Schlumberger

Sonic Scanner
Stoneley Mobility Analysis

Natural Fracture Analysis from Stoneley Waveform Reflectivity & Attenuation

8250 ft to 6500 ft

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

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WELL: Wallula Basalt Pilot #1
FIELD: Wildcat
County: Walla Walla
State: Washington
COUNTRY: USA

API No: Job No.:

Other Services: Sonic Scanner

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
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: DCS−Denver	Baseline: GF4.4	Log Analyst: S.Riley,G.Martinez

Field Engineer'

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

Sonic

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-1851773
FBSH-A 1730
GPIC-F
FBSC-B
FBSS-B

FE
HV
Tens

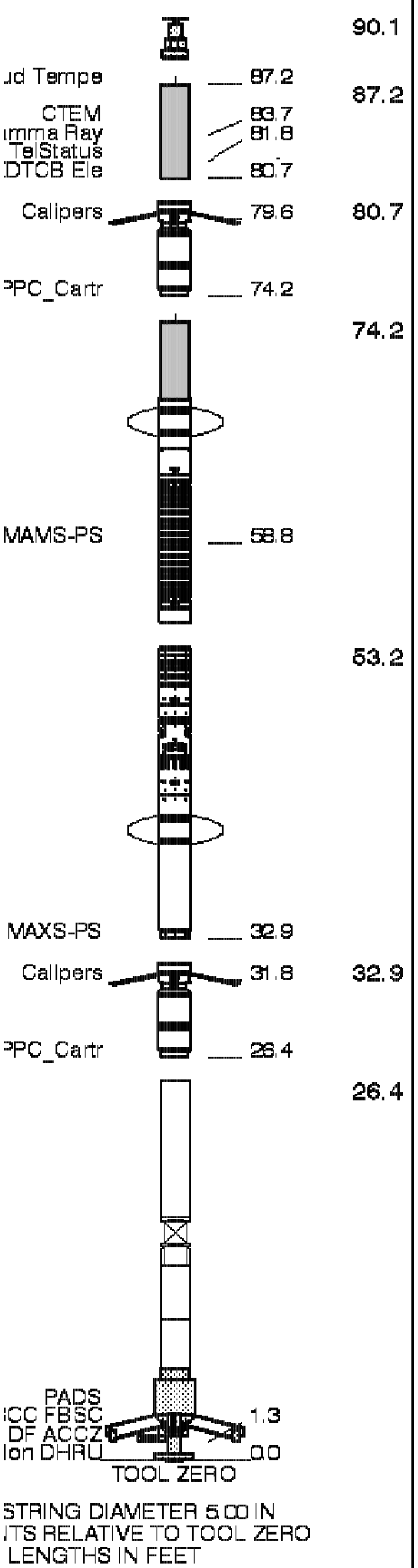
MAXIMUM
MEASUREMEN
ALL

s Remarks:

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

Scanner

HOLE EQUIPMENT



Log Analyst's Remarks:

OBJECTIVE:

Qualitative Fracture Identificatio
Comparison with FMI data to eva
of anisotropy.

AVAILABLE INPUT DATA:

STONELEY Waveforms (from re
DTST: DT – Stoneley
DTCO: DT – Compressional fro
DTSM: DT – Shear from CROS
anisotropy processing)
HD1 & HD2 or HDAR calipers fr
Scanner or from single arm calip
NPOR and RHOZ from Open H
GR
Mud Weight

DATA QUALITY:

Stoneley waveforms displayed c
relabelling of the formation arriva

PROCESSING DETAILS:

DT–Compressional (DTCO) was
program. DT–Shear (DTSM) wa
"Best DT" program as well as th
waveforms. The DT–Shear, DT–
for Sonic Fracture analysis.

Reflective and Transmission Co
Stoneley waveforms. A forward
due to borehole washouts and b
These effects were then backed
computed from the log Stoneley
Transmission Coefficients.

The modeled Reflection/Transm
bed boundaries, and mud prope
hydrocarbons in the borehole), w
Coefficients are affected by bore
fractures crossing the borehole.
Model) was made with the meas
of the composite print as an ora
presence of fractures are expect
in which the modeled Stoneley s
since it is an indication of VTI an
to finely laminated rocks such as

RESULTS:

A comparison between the mode
great influence of the more poro
to have little permeability. On th
with the highest porosity were th
Some differences were observe
porosity and little permeability. I
appeared to be confirmed by the

n using Sonic Scanner Stoneley Waveforms.
aluate fracture permeability. Examine the cause

eceivers #1 to #13)

n FAR MONOPOLE waveforms
S DIPOLE waveforms or DTSM_FAST (Fast Shear from

om 4 arm CALIPERS run in combination with the Sonic
per respectively
ole Neutron – Density logs.

ptimal coherence in the logged section and required little
al times.

s processed from monopole waveforms using "Best DT"
s processed from CROSS–DIPOLE waveforms using
e DT–Stoneley (DTST), which was derived from the MST
-Compressional, and DT–Stoneley are part of the inputs

efficients were computed from the filtered, stacked log
model estimated the effect of reflections, and attenuations
ed–boundaries using DTSM, DTCO, RHOB, and CALIPER data.
out of the Reflection and Transmission Coefficients
waveforms to obtain the final results of the Reflection and

ission Coefficients are generally affected by borehole rugosity,
rties(that can also be affected by the presence of light
while the measured Stoneley Reflection/Transmission
ehole rugosity, bed boundaries, mud properties, and open
A comparison of the modeled elastic Stoneley slowness (Tezuka
sured Stoneley slowness. This is presented in the first track
nge shading to indicate zones with permeability due to the
ted. In this same track it has also been flagged the sections
slowness is slower than the measured Stoneley slowness
nisotropy (or vertical anisotropy which is generally associated
s shales).

eled Stoneley and measured Stoneley slownesses displayed a
us zones. In general, the FMI interpreted fractures appeared
e other hand, Stoneley mobility analysis showed that the zones
e zones with the highest Stoneley mobility as well.
d in the sections of the basaltic flows where the minimum
n these zones the influence of segments in the fluid flow
e Stoneley mobility.

Processing Parameters: *

* Parameters are assumed to be default parameters unles

GENERAL

Stoneley waveform filtering from 0 to 2500 Hz for reflectio
coeffecients.

Multishot processing for all the slownesses.

Mud attenuation was calibrated at –2.5 db/m.below 3100 f

Isotropic and undisturbed waveform was selected at 3760

Graphic Illustration Captions:

ss otherwise specified.

n and transmission

t, and –3 db/m above it.

ft.

- MINXENE 0 ( ) 100
- MAXXENE 0 ( ) 100
- Cross–E
- TENS 1000 (lbf) 4000
- MD 1 : 240 ft

- Bit Size 6 (in) 16
- Gamma Ray 0 (gAPI) 150
- Hole Diam1 6 (in) 16
- Hole Diam2 6 (in) 16
- Hole Enlargem
- Ovalization
- Stoneley DT 300 (us/ft) 185
- Model Stonele 300 (us/ft) 180
- VTI Aniso
- St Perm S–Se
- Formation Top

- STTC@BHC 0.75 ( ) 1
- STTC@REC 0.75 ( ) 1
- STTC@TRA 0.75 ( ) 1
- STTC@MOD 0.75 ( ) 1
- B/H Eff

- STRC@UP 0 ( ) 0.25
- STRC@MOD 0 ( ) 0.25
- B/H Eff.

- STRC@DN 0 ( ) 0.25
- STRC@MOD 0 ( ) 0.25
- B/E Eff.

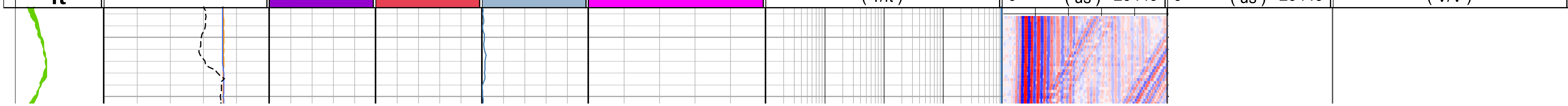
- FWID_DF 0 (in) 0.1
- Stoneley Apert

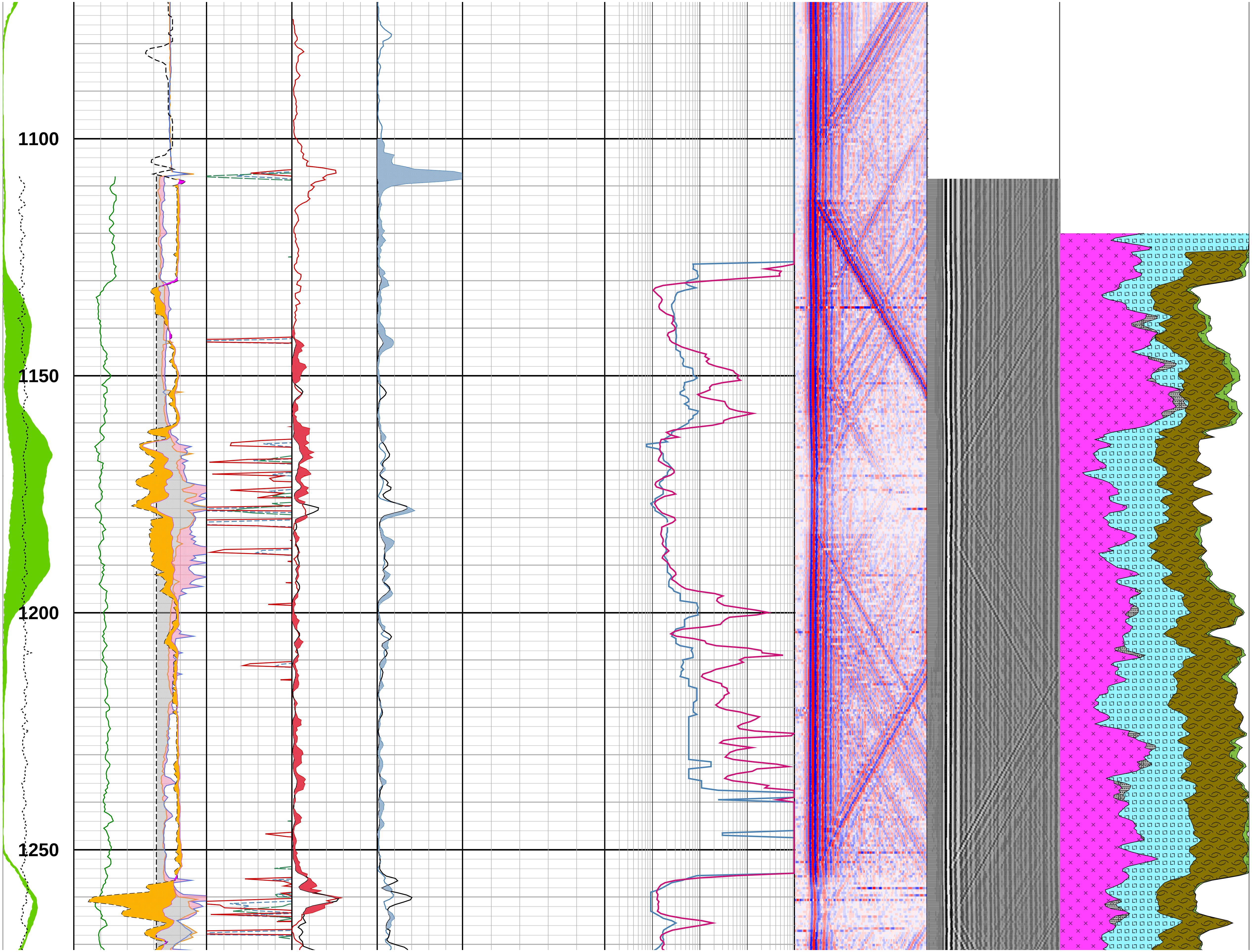
- ELAN Permeability 100000 (mD) 0.01
- Mobility 1e+06 (mD/cP) 0.001
- Segments Traces 10 (1/ft) 0
- Trace Length Open 10 (1/ft) 0

- Stoneley VDL 0 (us) 20440

- Stoneley Mode 0 (us) 20440

- Water
- Titanium Oxide
- Augite
- Glass
- Zeolite
- Labradorite
- ELAN_VOLUMES ELAN_P 1 (V/V) 0

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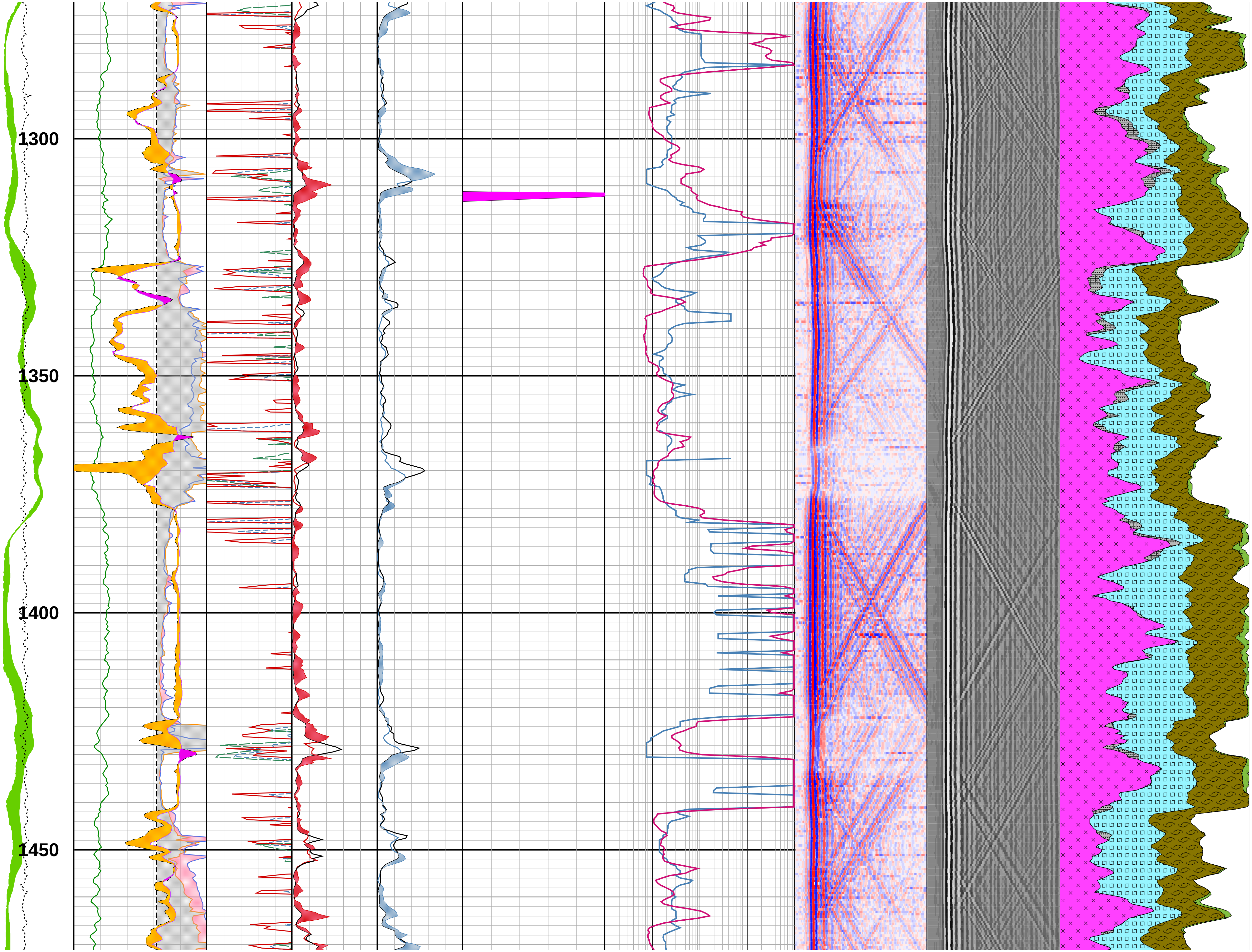
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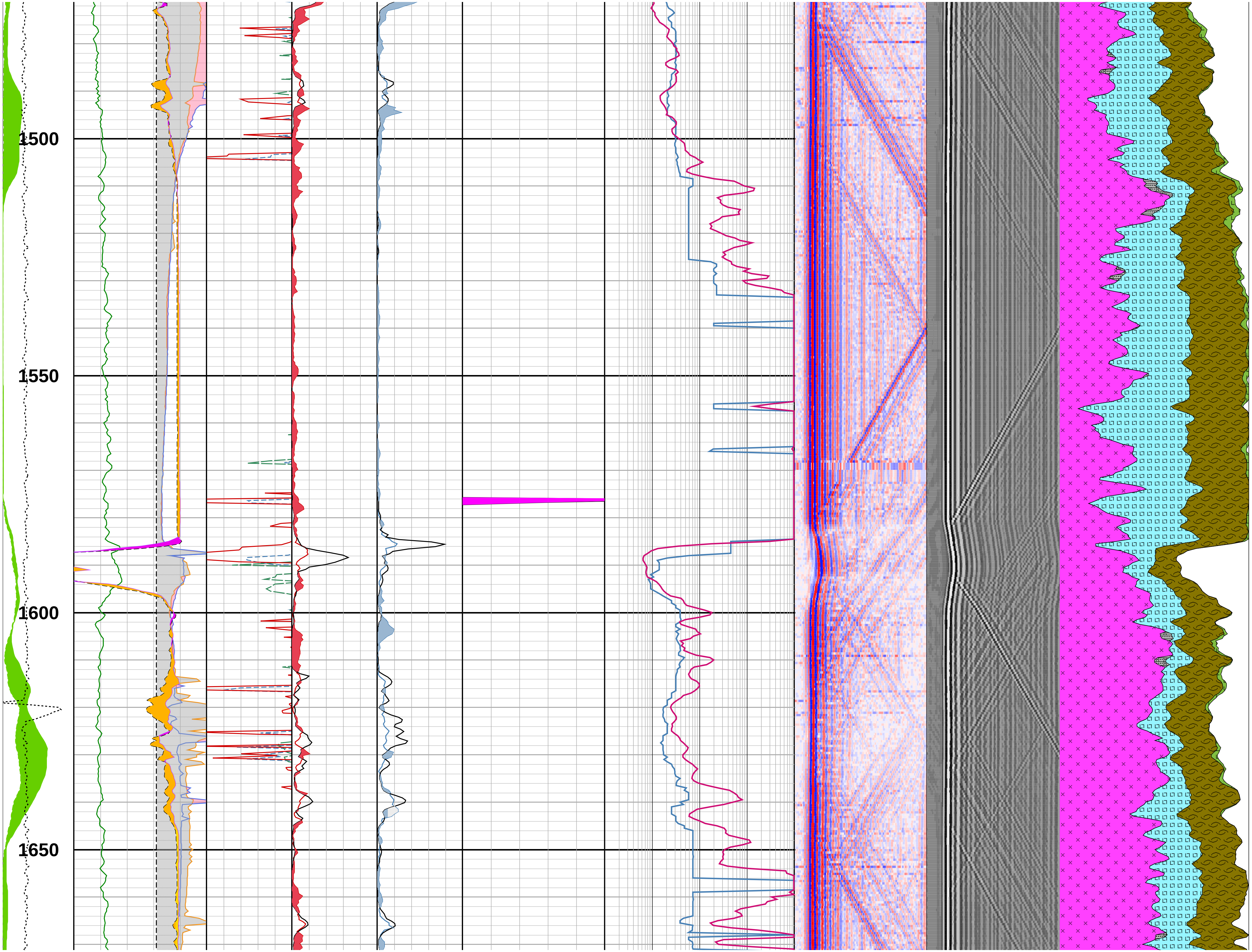
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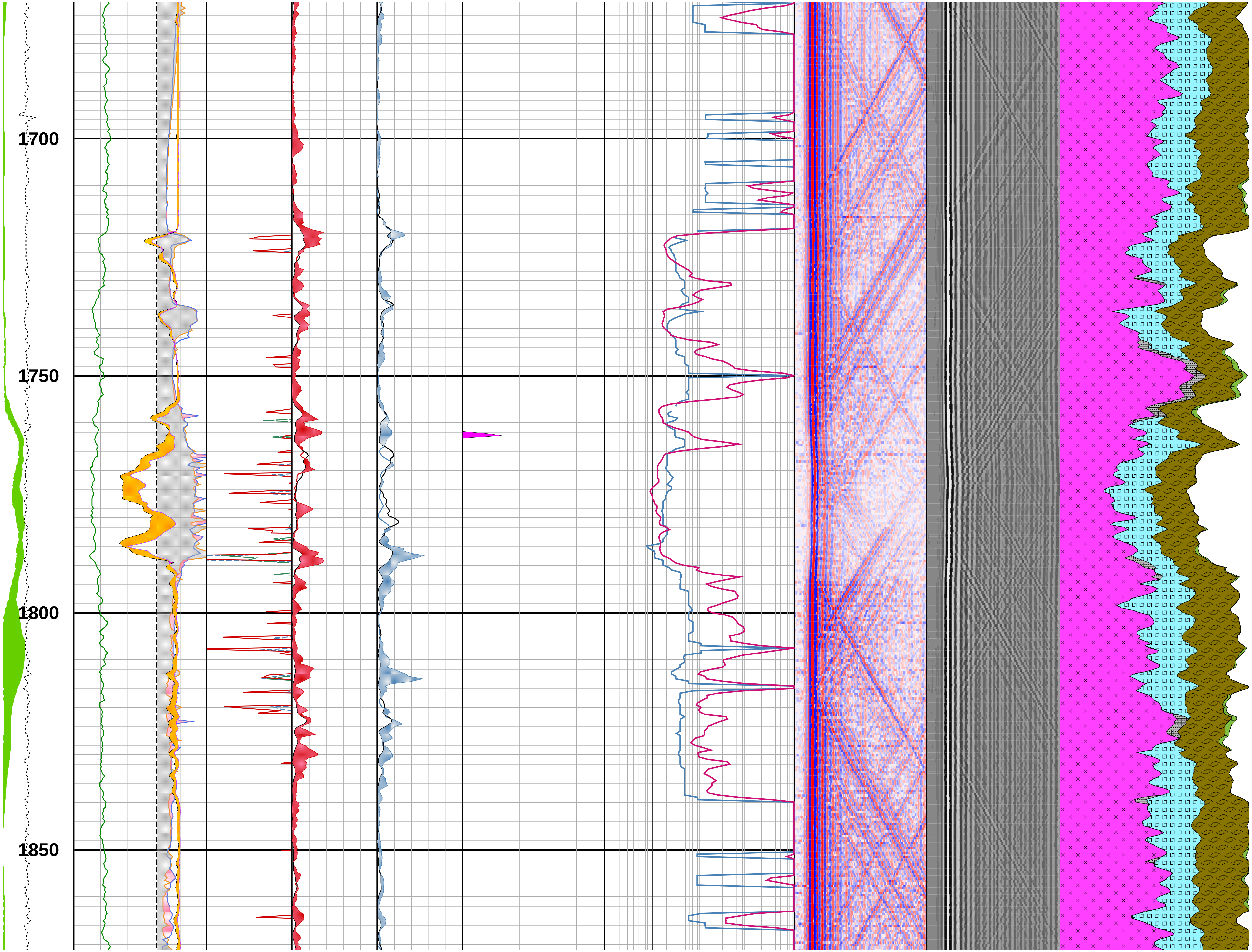
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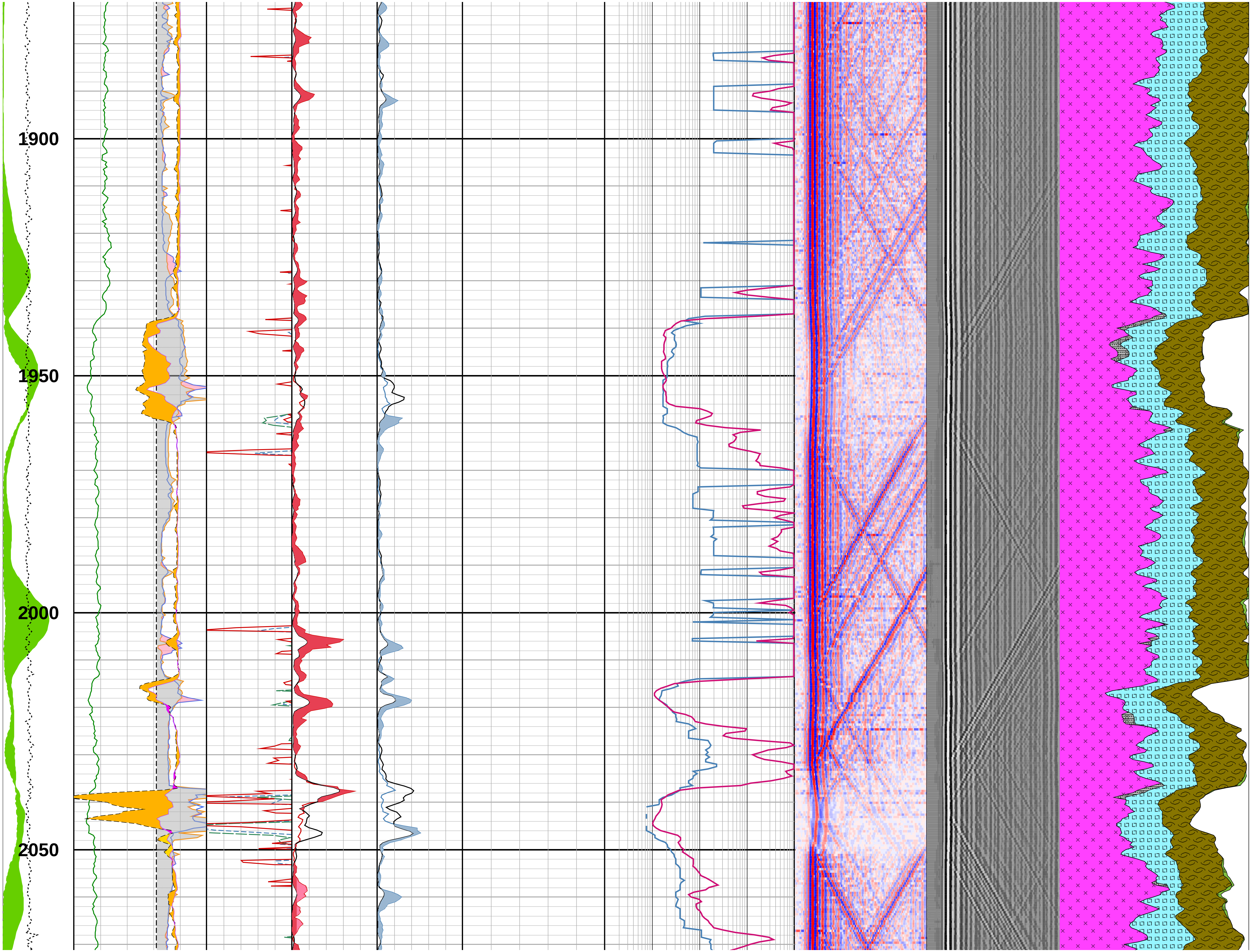

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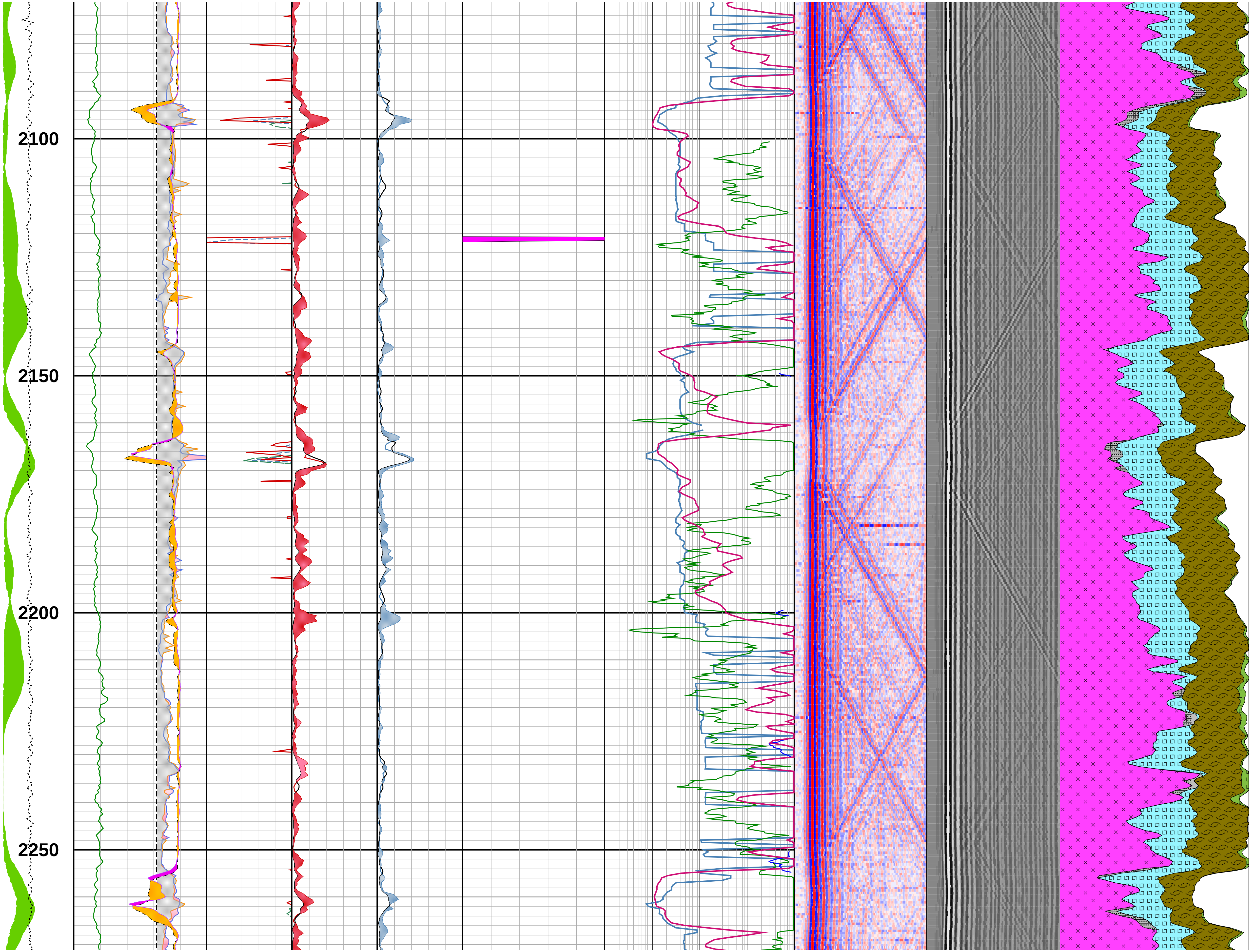
2000
2050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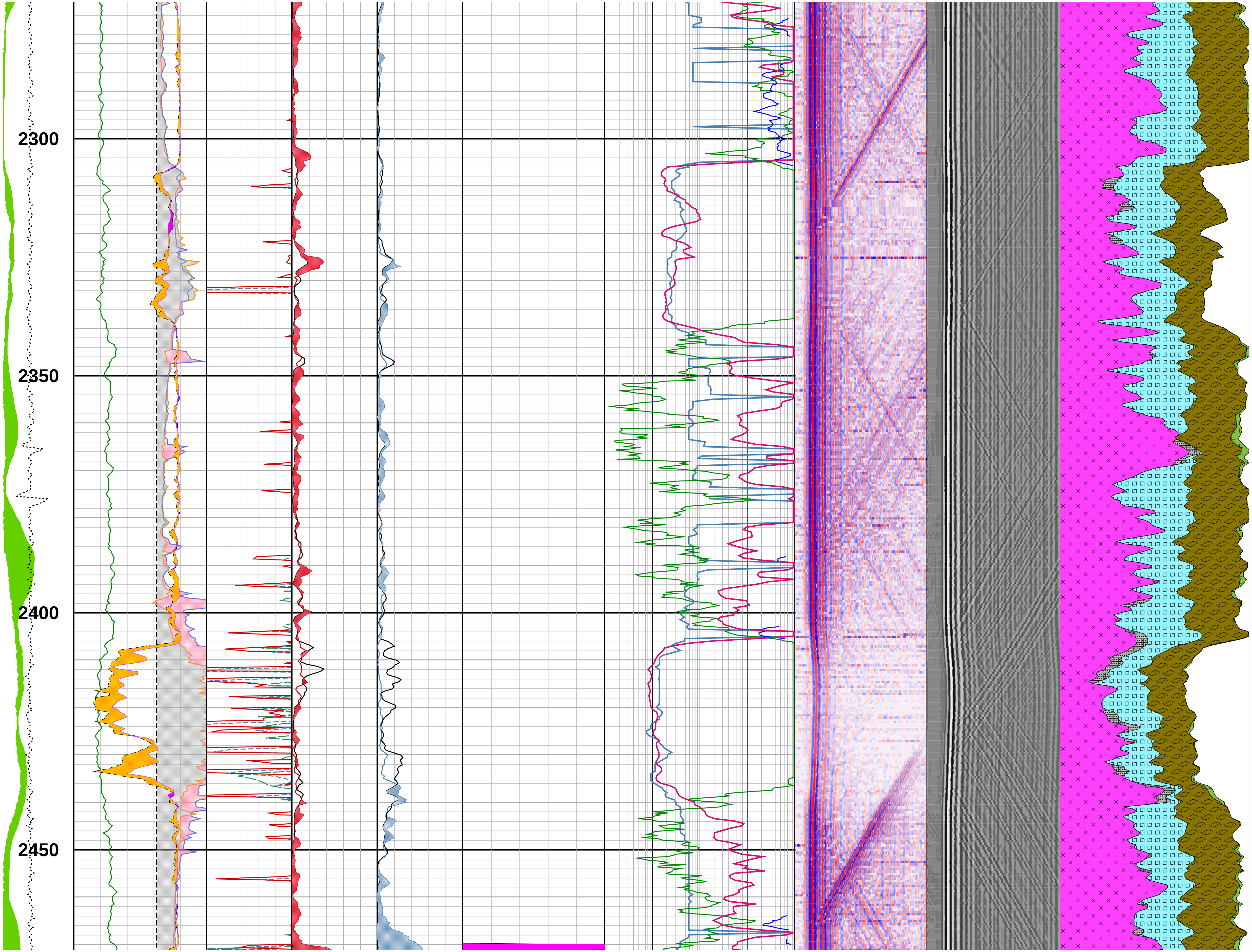
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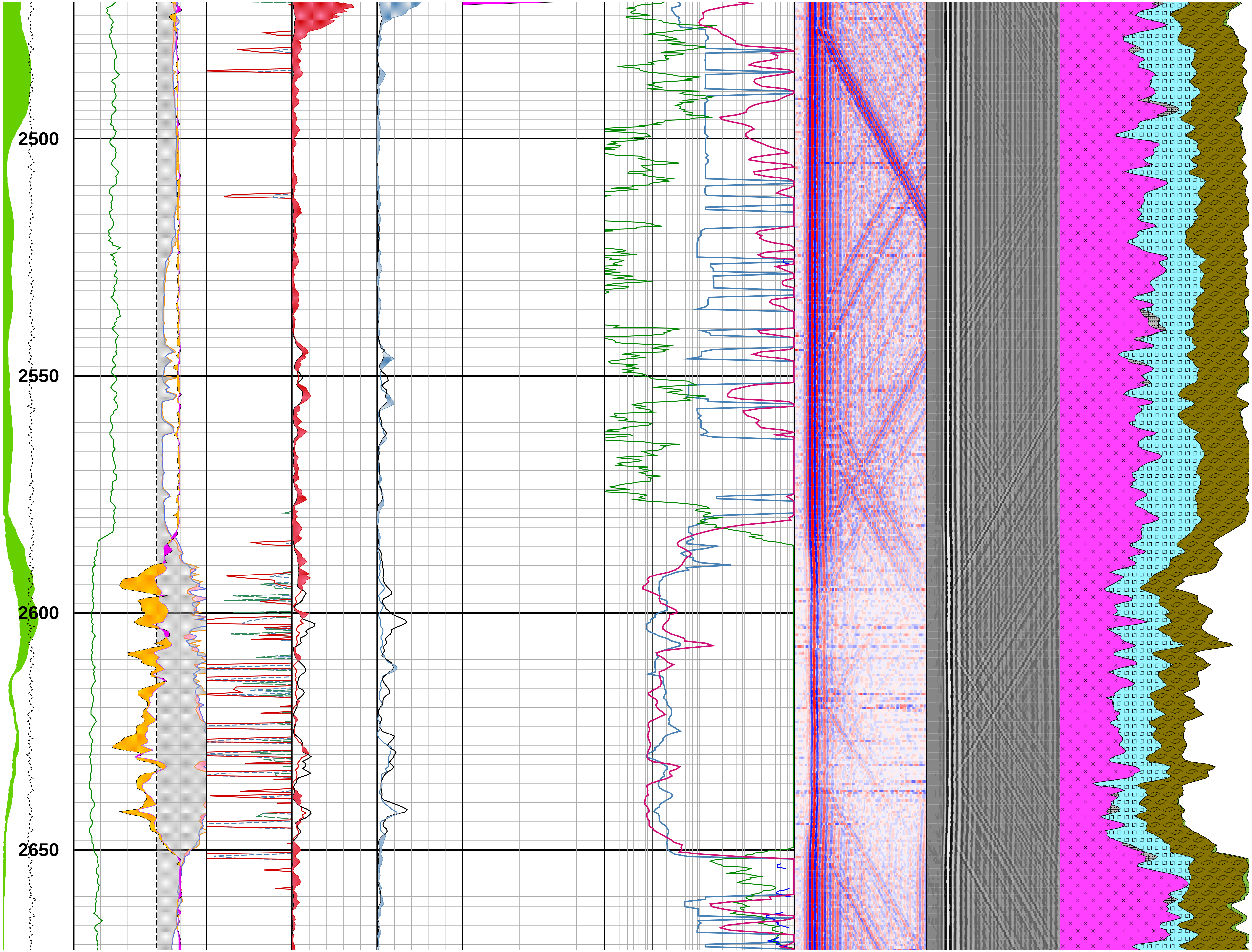
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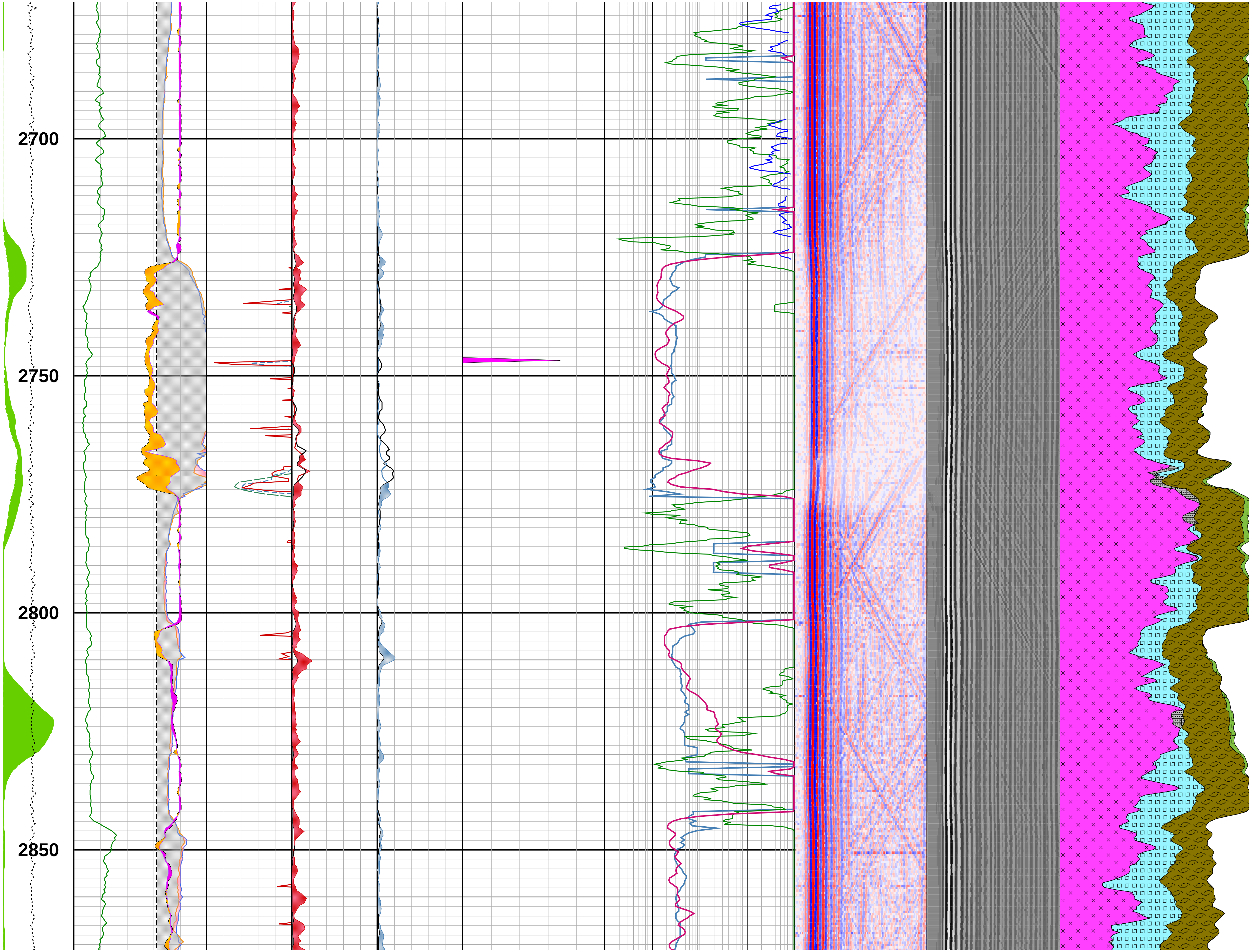
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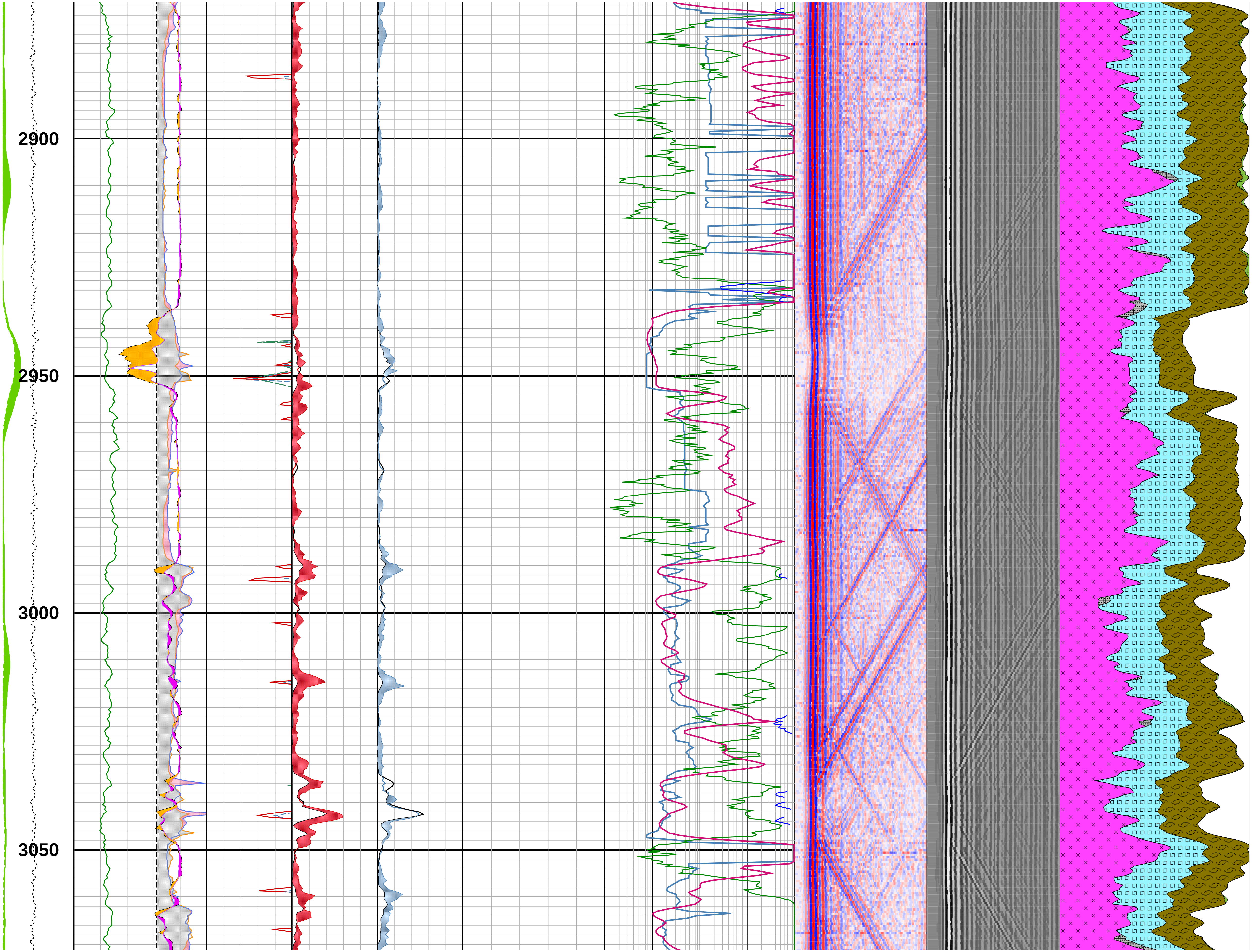
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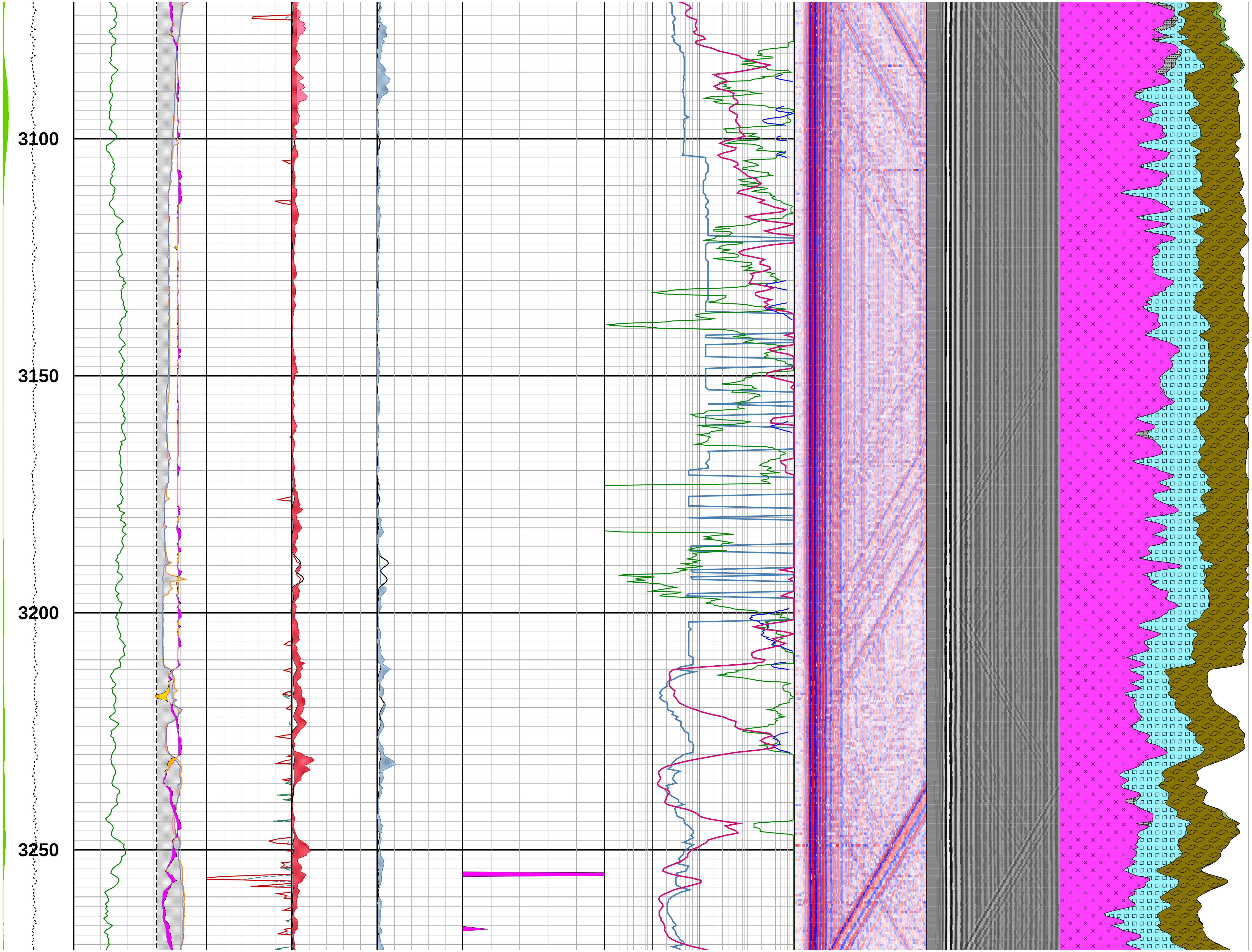

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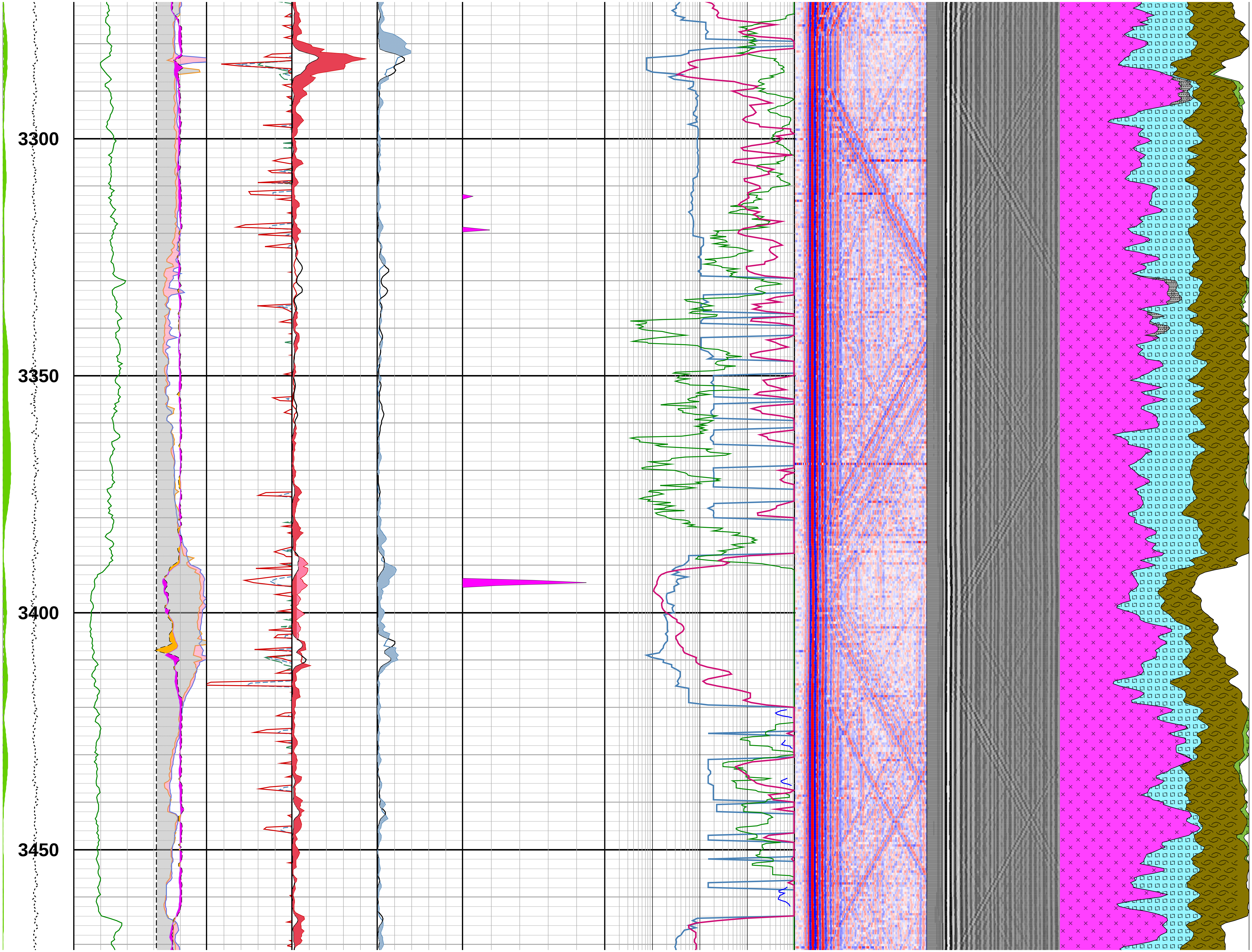

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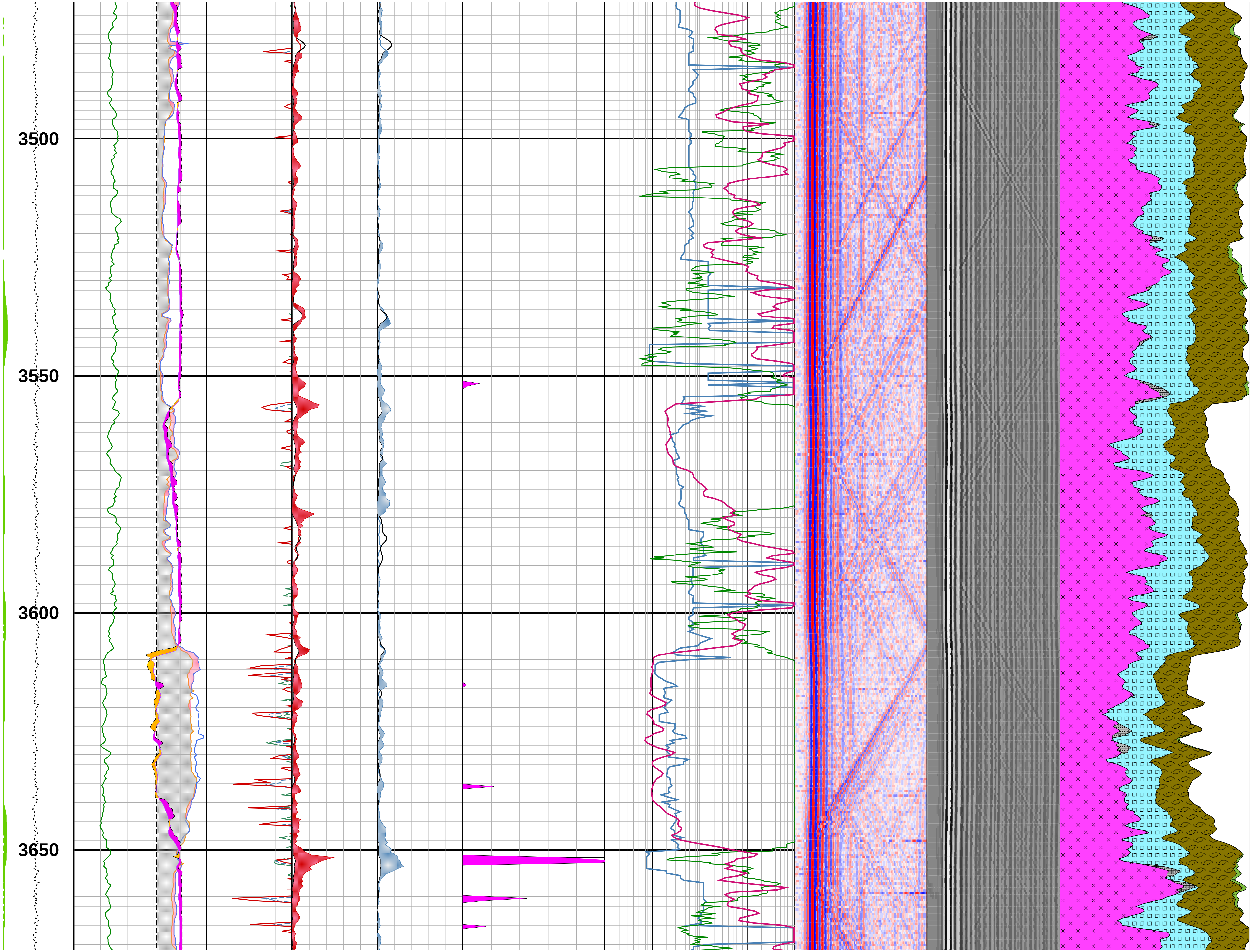
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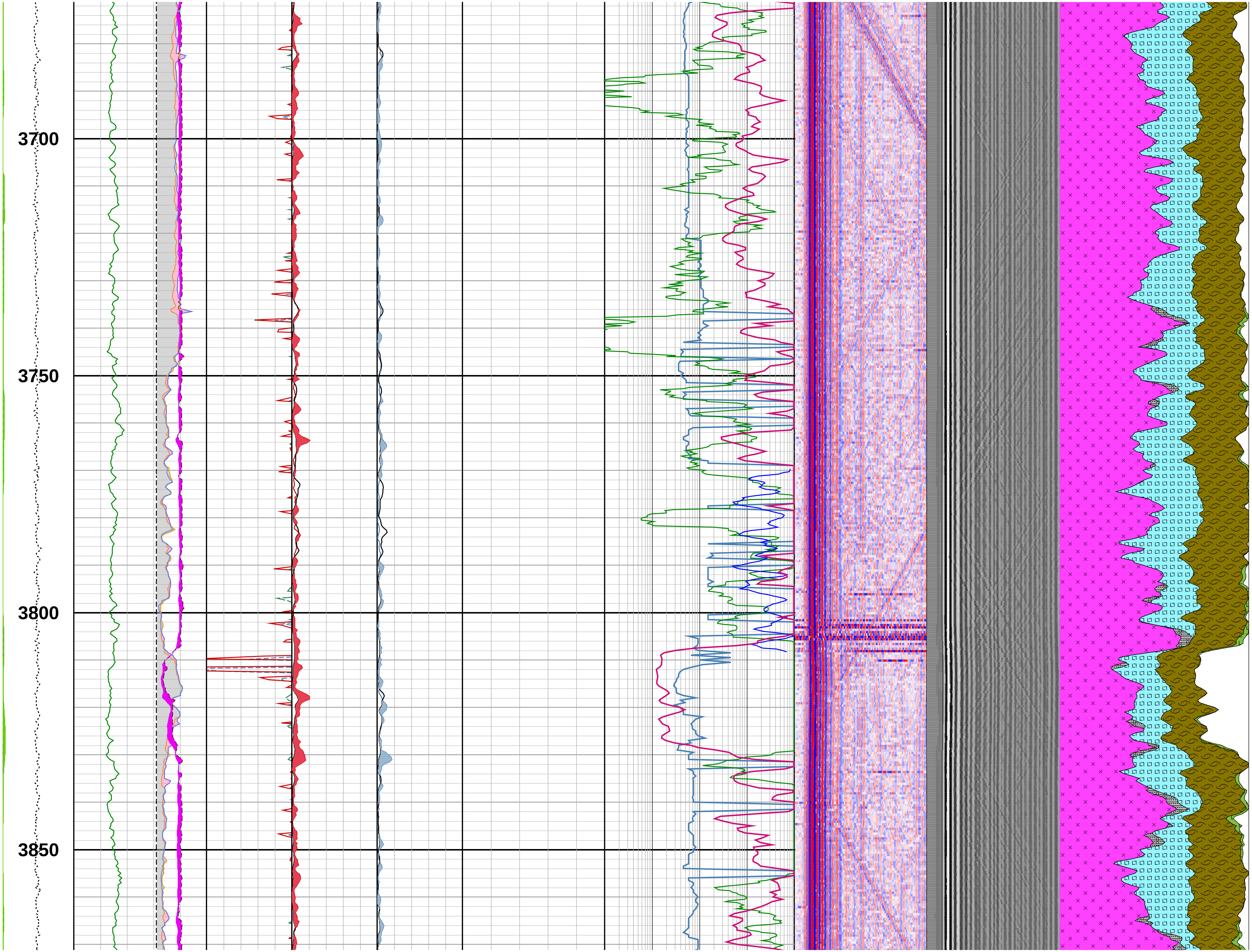
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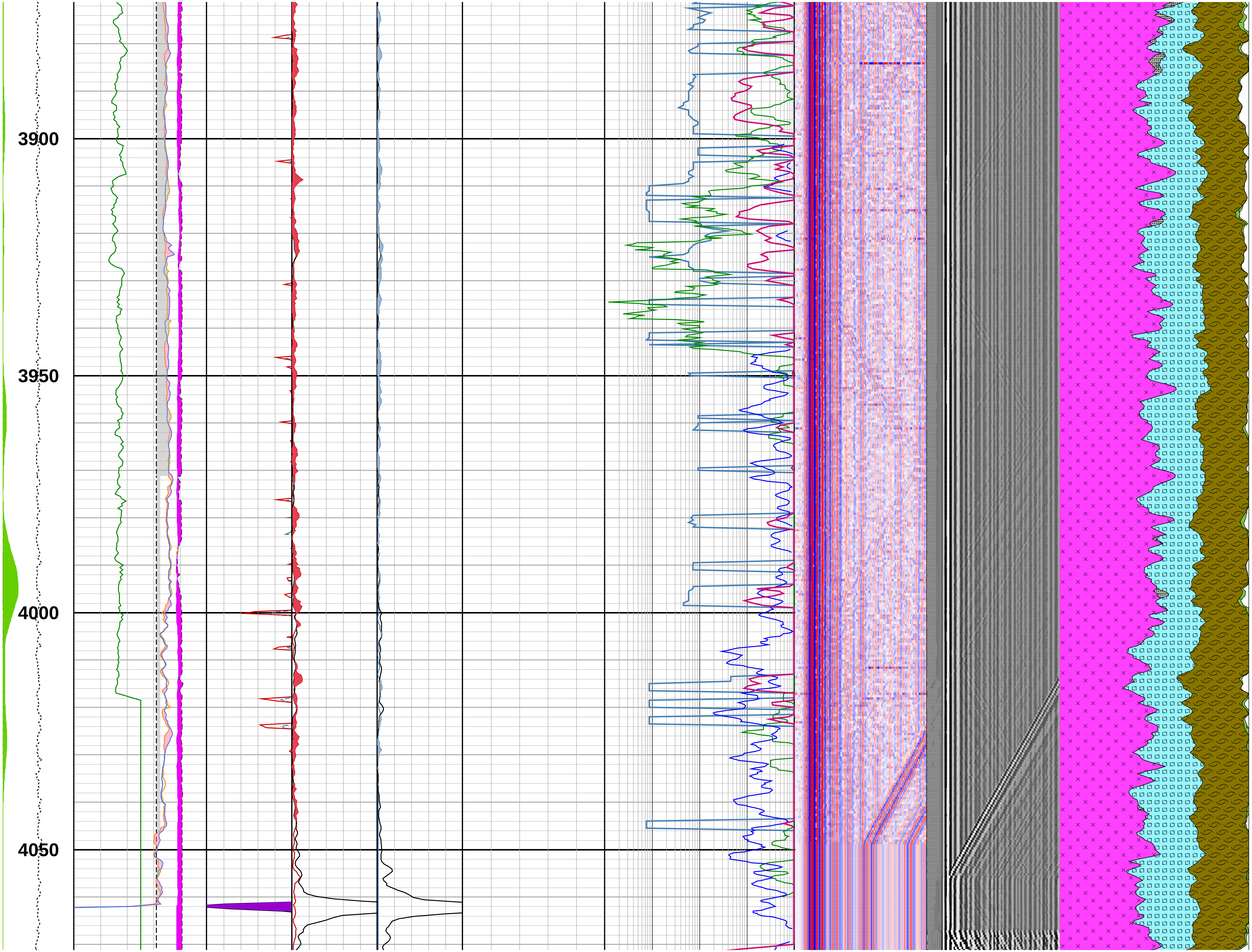
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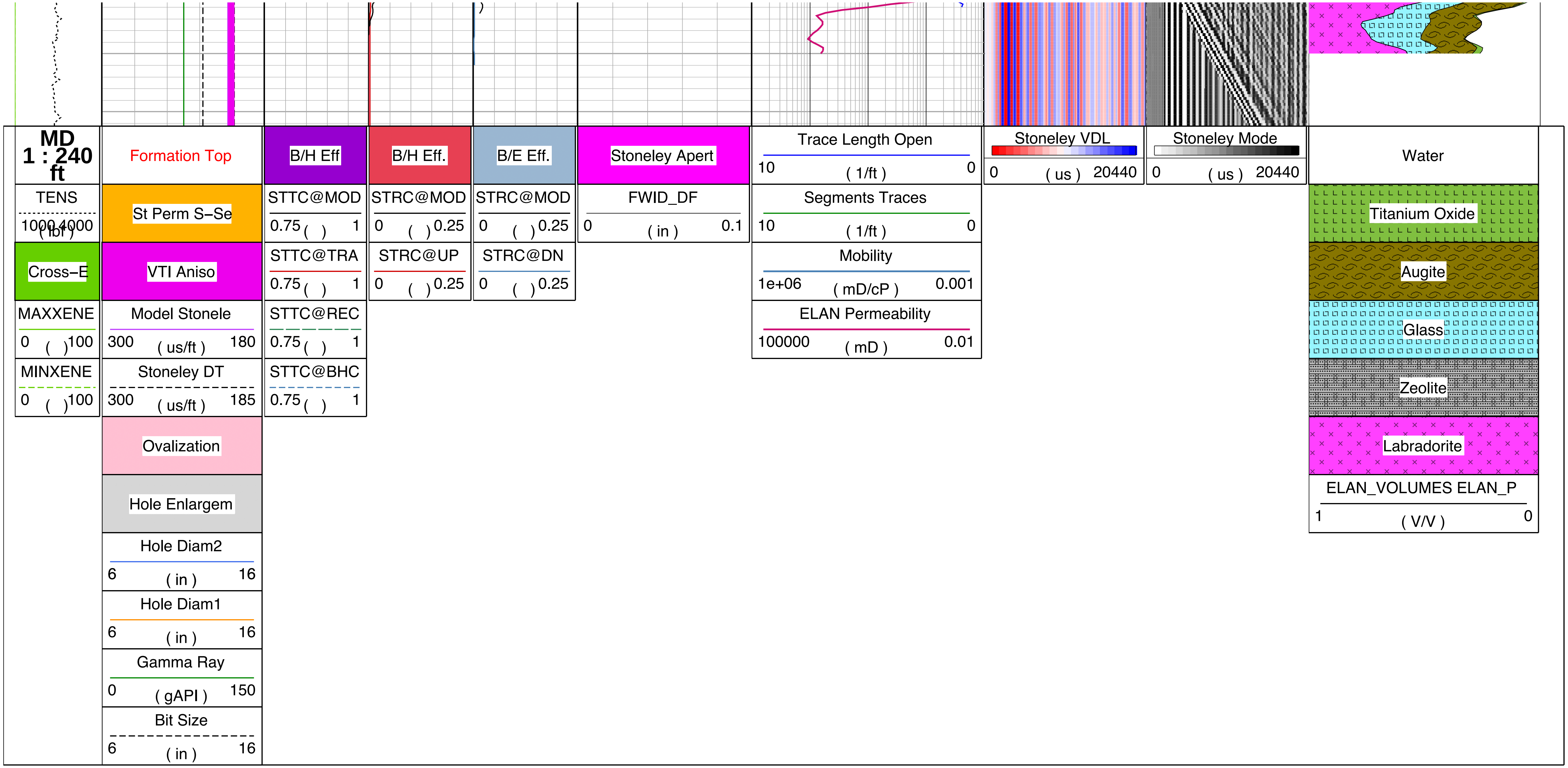
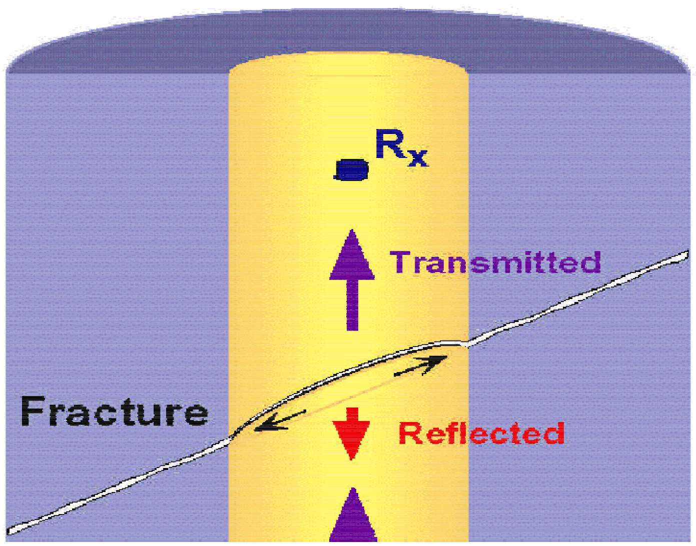


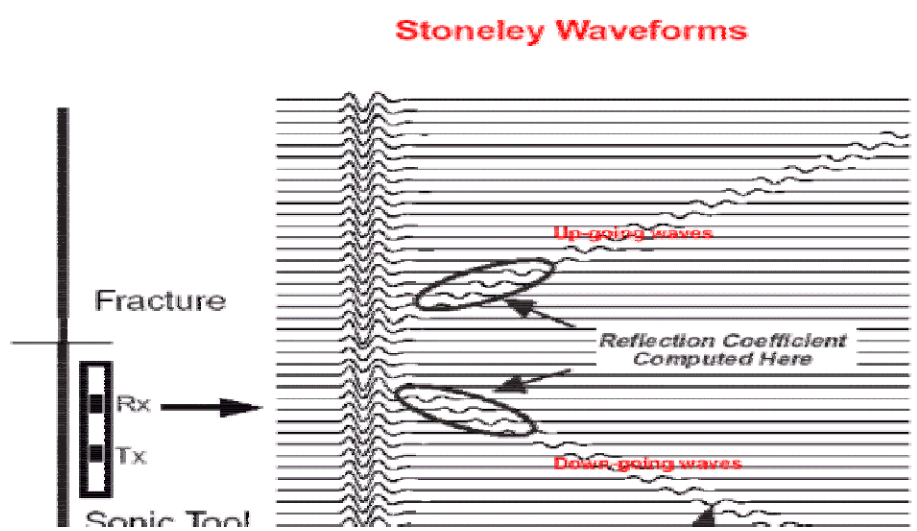
Stoneley Wave

Interface wave that travels at the borehole wall

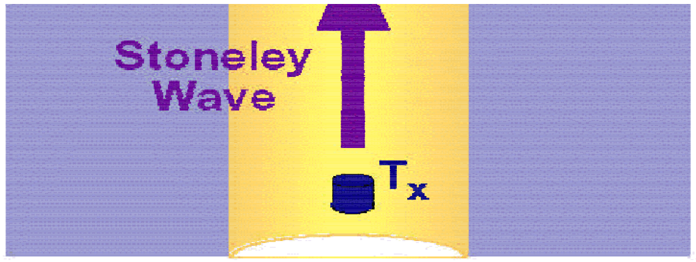
Sensitive to:

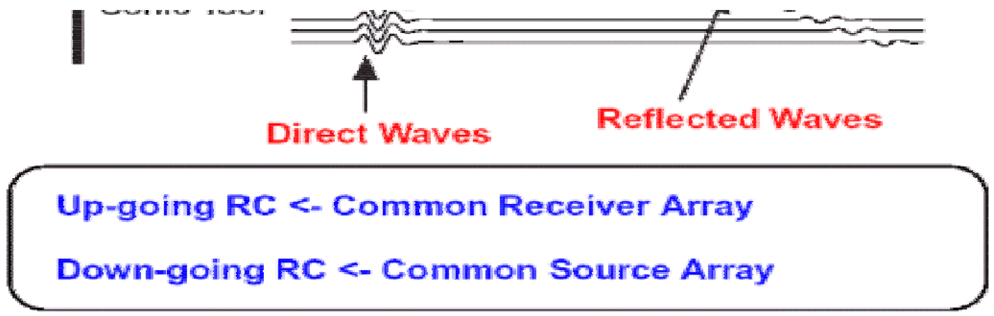
- **Fluid Velocity**
- **Hole size**
- **Formation shear**





Formation Shear
Fluid Mobility
Open Fractures





Technical Paper References:

SEGJ
"Fracture Evaluation from Inversion of Stoneley Transmission and Reflections"; T. Endo, K. Tezuka, T. Fukushima, A. Brie, H. Mikada and M. Miyairi; SEGJ International Symposium, 1998.

SPWLA
"Fracture and Permeability Evaluation in a Fault Zone from Sonic Waveform Data"; Takeshi Endo, Schiumberger K.K., Wireline & Testing, Fuchinobe, Japan, Hisao Ito, Geological Survey of Japan, Tsukuba, Japan, Alain Brie, Schlumberger K.K., Wireline & Testing, Fuchinobe, Japan, Mohammed Badri, Schlumberger Logelco Inc., Wireline & Testing, Cairo, Egypt, and Mohamed El Sheikh, Agiba Petroleum Company, Cairo, Egypt; SPWLA Annual Symposium in June 1997

SPWLA
"Fracture Evaluation from Dipole Shear Anisotropy and Borehole Stoneley Waves"; Takeshi Endo, Schiumberger K.K., Wireline & Testing, Fuchinobe, Japan, Alain Brie, Schlumberger K.K., Wireline & Testing, Fuchinobe, Japan, Mohammed Badri, Schlumberger Logelco Inc., Wireline & Testing, Cairo, Egypt; SPWLA Annual Symposium in June 1996

Output Channels From This Processing:

```
                DESCRIPTION OF SONFRAC CURVES
                --------------------------------

STONELEY TRANSMISSION AND REFLECTION

Name            Description


STTC.BHC                Stoneley Transmission Coefficient - Bore Hole
Compensated mode
                (Average of Transmission Coefficients of Transmitter array and
                Receiver array direct waves).

STTC.TRA        Stoneley Transmission Coefficient - Transmitter array mode.

STTC.REC        Stoneley Transmission Coefficient - Receiver array mode.

REFCD.MST       Flag of Stoneley Downgoing Reflection Coefficient for each
identified reflector (EVENTD =1).

REFCU.MST       Flag of  Stoneley Upgoing Reflection Coefficient for each
```

identified reflector (EVENTU =1).

EVENTD Flag for identified downgoing reflector (1 for a real reflector, 0 for a non-real reflector).

EVENTU Flag for identified upgoing reflector (1 for a real reflector, 0 for a non-real reflector).

STRC.DN Stoneley Downgoing Reflection Coefficient.

STRC.UP Stoneley Upgoing Reflection Coefficient.

(ii) FRACTURE APERTURE DISTRIBUTION

FWID_DF Computed Fracture Width (from the dipping fracture model with borehole correction).

FERR_DF Errors of inversion from the dipping fracture model with borehole correction.

FPERM_DF Fracture Permeability (from the dipping fracture model with borehole correction).

FWID_AHF Computed Fracture Width (from the apparent horizontal fracture model with borehole correction).

FERR_AHF Errors of inversion from the dipping fracture model with borehole correction.

FPERM_DF Fracture Permeability (from the dipping fracture model with borehole correction).

FWID_AHF Computed Fracture Width (from the apparent horizontal fracture model with borehole correction).

FERR_AHF Errors of inversion from the dipping fracture model with borehole correction.

FPERM_AHF Fracture Permeability (from apparent horizontal fracture model with borehole correction).

FVDA Apparent Fracture Density input by user.

DIP Fracture Dip Angle input by user.