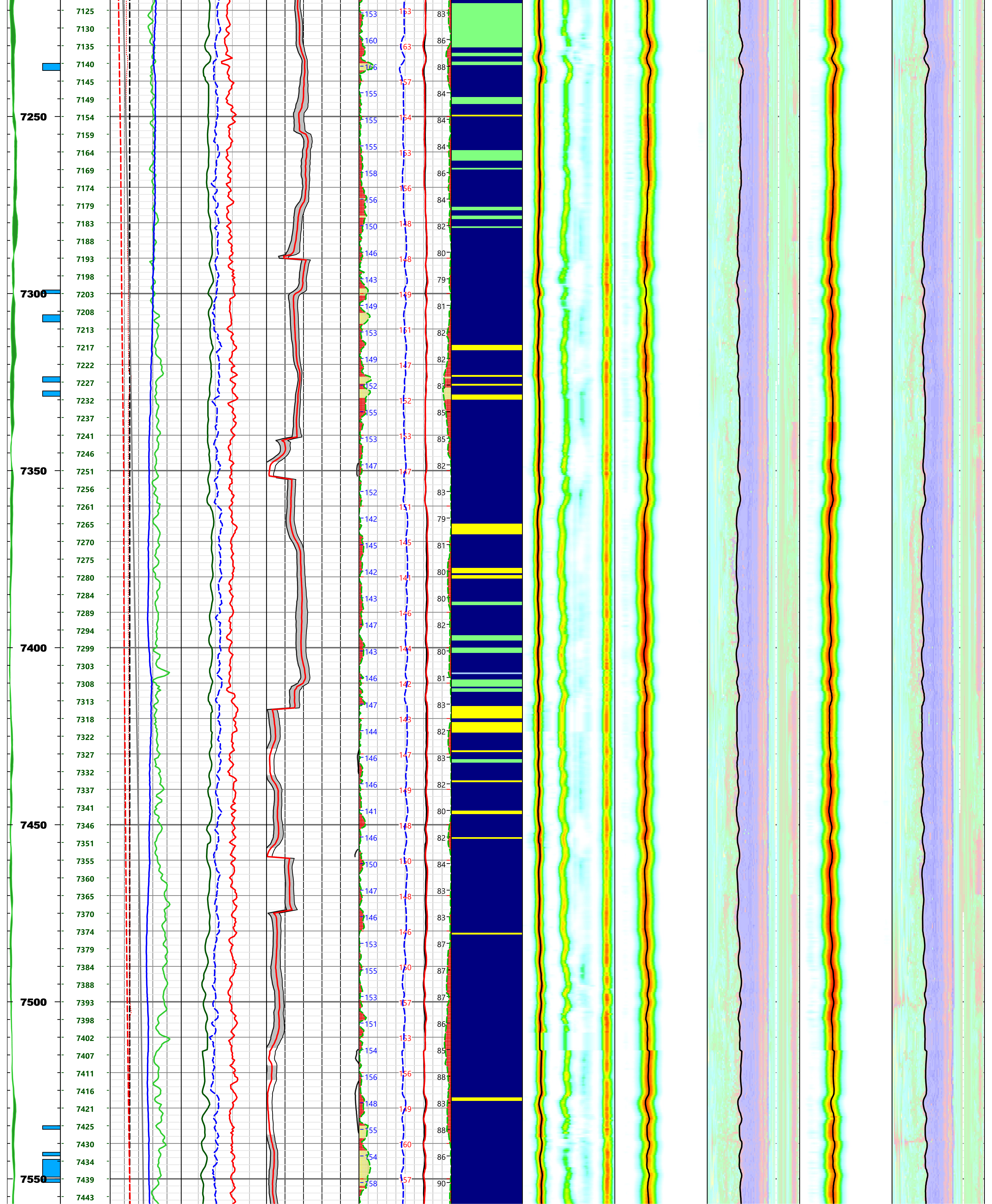
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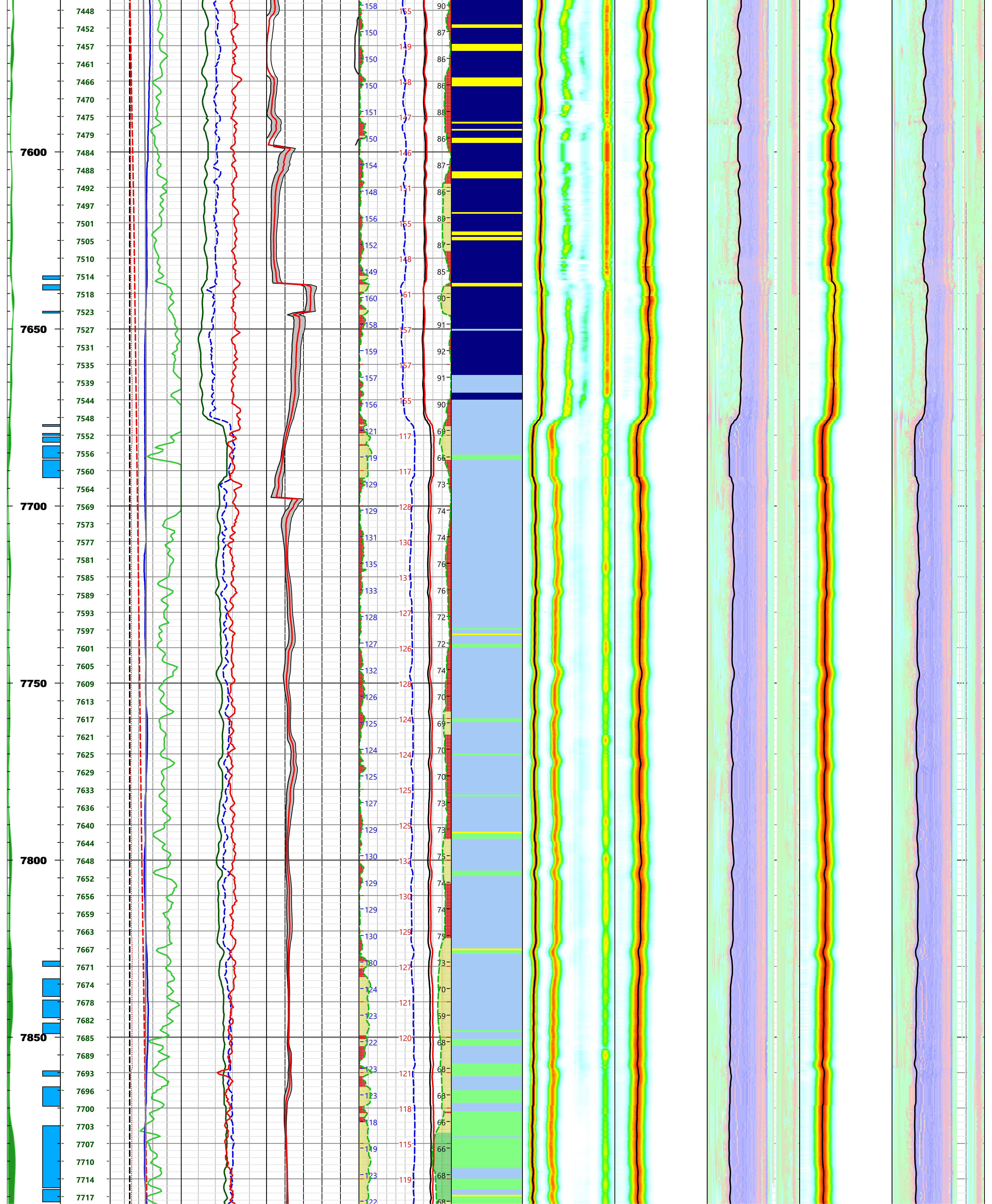
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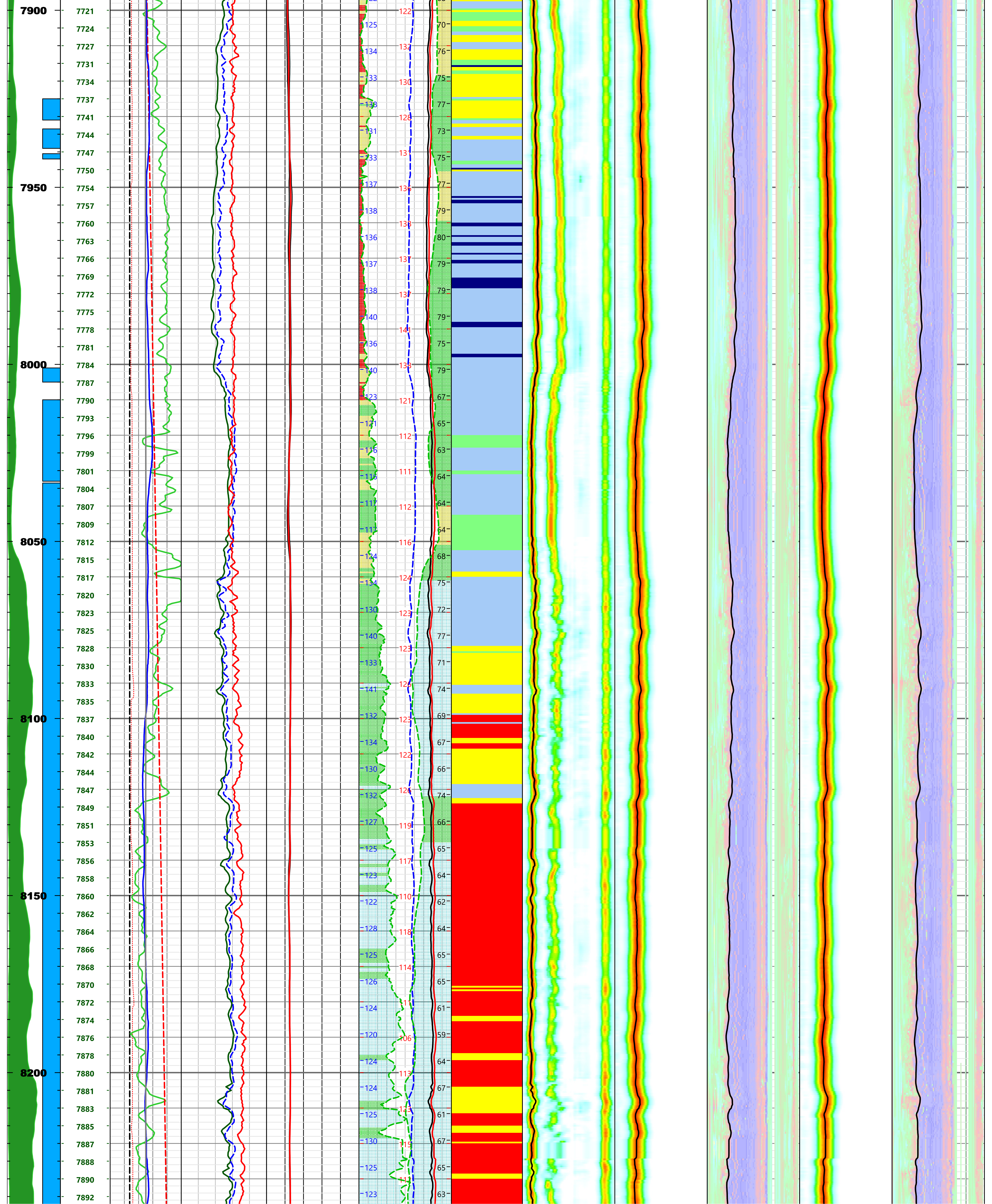
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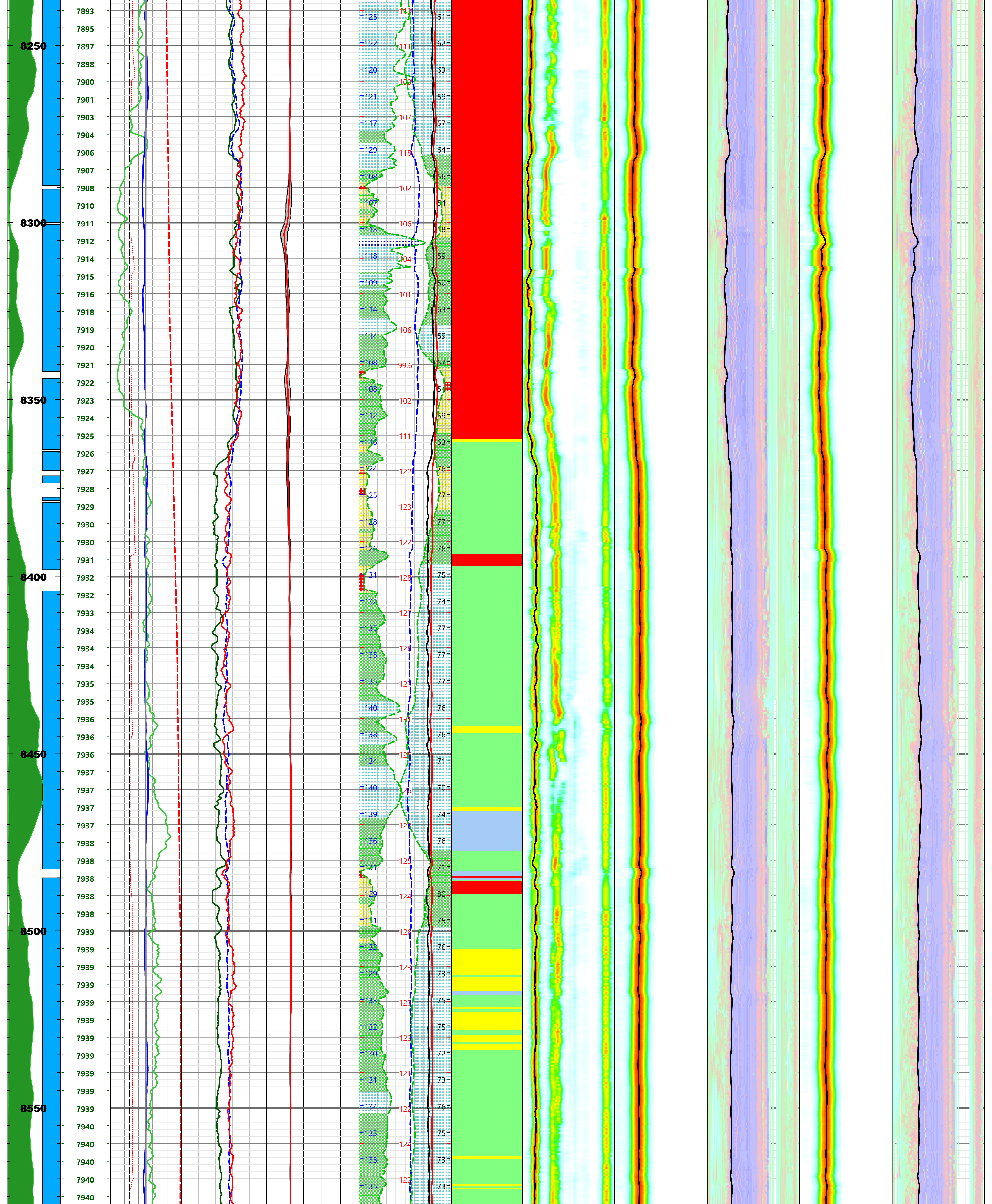
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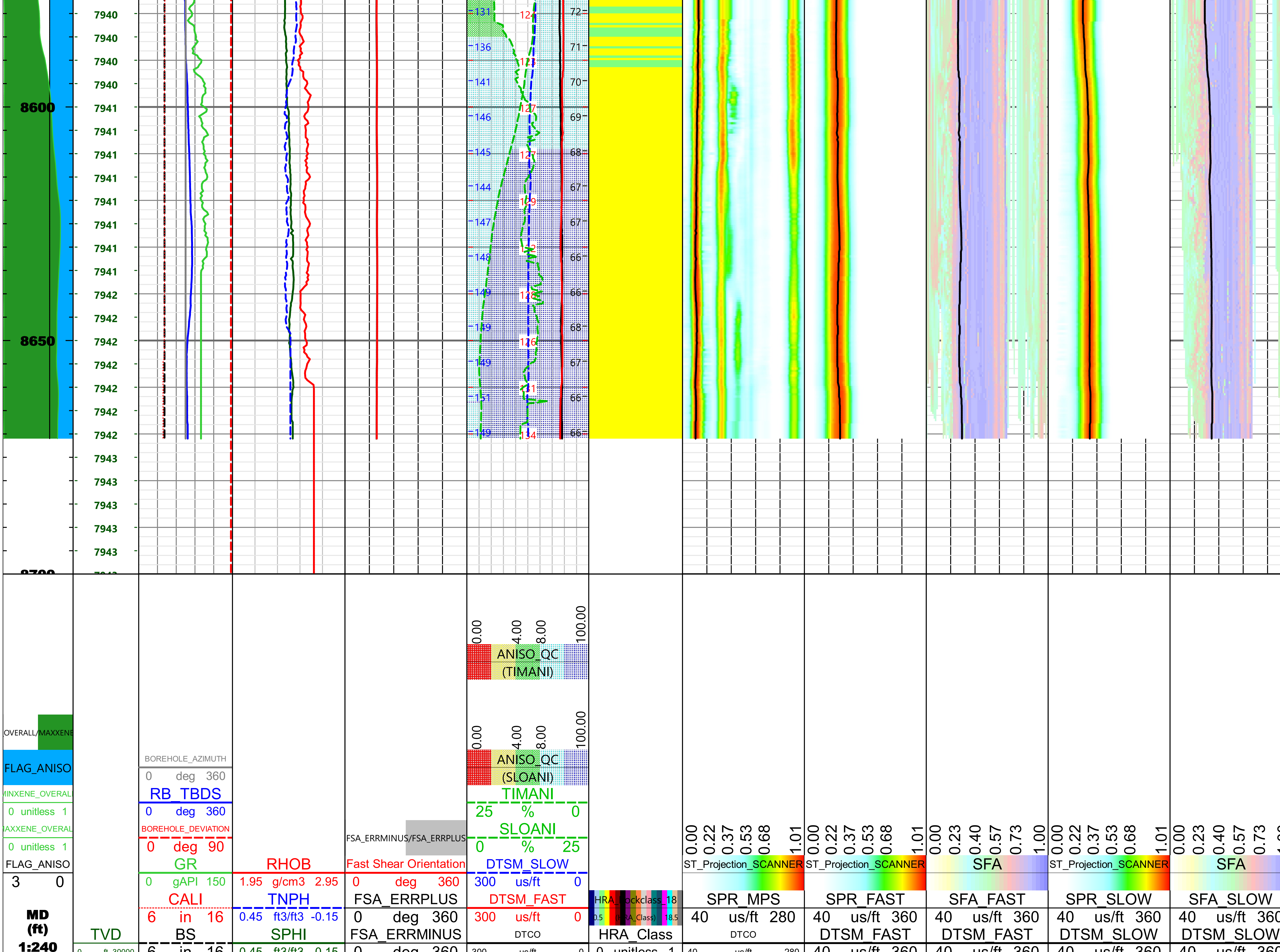
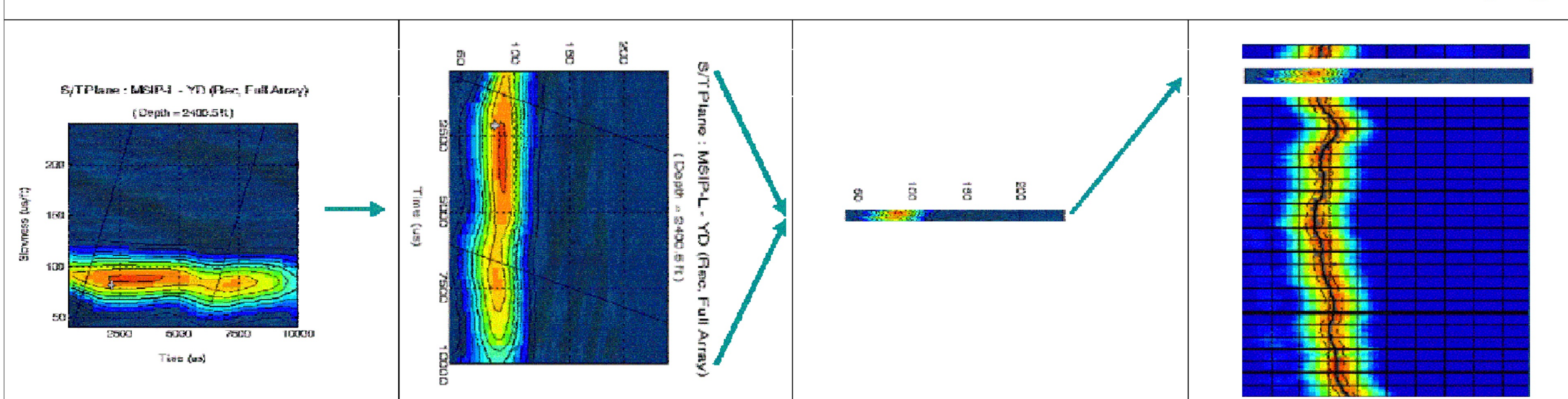
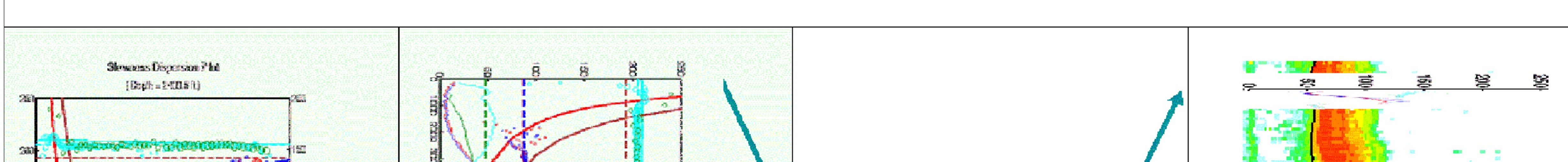


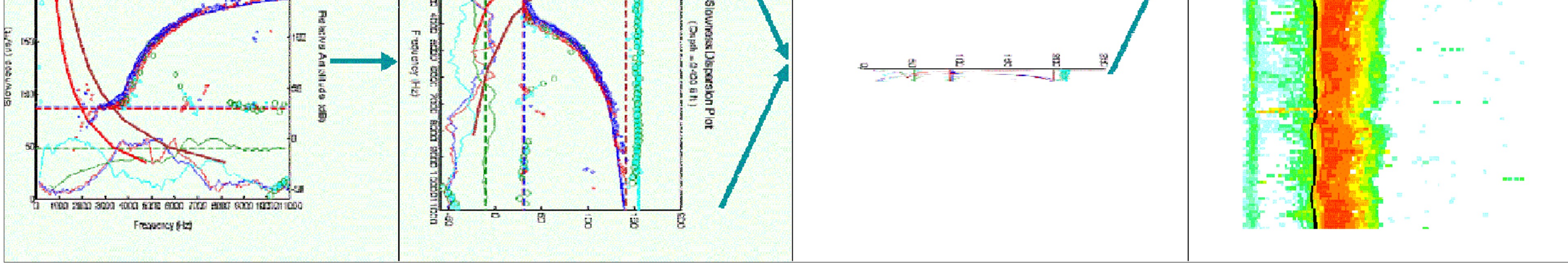
Quality Control Projection Logs

Slowness Time Coherency Log



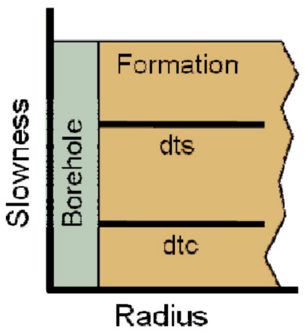
Slowness Frequency Analysis Log

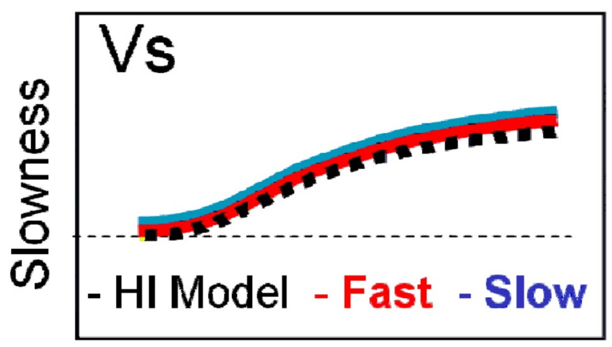




Homogeneous Isotropic Model

Homogeneous Isotropic





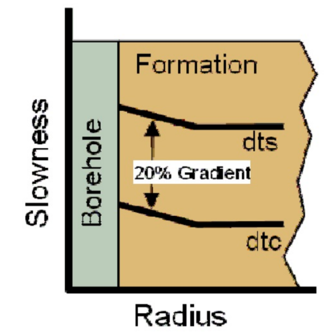
Vp,s

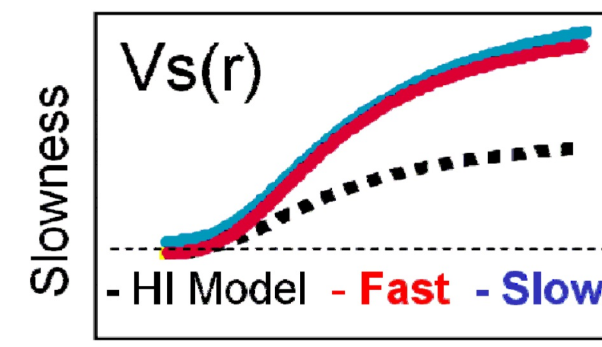
Frequency

Shear slowness is the same in all directions, which is the basis of the Homogeneous Isotropic (HI) formation model.

Inhomogeneous Isotropic Model

Inhomogeneous Isotropic





Vp(r),Vs(r)
change with distance

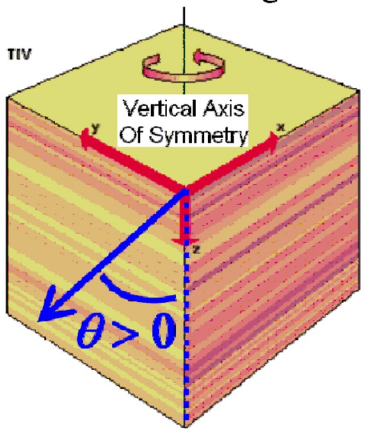
Frequency

Shear slowness changes with distance from the borehole. On dispersion plots, fast and slow shear curves will overlay and be higher than the HI model at higher frequencies.

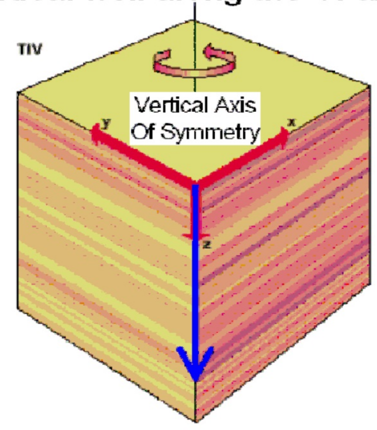
Homogeneous Anisotropic Formation Model

Transverse Isotropic Vertical – TIV
Shales & Bedding or Layering - $V_s(\theta)$

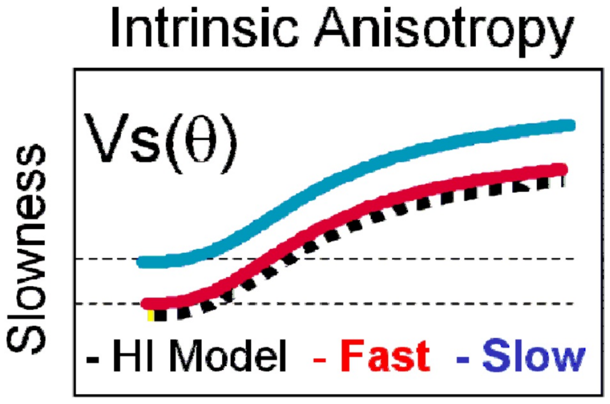
Deviated well at angle to TI axis



Vertical well along the TI axis

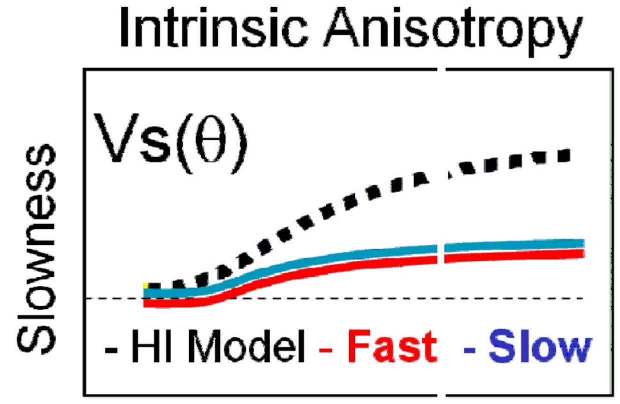


Intrinsic Anisotropy



Frequency

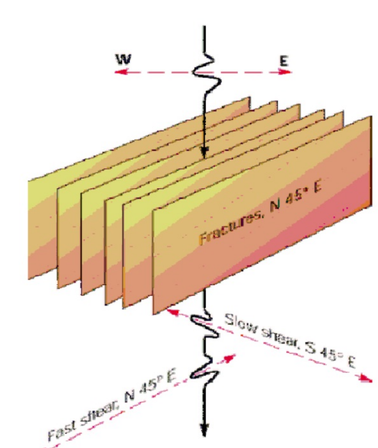
Intrinsic Anisotropy



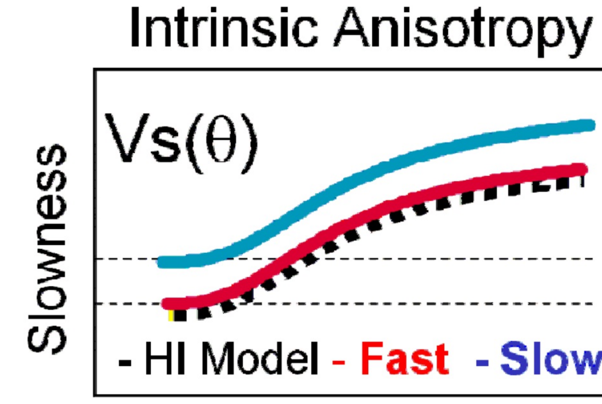
Frequency

Shear velocity is function of angle in shales. On dispersion plots, the fast and slow shear are parallel to each other, and their relationship to the HI model is a function of angle.

Transverse Isotropic Horizontal – TIH
Fractures - $V_s(\theta)$



Intrinsic Anisotropy

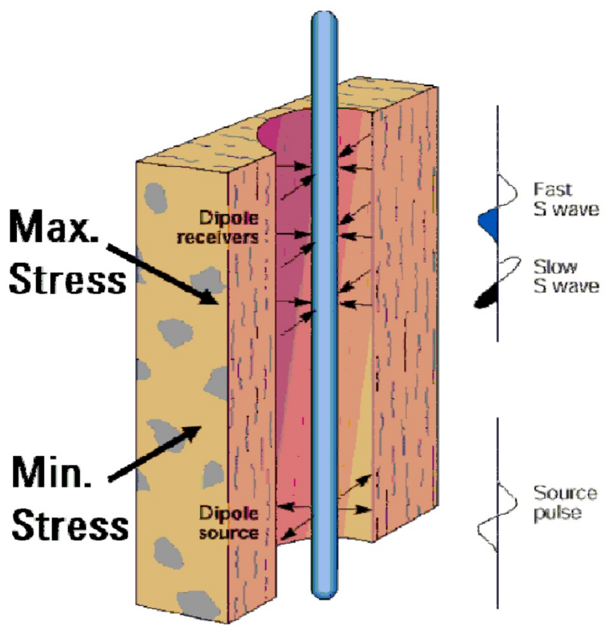


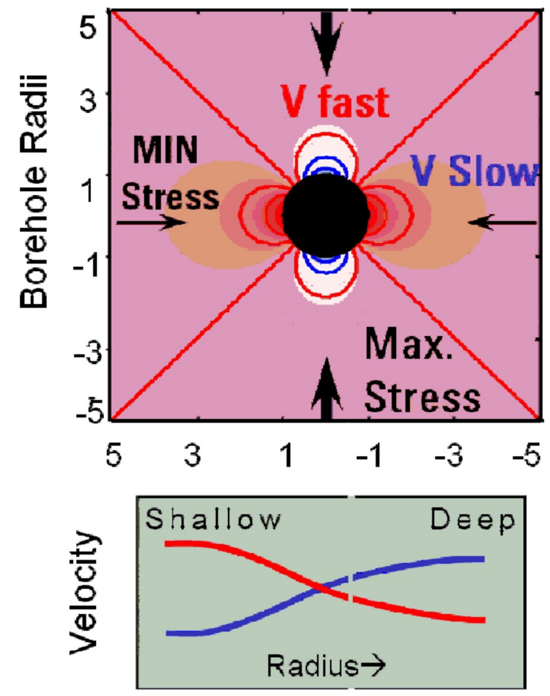
Frequency

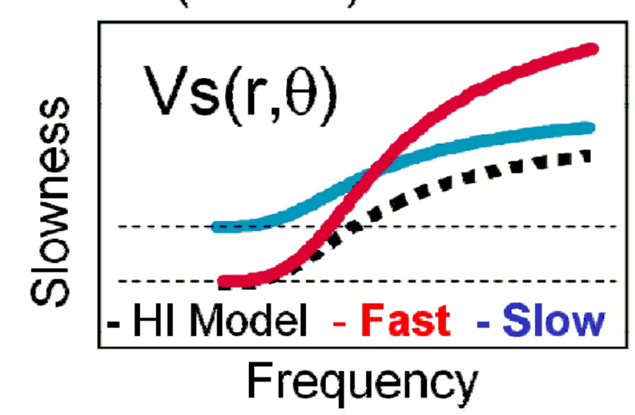
Shear travels slower across fractures. On dispersion plots, the fast and slow shear are parallel to each other, with the slow shear shape close to that of the HI model.

Inhomogeneous Anisotropic Formation Model

Intrinsic Anisotropy – Stress Induced – $V_s(r,\theta)$







Shear velocity is a function of radius and angle, with the slowest shear velocity in the direction of minimum stress. On a dispersion plot, this is characterized as a crossover of the fast and slow shear as frequency increases.

Sonic Scanner

Schlumberger

COMPANY: Crestone Peak Resources Operating LLC
WELL: COSSLETT 1F-22H-B168
FIELD: Wattenberg
COUNTY: Weld
STATE: Colorado
COUNTRY: USA

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API No.: 05-123-47675

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