



**Weatherford**

ARRAY INDUCTION-RTAP  
SHALLOW FOCUSED ELECTRIC  
LOG

COMPANY				EAST CHEYENNE GAS STORAGE LLC			
WELL				ECGS No 6-21 WPD004-2			
FIELD				WEST PEETZ			
PROVINCE/COUNTY				LOGAN			
COUNTRY/STATE				U.S.A / COLORADO			
LOCATION				SHL: 1440' FSL & 2297' FWL			
SEC 6	TWP 11N	RGE 52W	Other Services				
Latitude				MPD/MDN			
Longitude							
API Number		0507509426-0000					
Permanent Datum GL, Elevation 4557 feet							
Log Measured From KB							
Drilling Measured From KB							
Date	18-OCT-2014			Elevations: feet			
Run Number	1			KB	4567.00		
Service Order	2577-100789597			DF	4566.00		
Depth Driller	5440.00			feet	4557.00		
Depth Logger	5440.00			feet			
First Reading	5437.00			feet			
Last Reading	300.00			feet			
Casing Driller	1220.00			feet			
Casing Logger	1213.00			feet			
Bit Size	8.750			inches			
Hole Fluid Type	WBM						
Density / Viscosity	9.60 lb/USg			70.00 SEC/QT			
PH / Fluid Loss	8.00						
Sample Source	FLOWLINE						
Rm @ Measured Temp	2.21 @ 65.7			ohm-m			
Rmf @ Measured Temp	1.76 @ 65.7			ohm-m			
Rmc @ Measured Temp	2.65 @ 65.7			ohm-m			
Source Rmf / Rmc	FLOWLINE						
Rm @ BHT	0.89 @168.0			ohm-m			
Time Since Circulation	5 HOURS						
Max Recorded Temp	168.00			deg F			
Equipment / Base	13173			CASPER			
Recorded By	M.RICHINS						
Witnessed By	R.LYNDE						

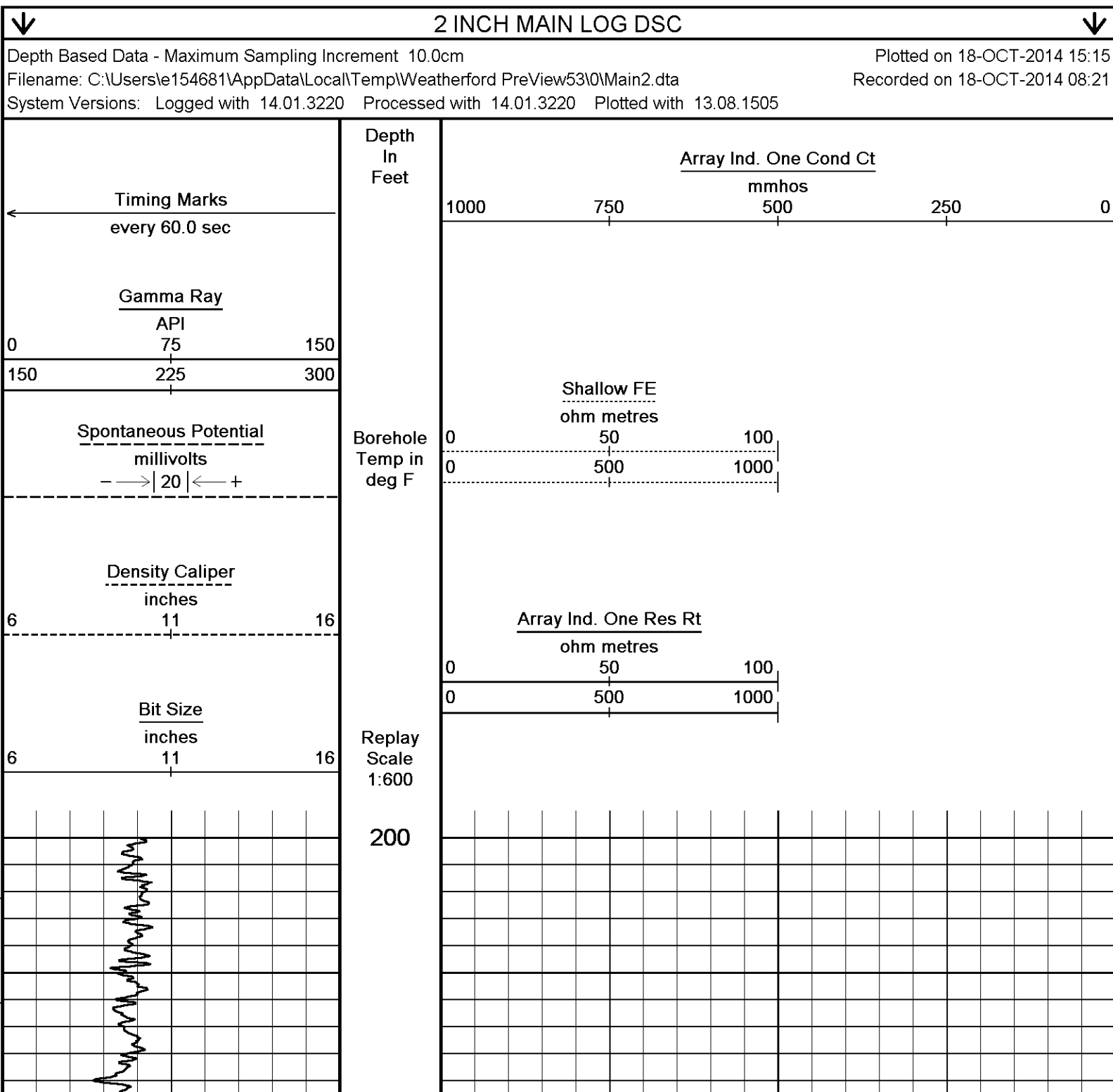
BOREHOLE RECORD					Last Edited: 17-OCT-2014 20:59
Bit Size inches		Depth From feet		Depth To feet	
8.750		1219.00		5260.00	
CASING RECORD					
Type	Size inches	Depth From feet	Shoe Depth feet	Weight pounds/ft	
Surface	9.625	0.00	1219.00	36.00	

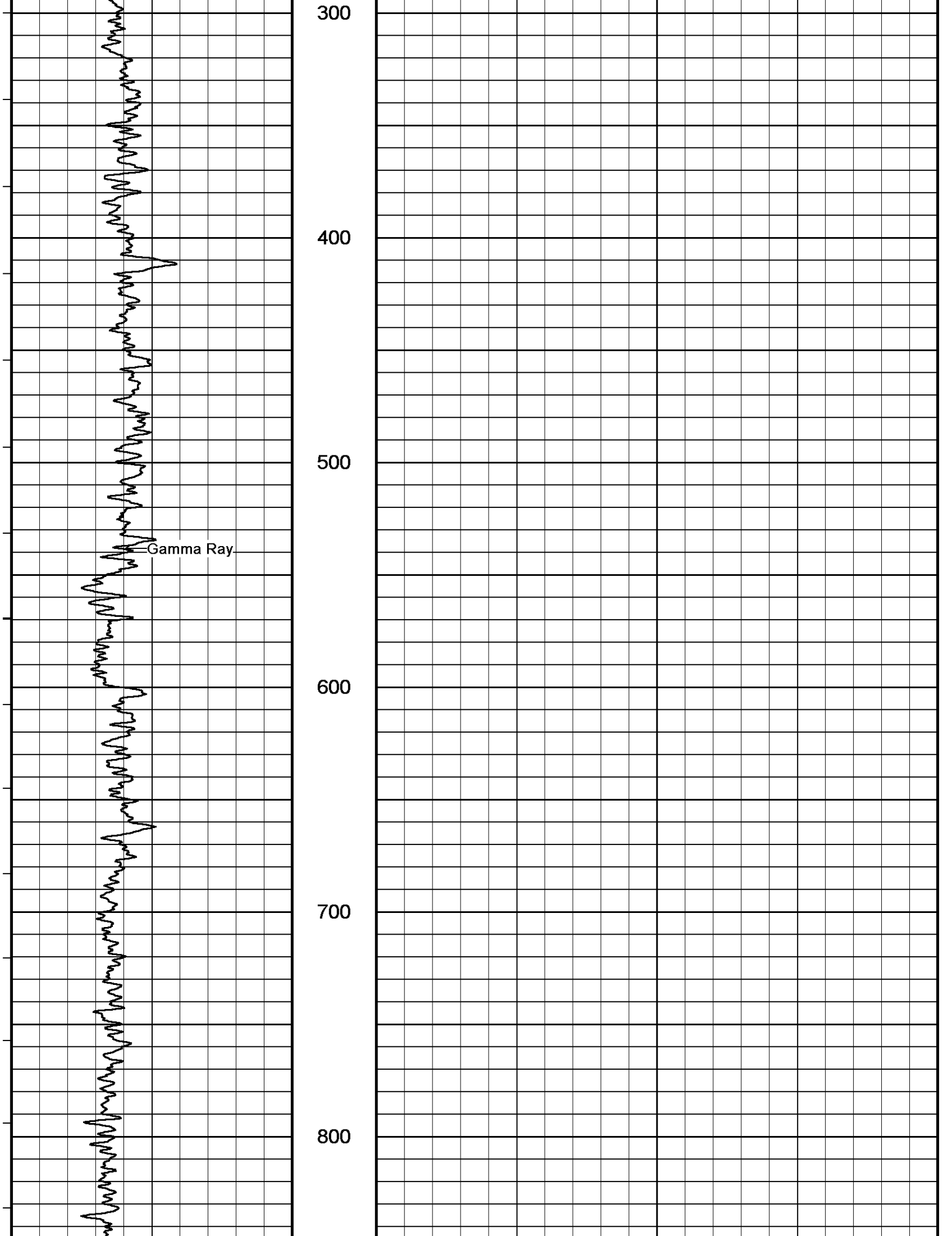
REMARKS
SOFTWARE VERSION: 14.01.3220
MCG, MDN, MPD, MFE, MIE, AND MAI RAN IN COMBINATION.
HARDWARE: MAI: 0.5" STAND OFF, SEE TOOL STRING.
TIGHT PULLS, BOREHOLE SIZE AND RUGOSITY WILL AFFECT REPEATABILITY AND DATA QUALITY.
ALL INTERVALS LOGGED AND SCALED PER CUSTOMER'S REQUEST.
IMAGE TOOL PACKED UP WITH MUD AND WELL DEBRIS. REPEAT PASS PRESENTED INSTEAD OF MAIN. IMAGE PULLED 300 FEET OFF BOTTOM.
POROSITY TOOLS PULLED TO 3900 FEET PER CUSTOMER REQUEST.
RESISTIVITY PULLED TO SURFACE CASING, AND GAMMA PULLED TO SURFACE.
TOTAL HOLE VOLUME FROM TD (5440 FEET) TO SURFACE CASING = 1840 CUBIC FEET

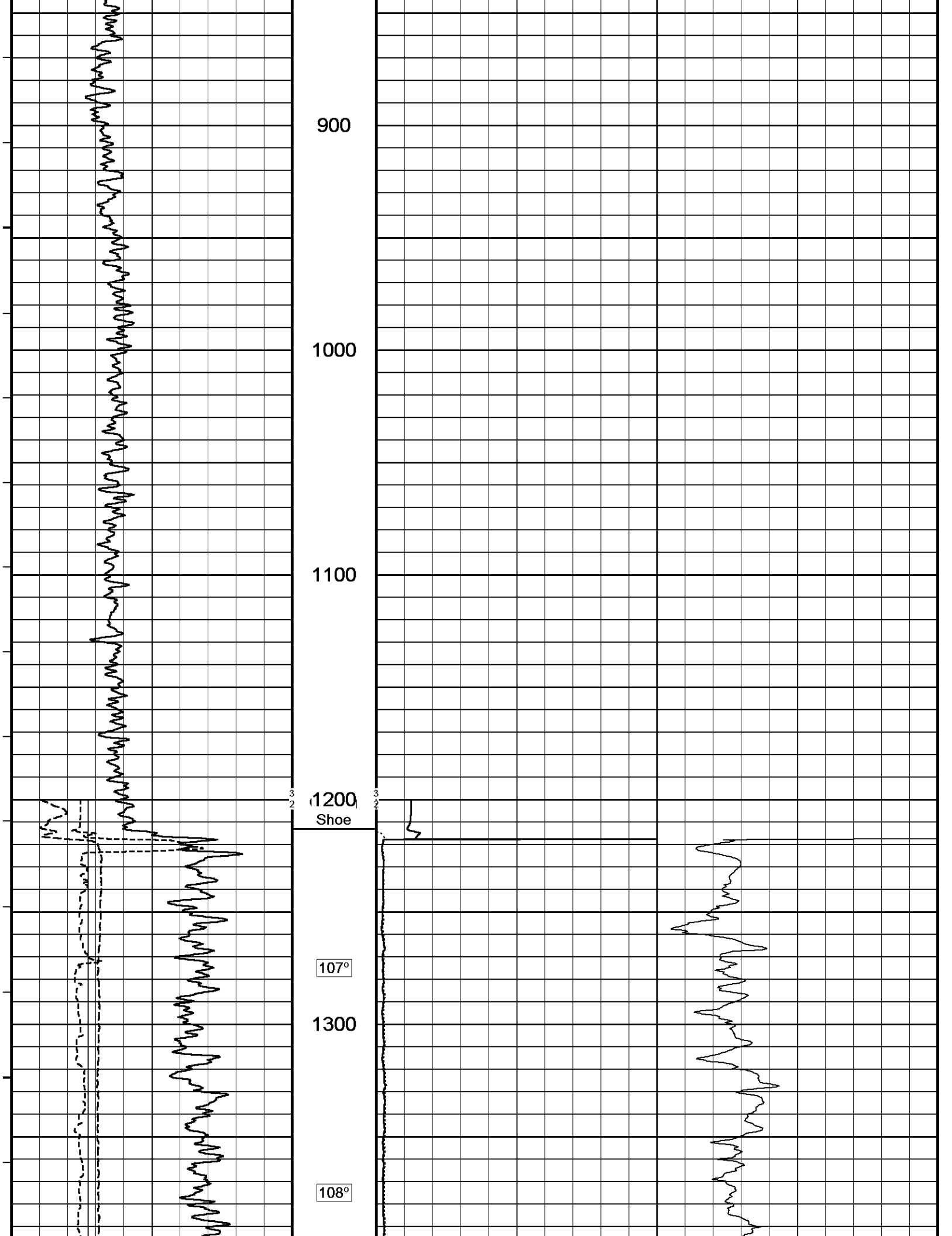
ANNUAL HOLE VOLUME FROM TD (01151 FEET) TO SURFACE CASING = 1018.0001 FEET.

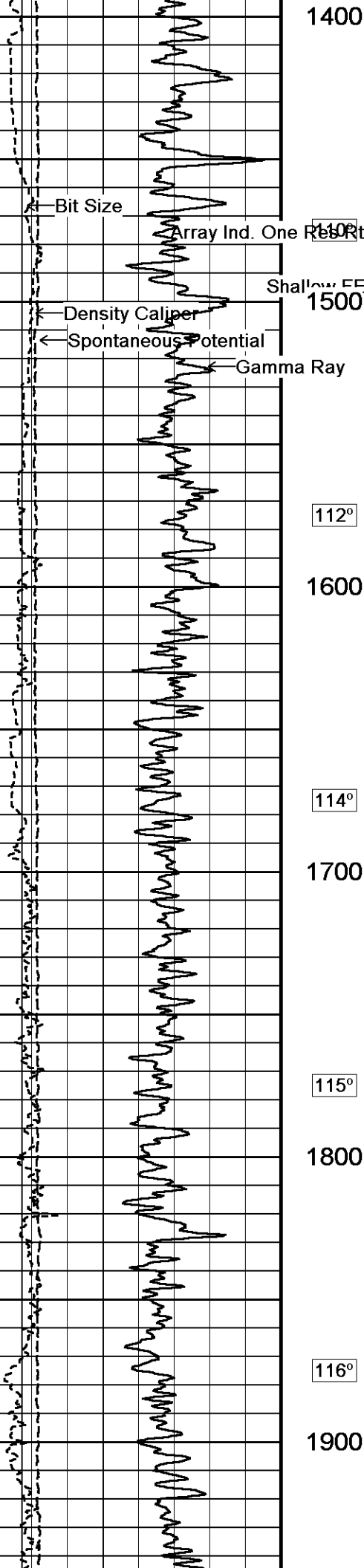
ANNULAR HOLE VOLUME WITH 7" CASING FROM TD TO SURFACE CASING = 720

In interpreting, communicating or providing information and/or making recommendations, either written or oral, as to logs or test or other data, type or amount of material, or Work or other service to be furnished, or manner of performance, or in predicting results to be obtained, the Contractor will give the Company the benefit of the Contractor's best judgment based on its experience and will perform all such Work in a good and workmanlike manner. Any interpretation of test or other data, and any recommendation or reservoir description based upon such interpretations, are opinions based upon inferences from measurements and empirical relationships and assumptions, which inferences and assumptions are not infallible, and with respect to which professional engineers and analysts may differ. ACCORDINGLY ANY INTERPRETATION OR RECOMMENDATION RESULTING FROM THE SERVICES WILL BE AT THE SOLE RISK OF THE COMPANY, AND THE CONTRACTOR CANNOT AND DOES NOT WARRANT THE ACCURACY, CORRECTNESS OR COMPLETENESS OF ANY SUCH INTERPRETATION OR RECOMMENDATION, WHICH INTERPRETATIONS AND RECOMMENDATIONS SHOULD NOT, THEREFORE, UNDER ANY CIRCUMSTANCES BE RELIED UPON AS THE SOLE OR MAIN BASIS FOR ANY DRILLING, COMPLETION, WELL TREATMENT, PRODUCTION OR FINANCIAL DECISION, OR ANY PROCEDURE INVOLVING ANY RISK TO THE SAFETY OF ANY DRILLING ACTIVITY, DRILLING RIG OR ITS CREW OR ANY OTHER INDIVIDUAL. THE COMPANY HAS FULL RESPONSIBILITY FOR ALL DECISIONS CONCERNING THE SERVICES.









1400

1500

1600

1700

1800

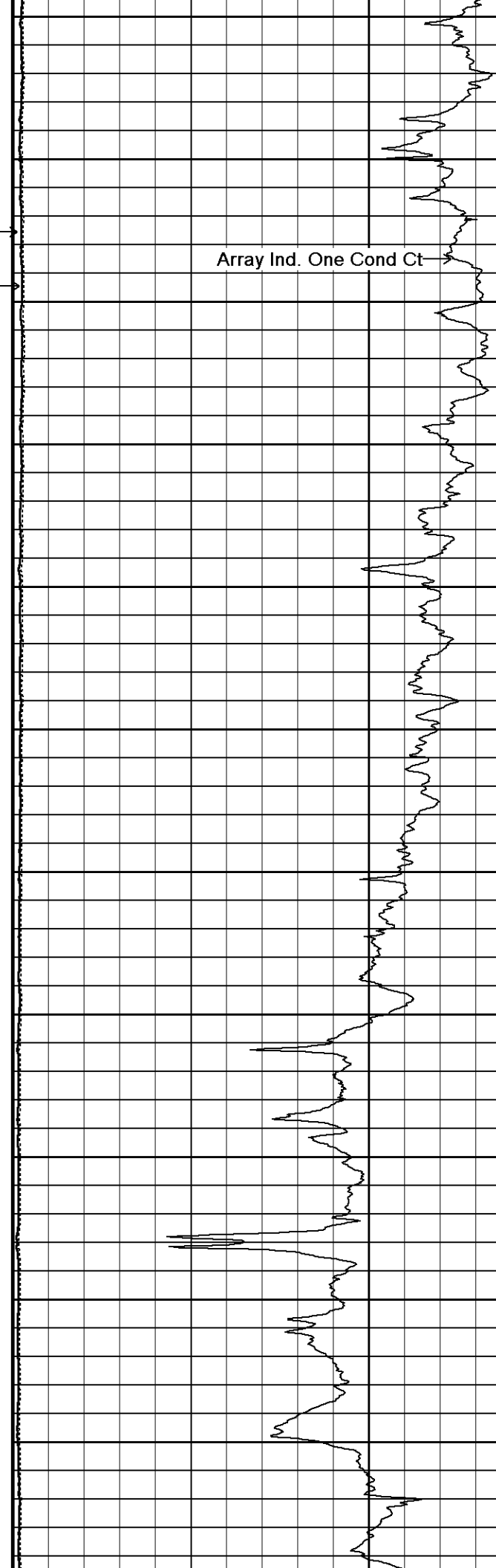
1900

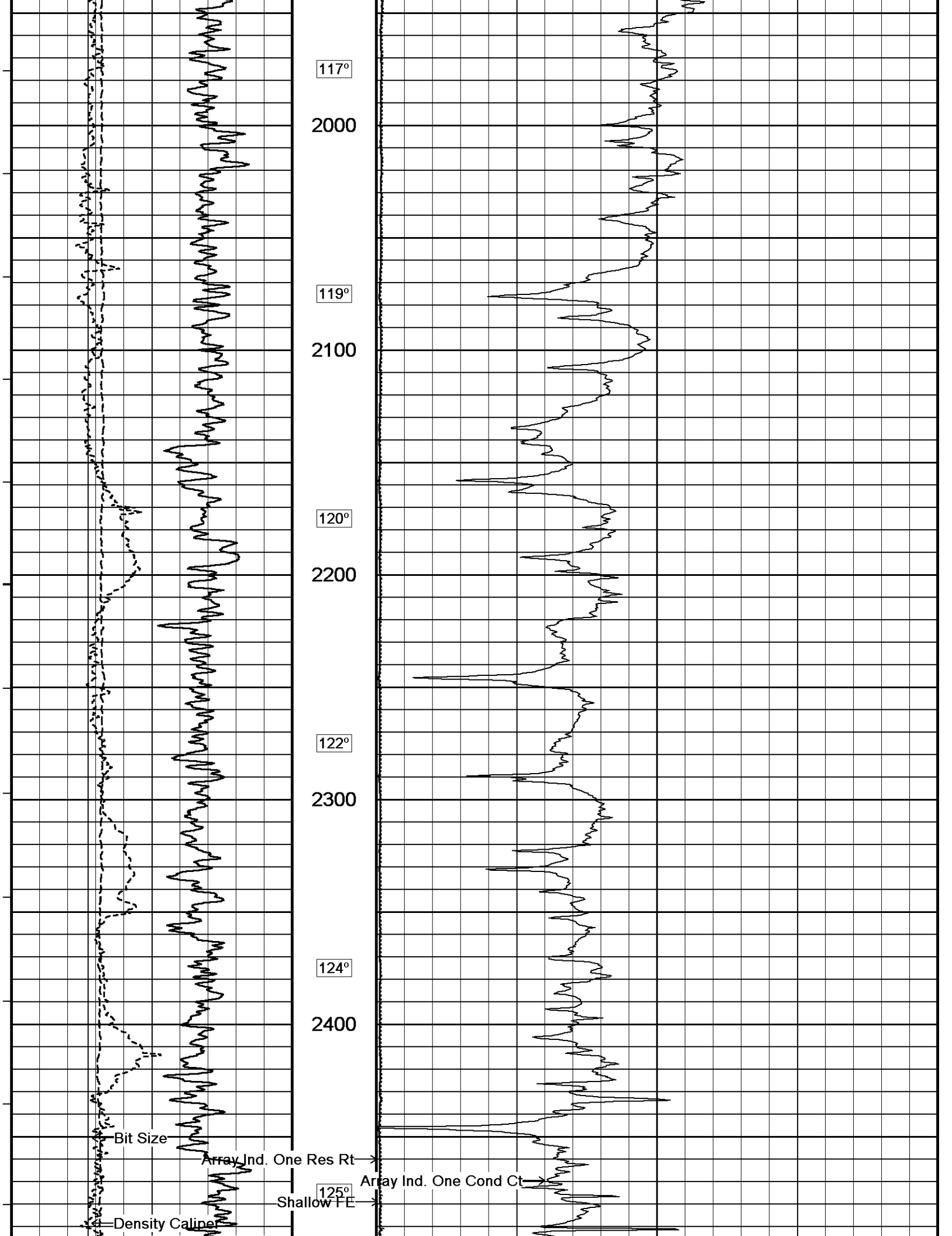
112°

114°

115°

116°





Spontaneous Potential  
Gamma Ray

2500

126°

2600

127°

2700

128°

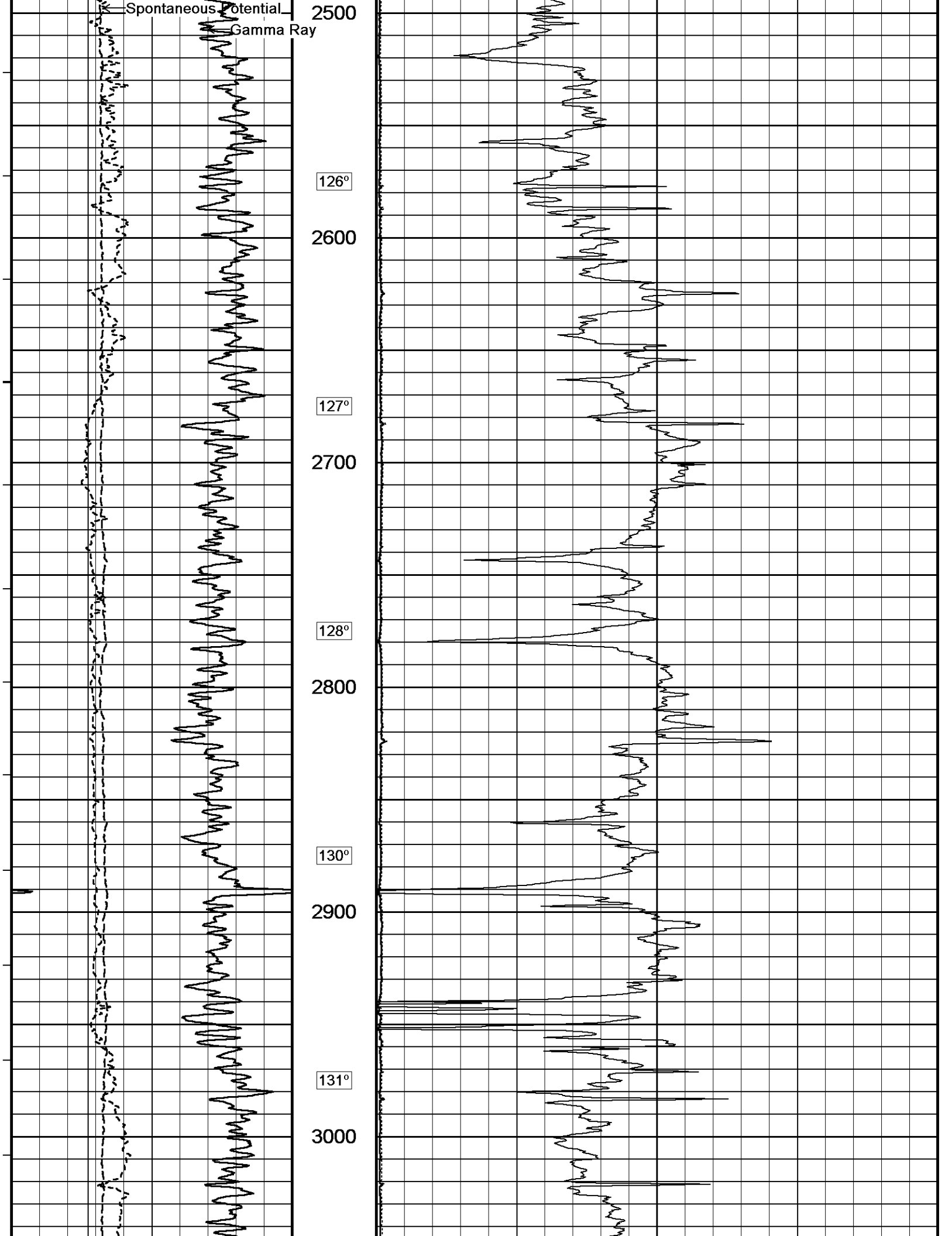
2800

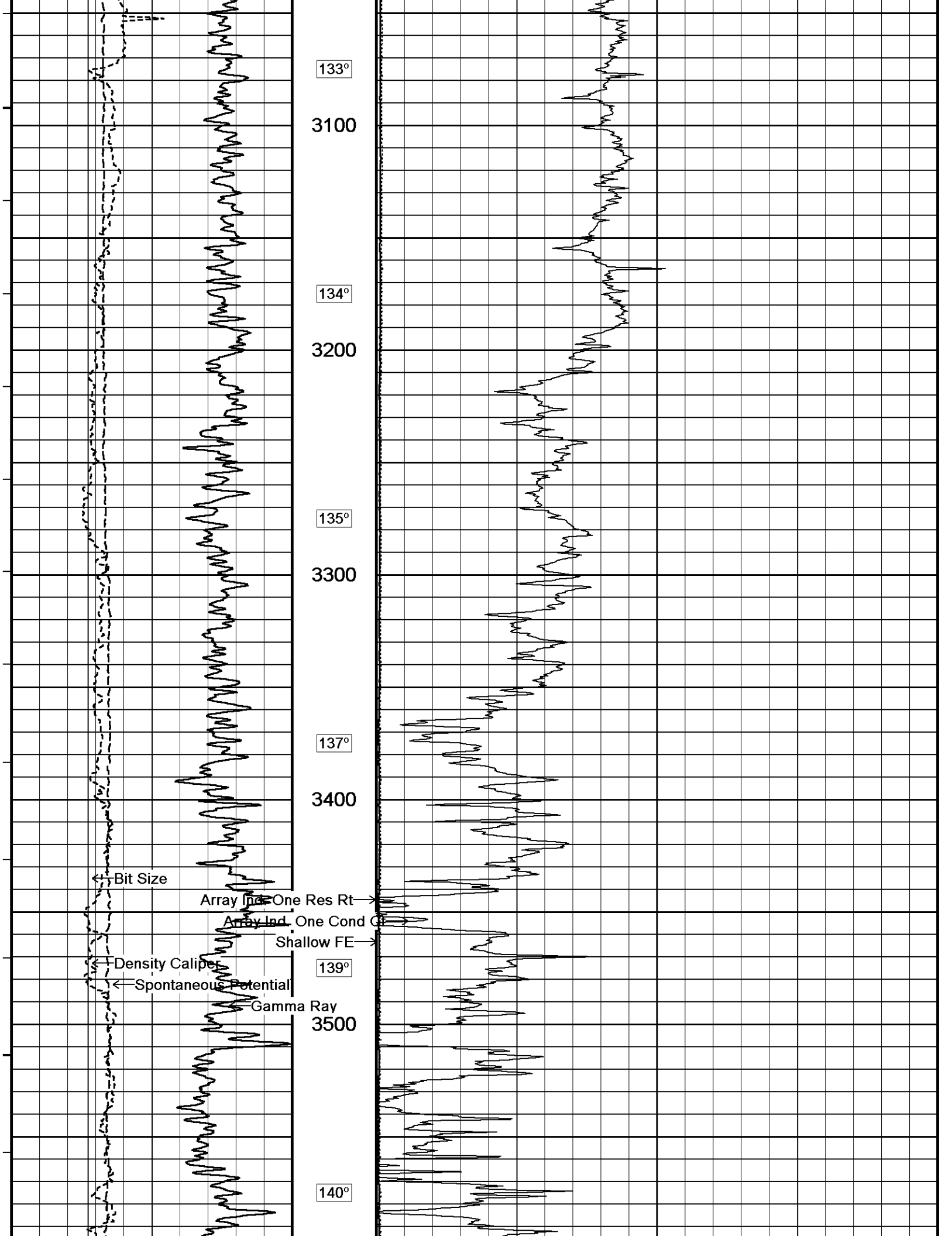
130°

2900

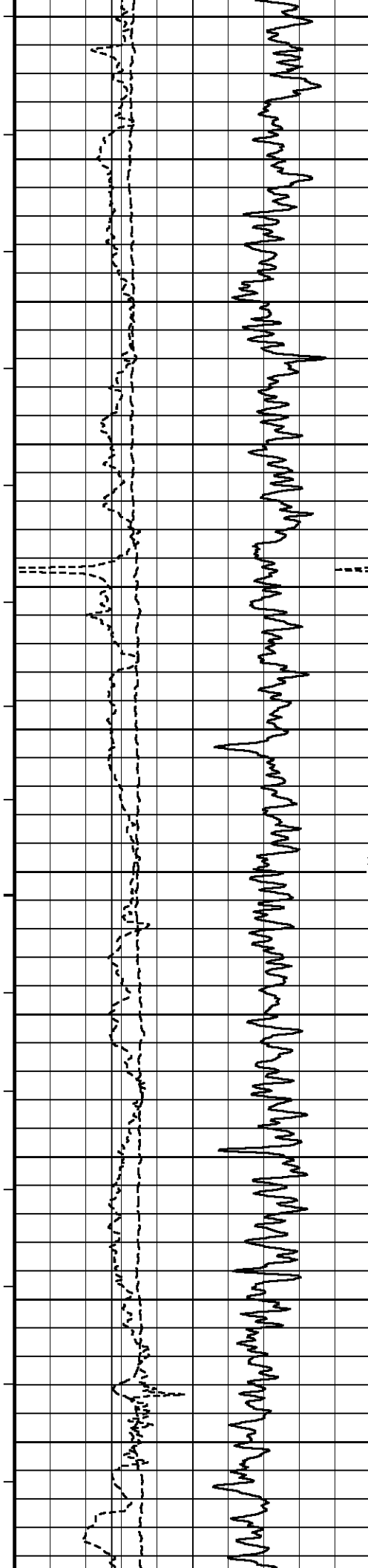
131°

3000









3600

142°

3700

143°

3800

145°

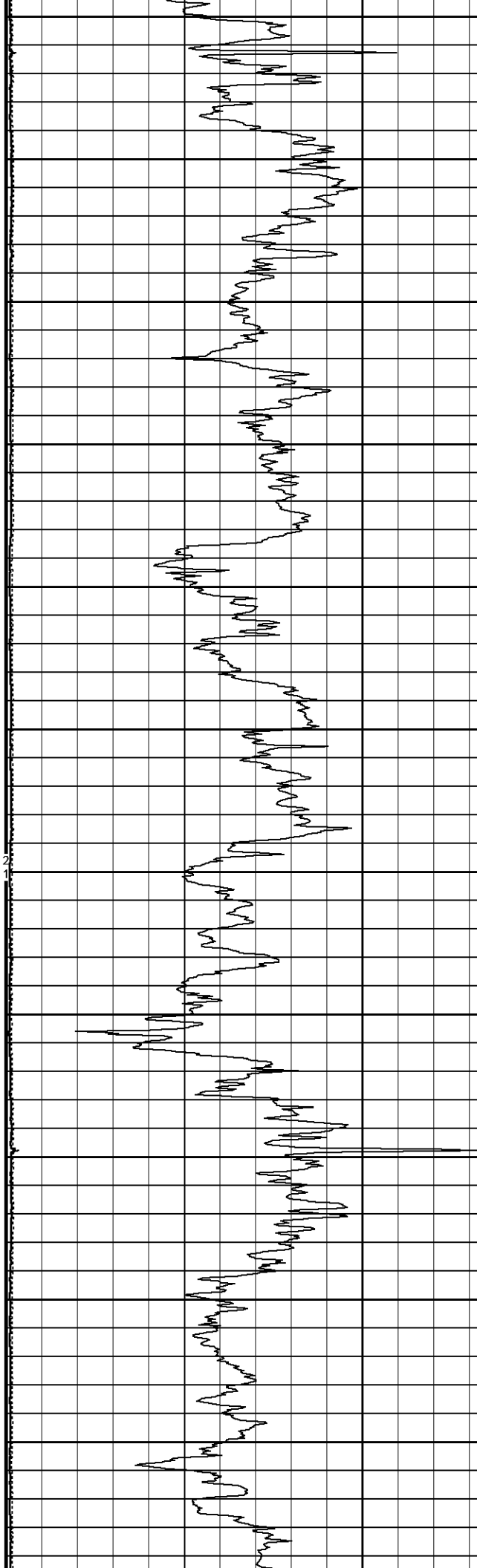
3900

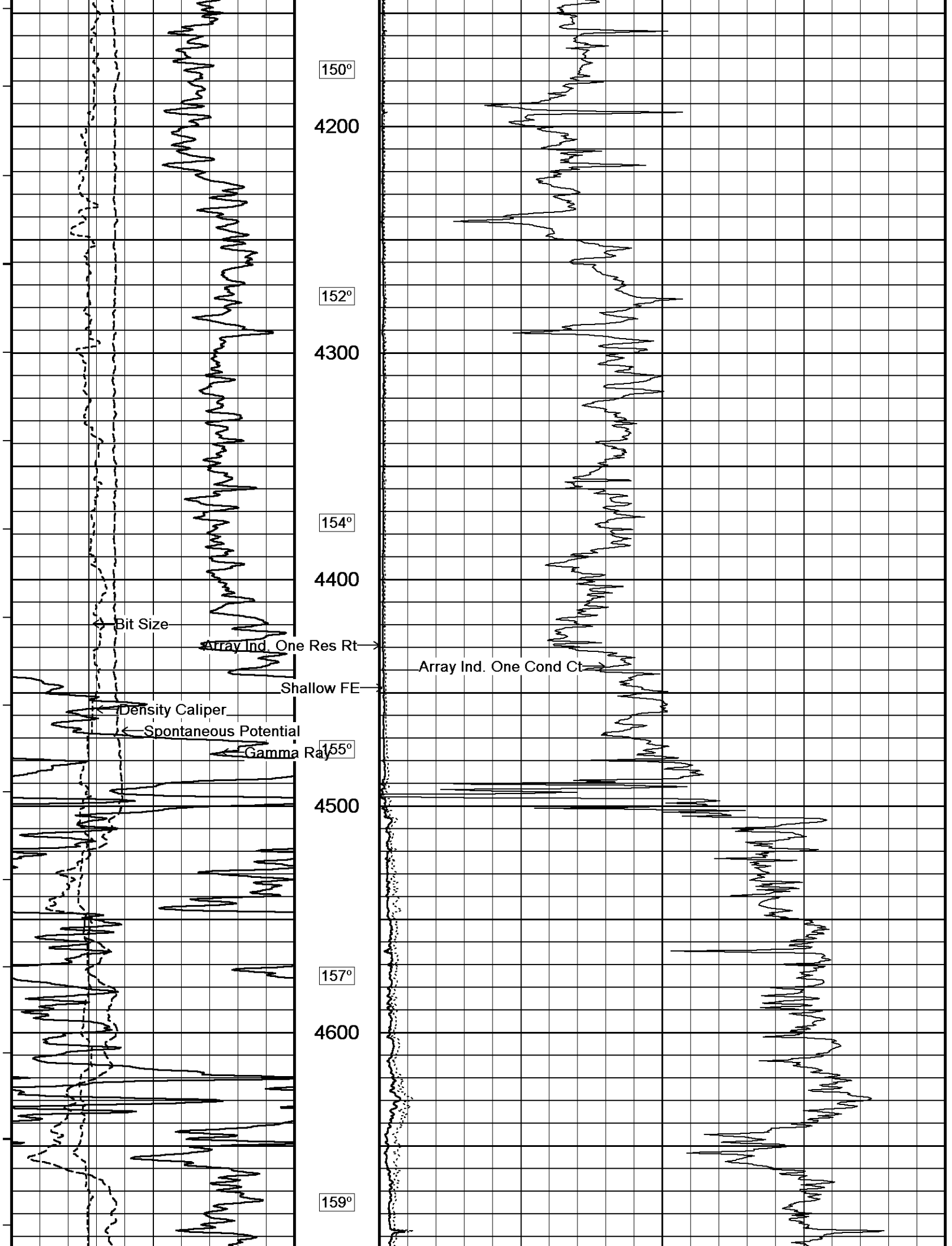
147°

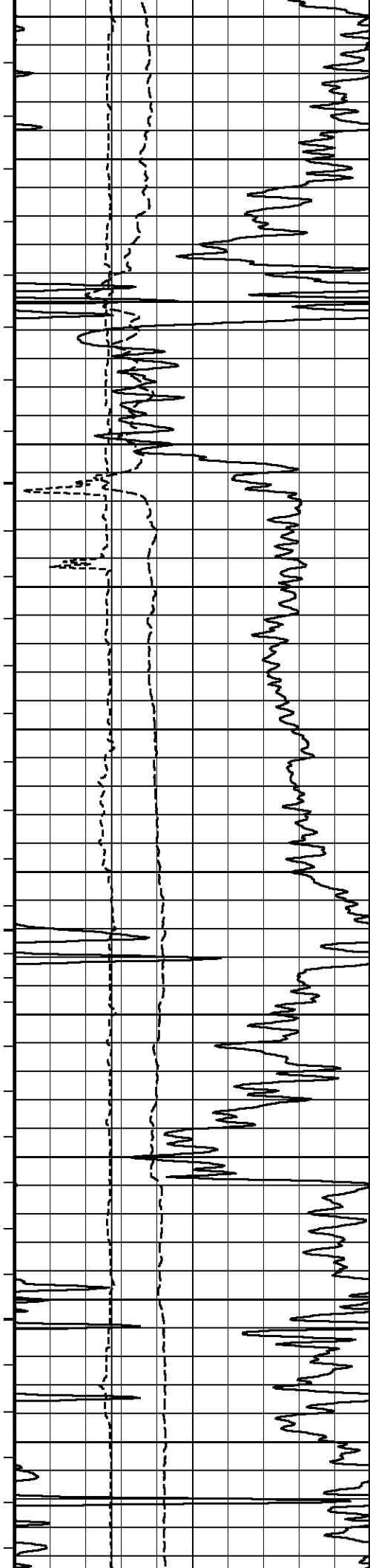
4000

148°

4100







4700

160°

4800

163°

4900

164°

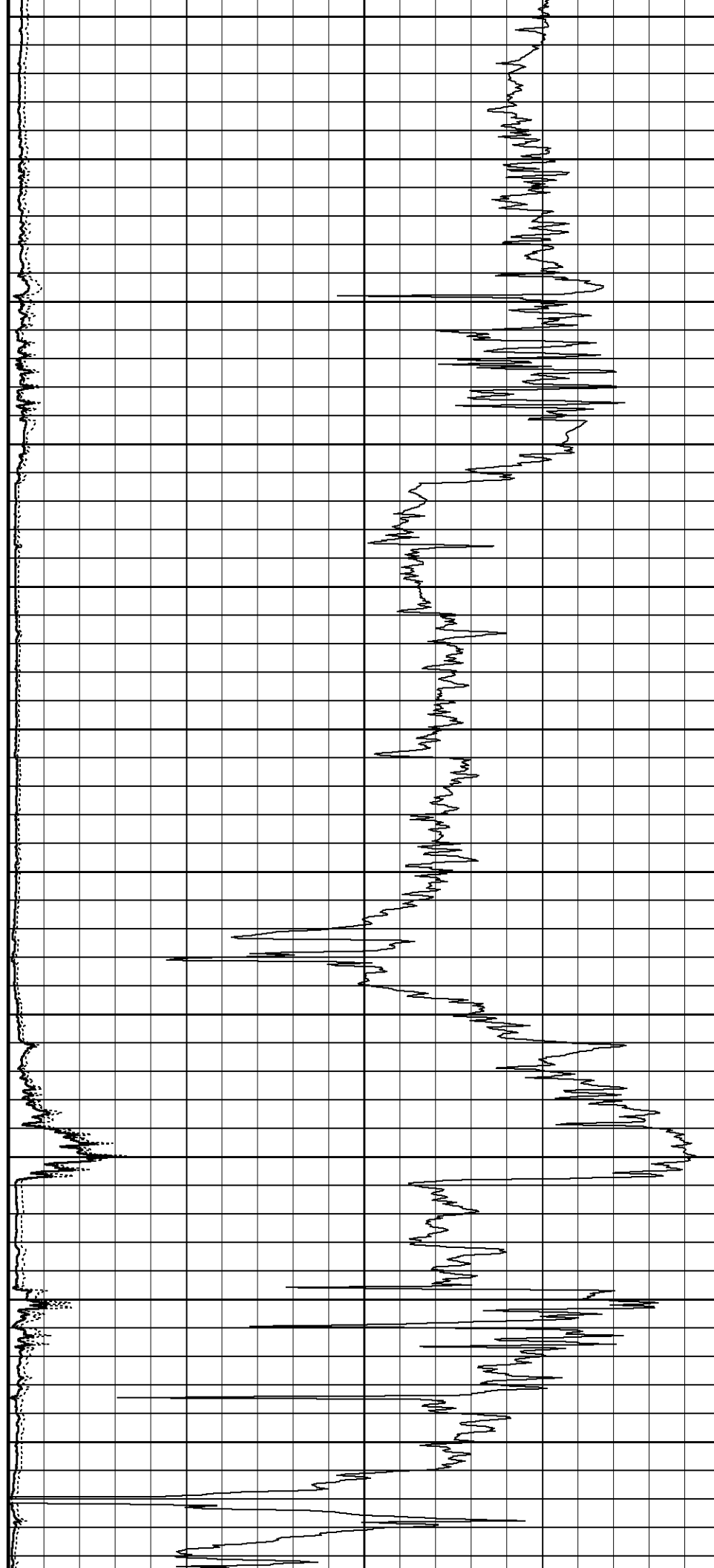
5000

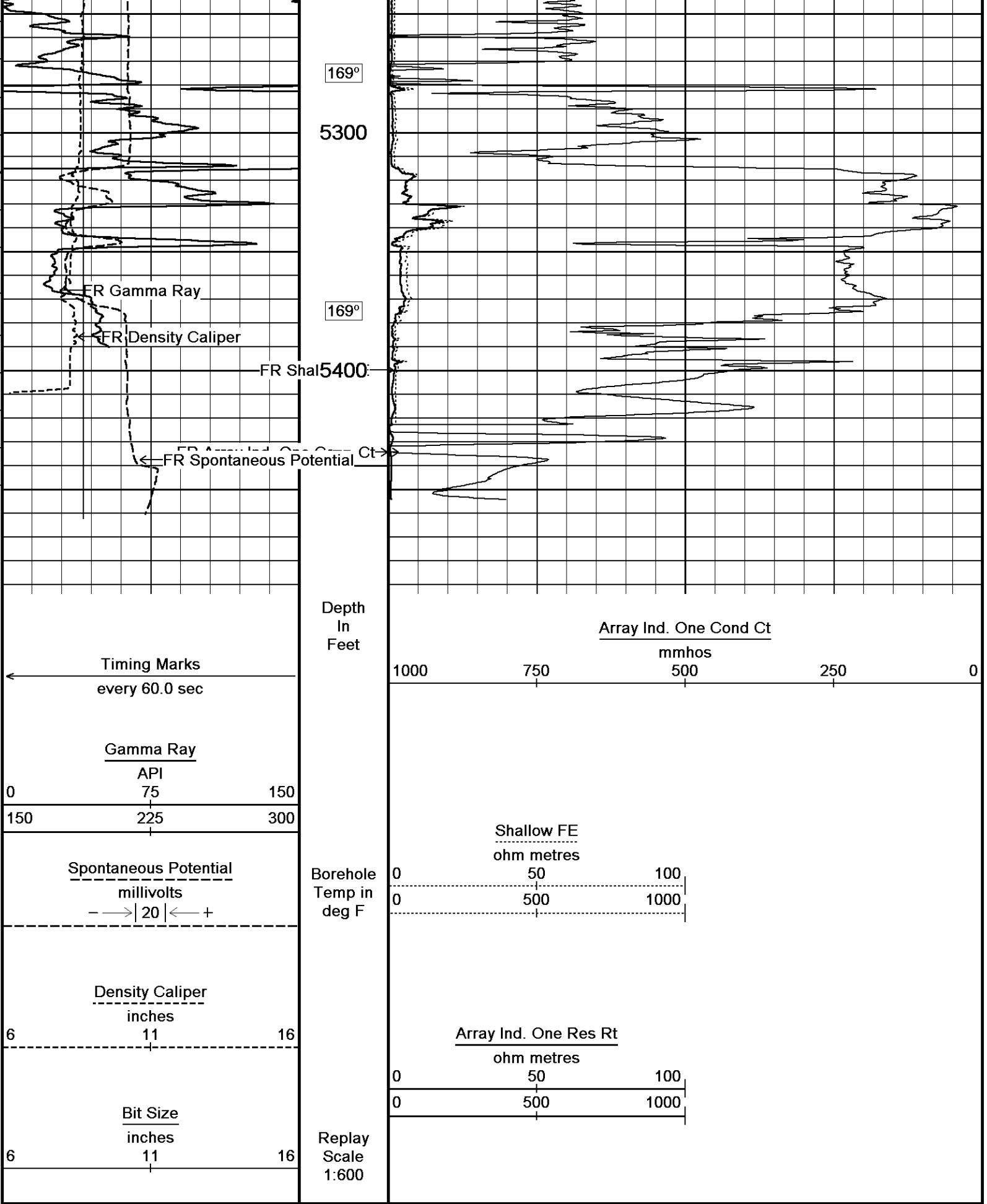
165°

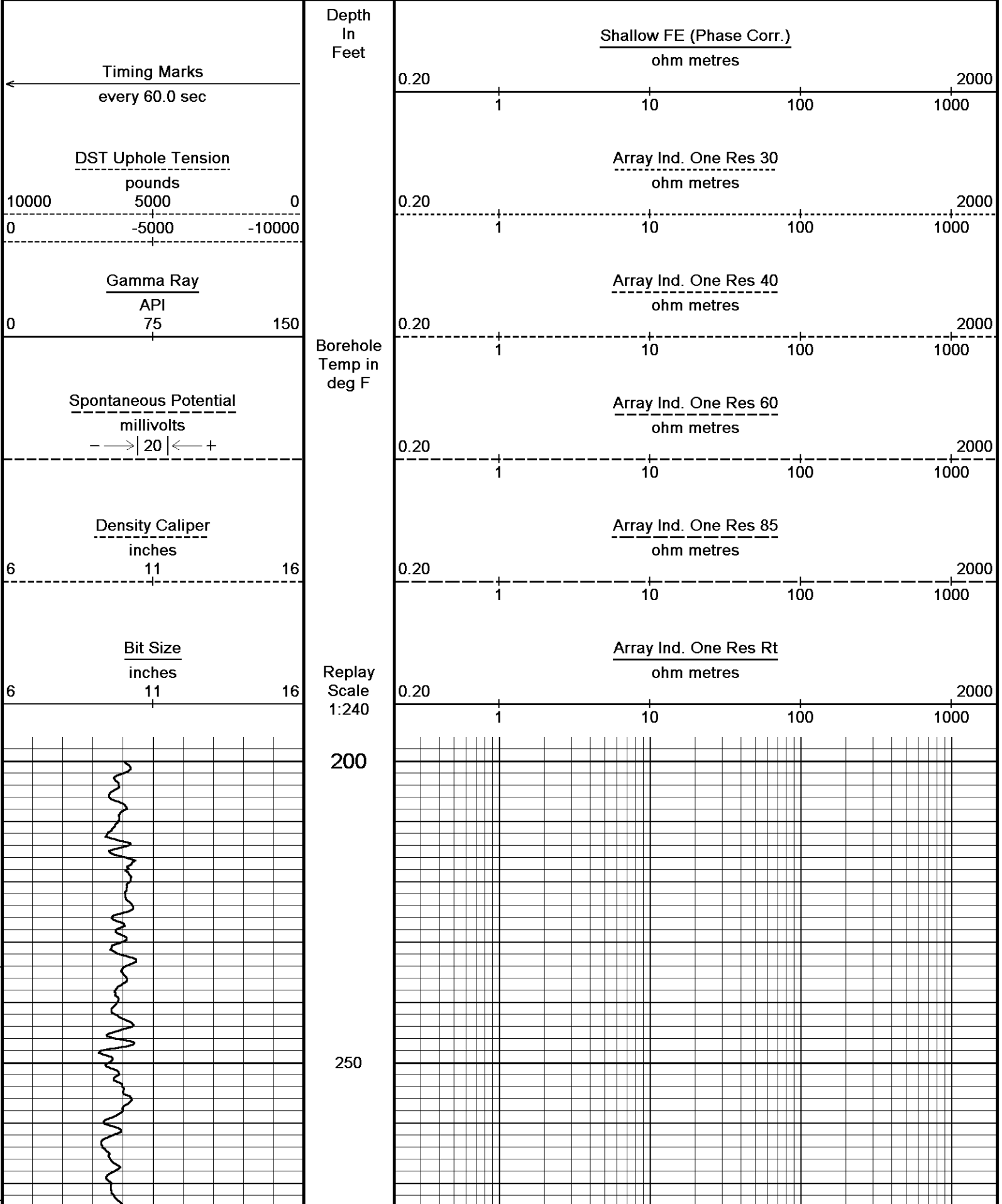
5100

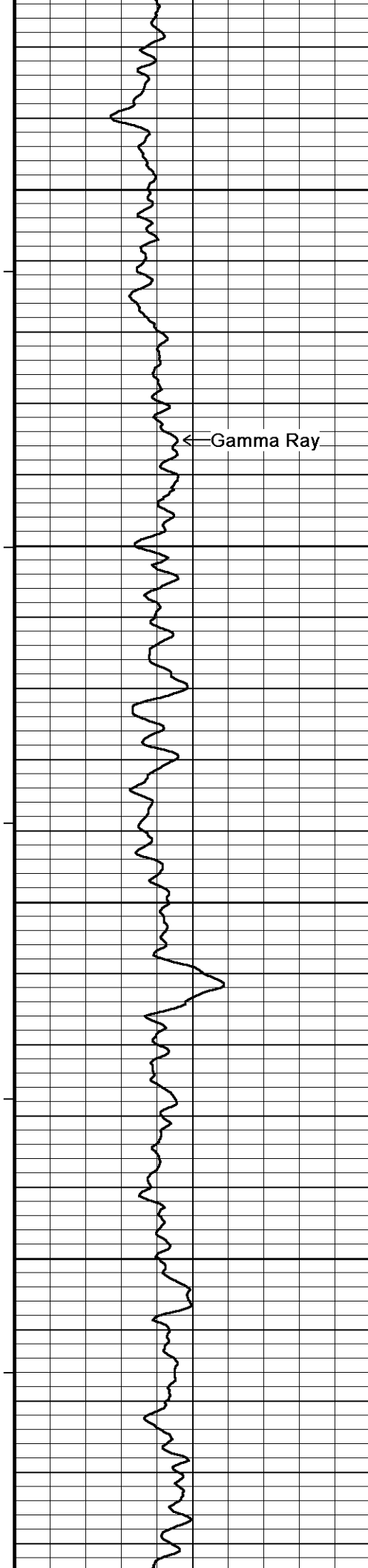
166°

5200









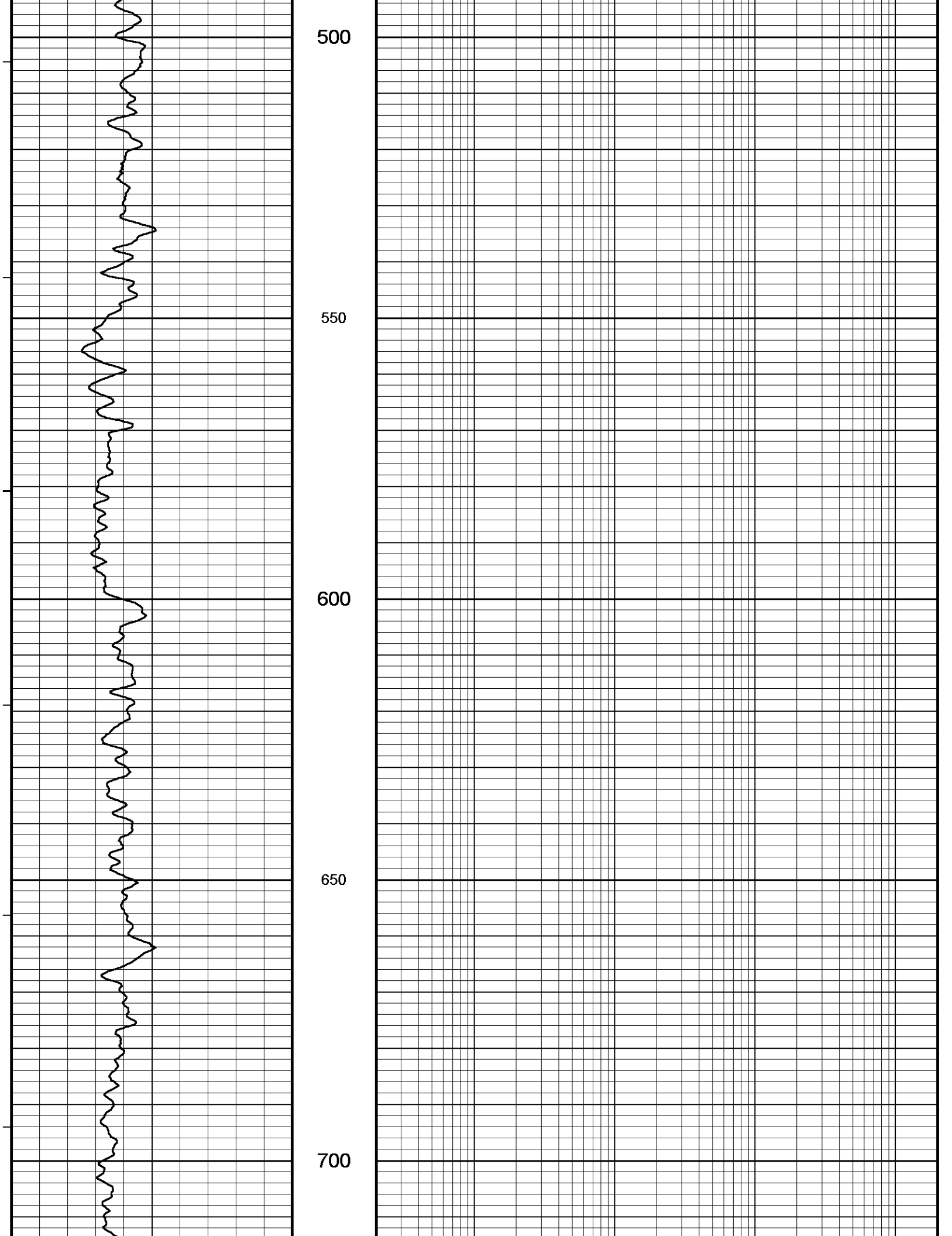
300

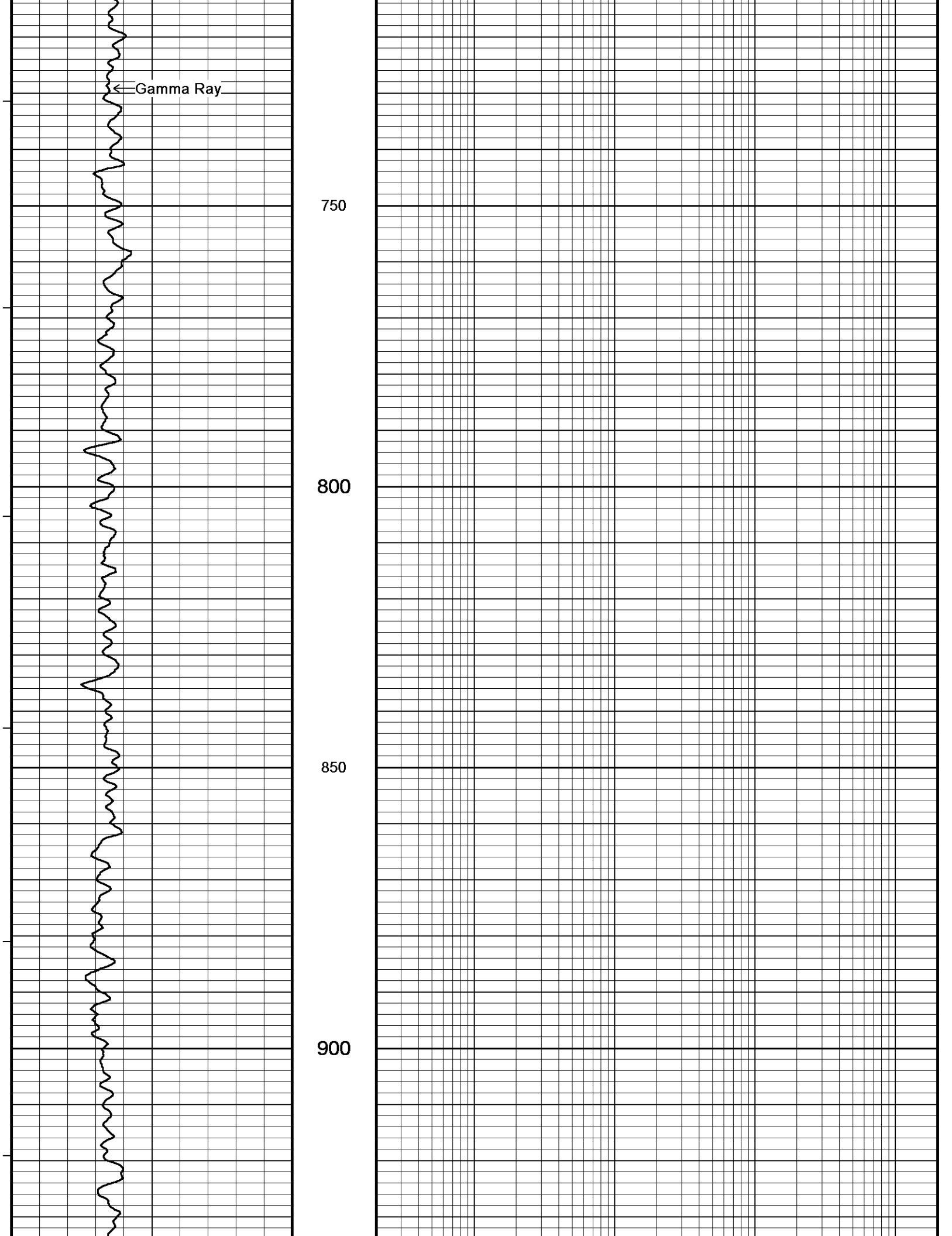
350

400

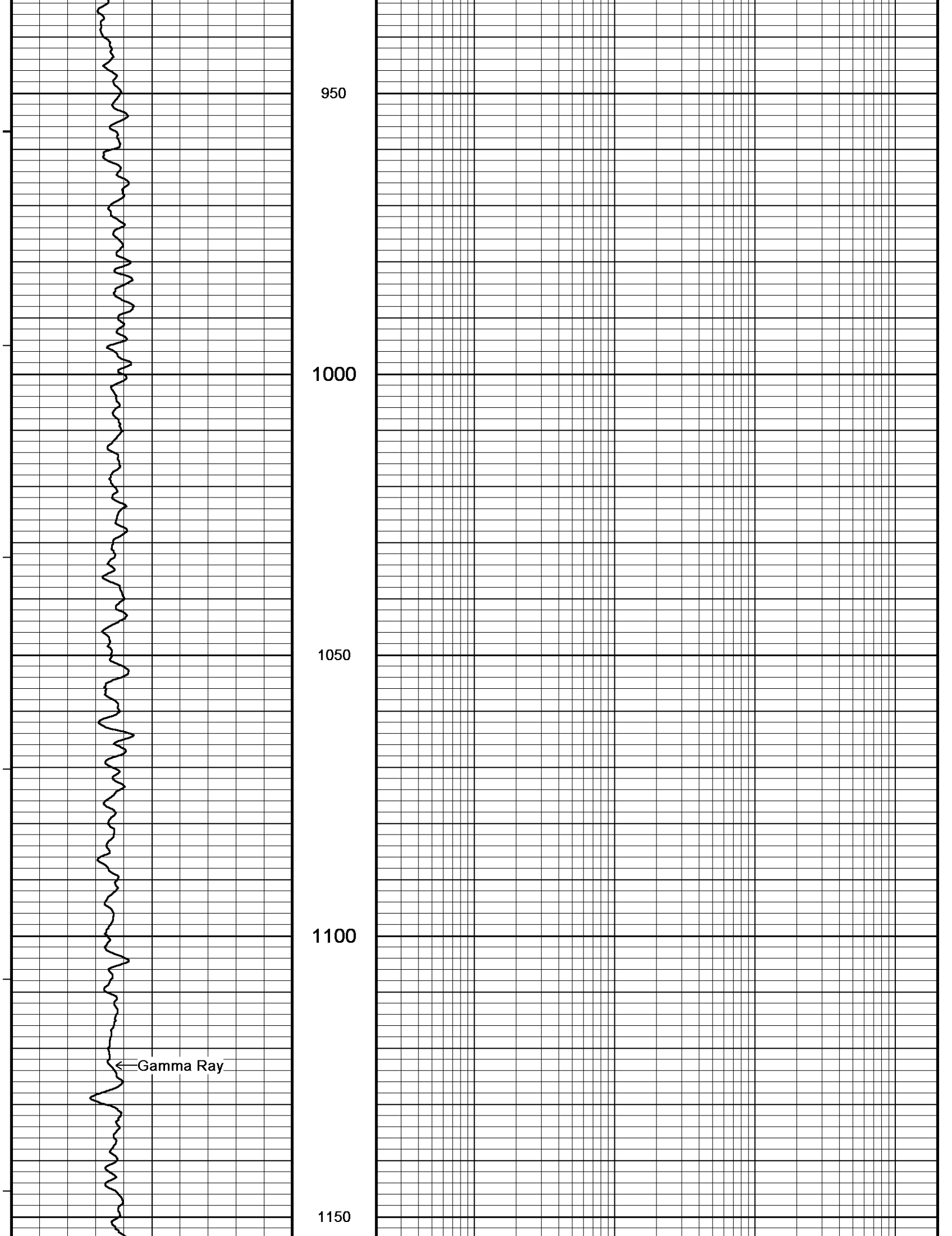
450

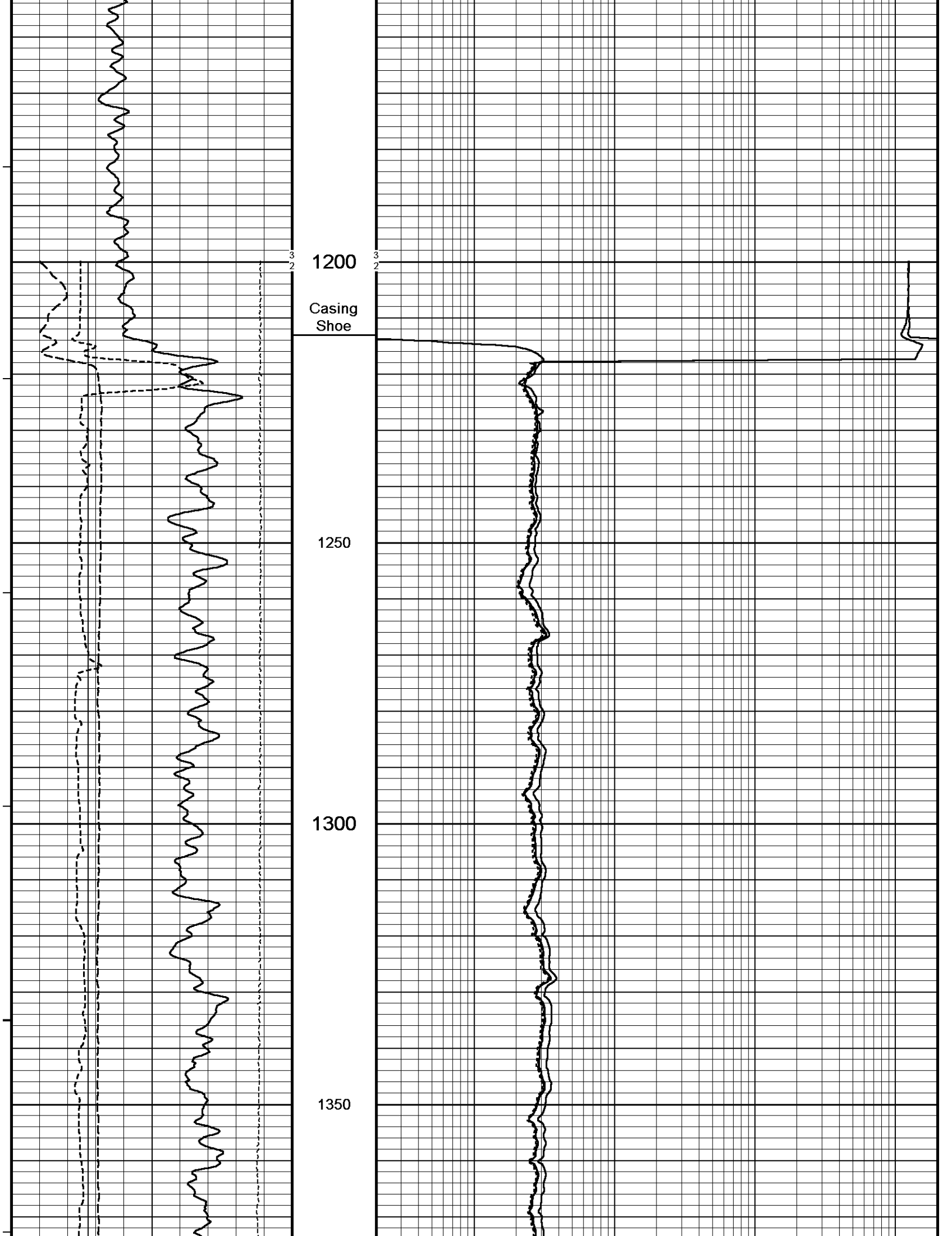
← Gamma Ray

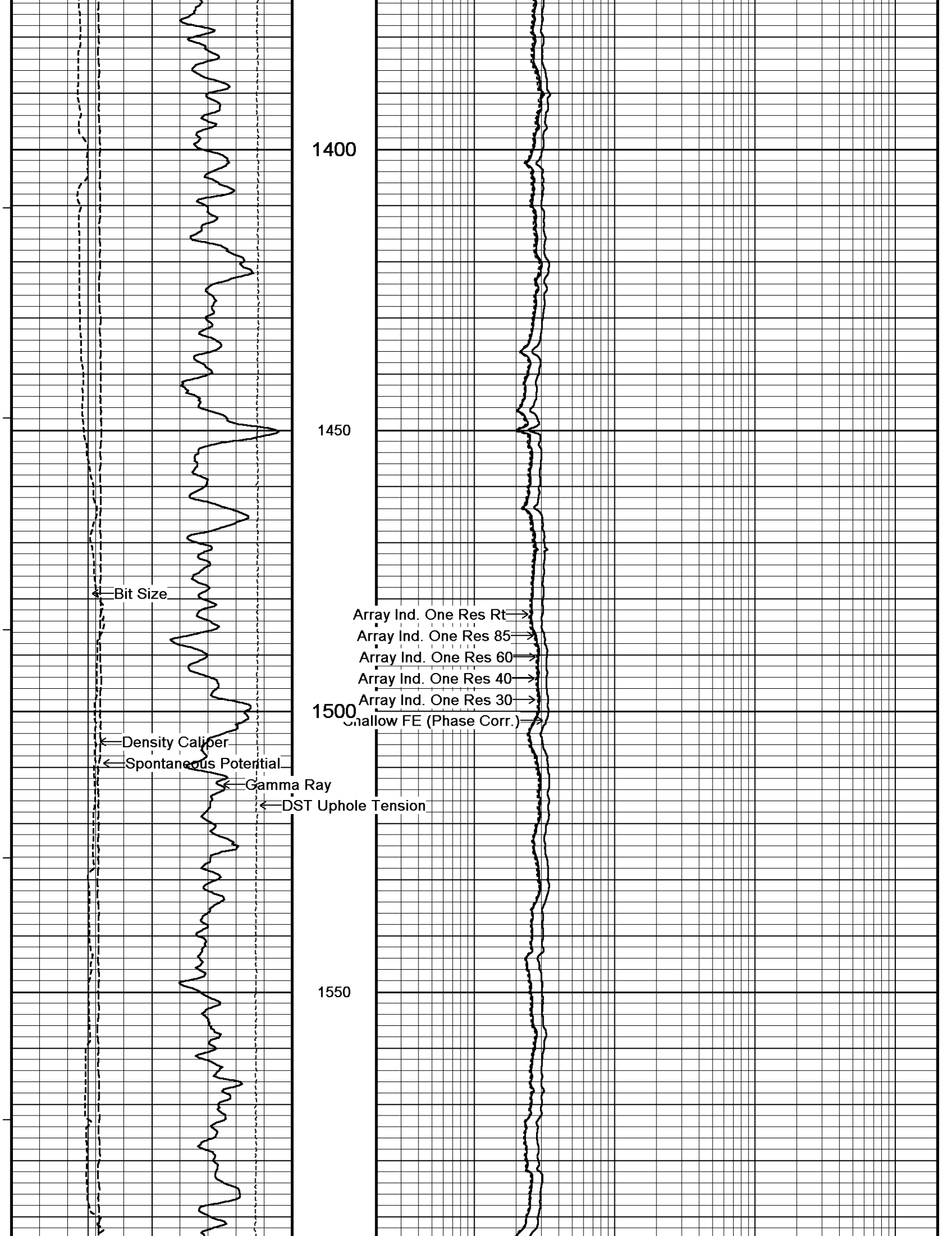


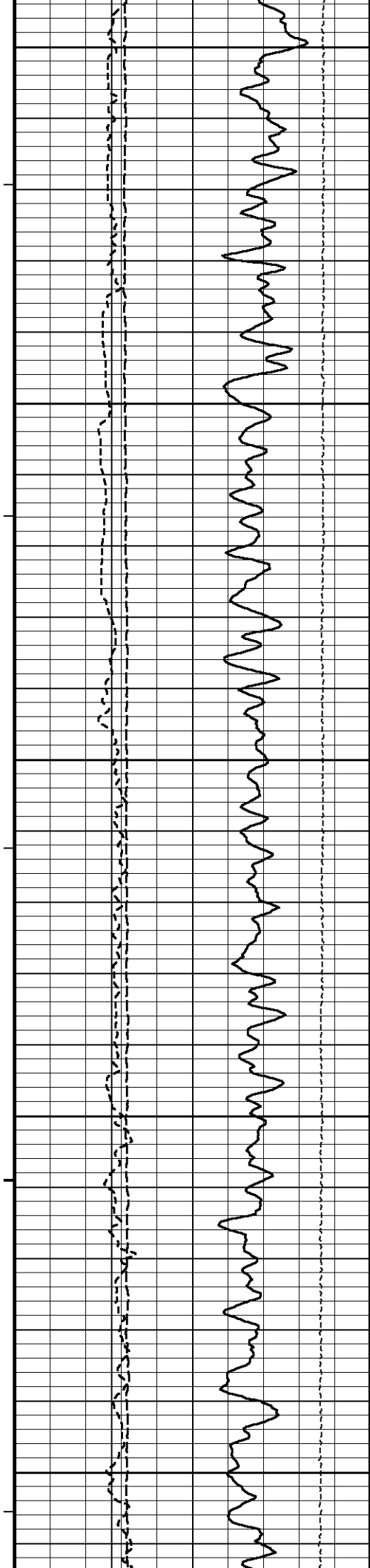












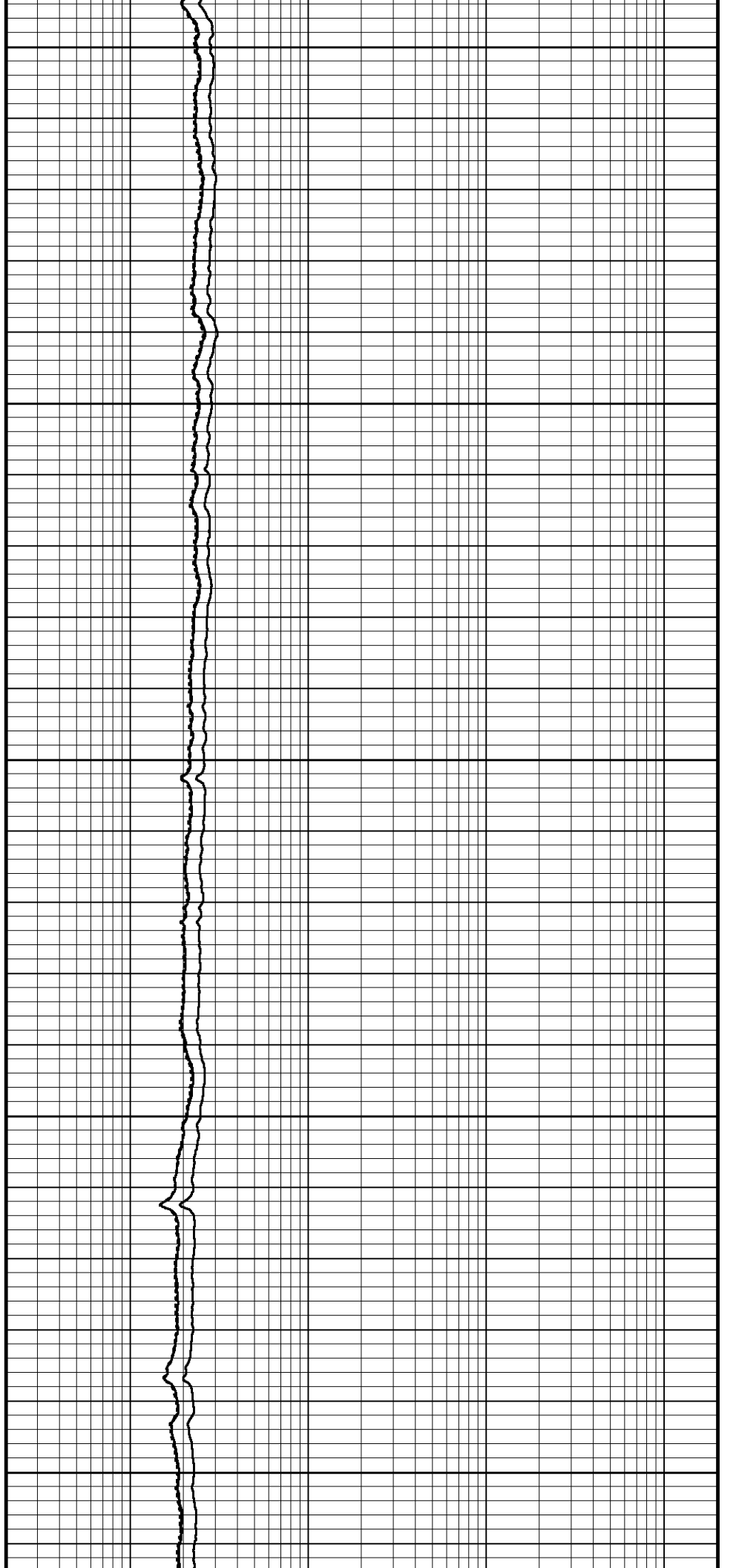
1600

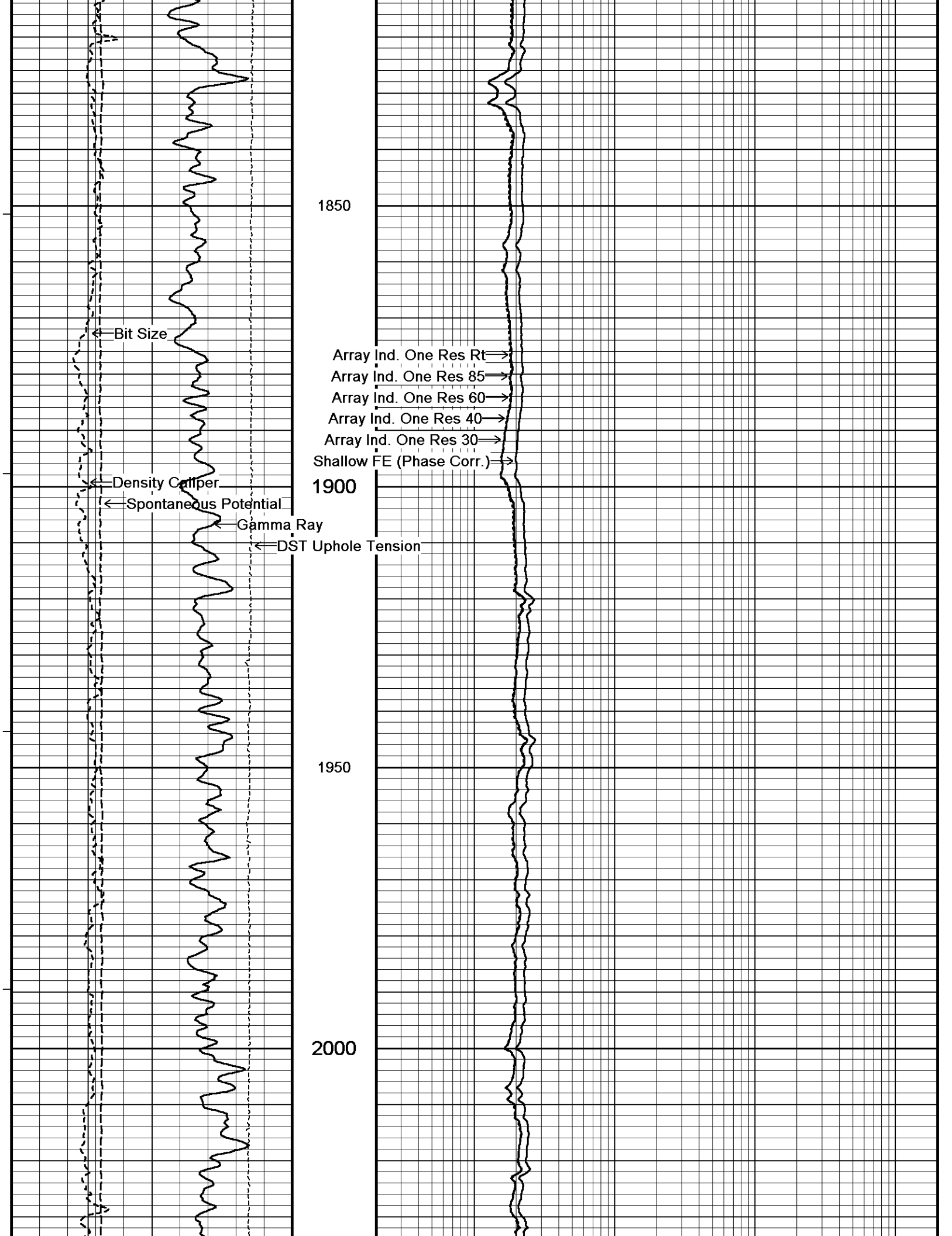
1650

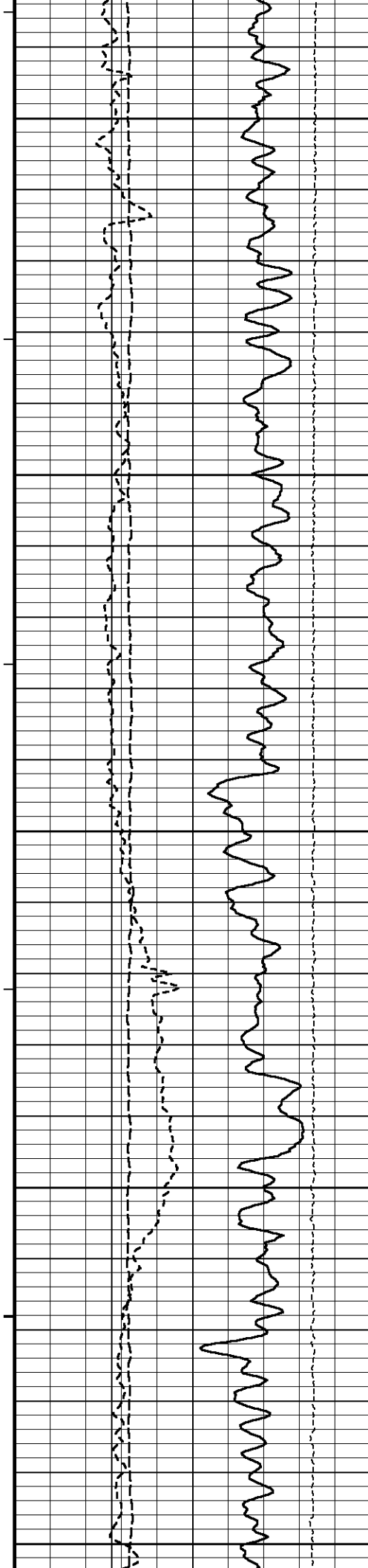
1700

1750

1800







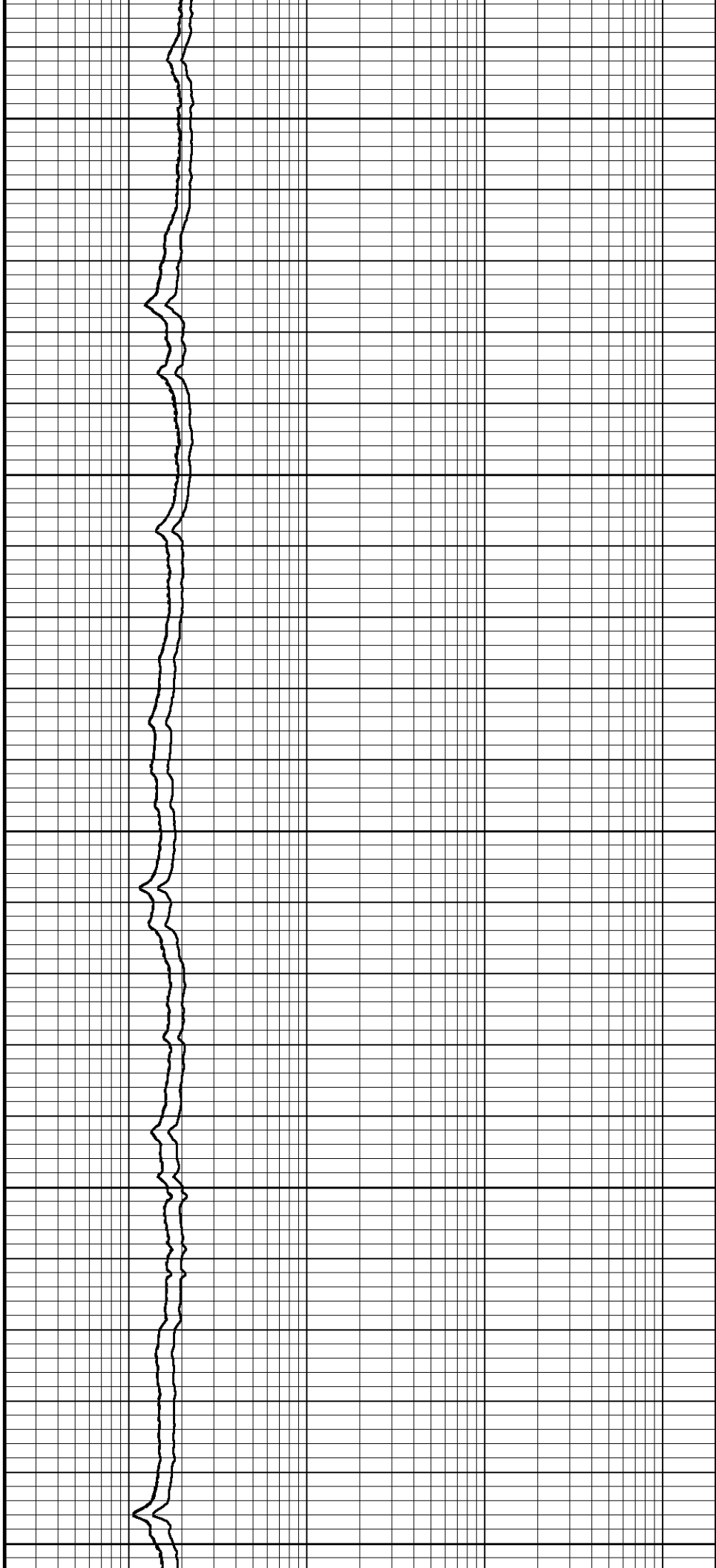
2050

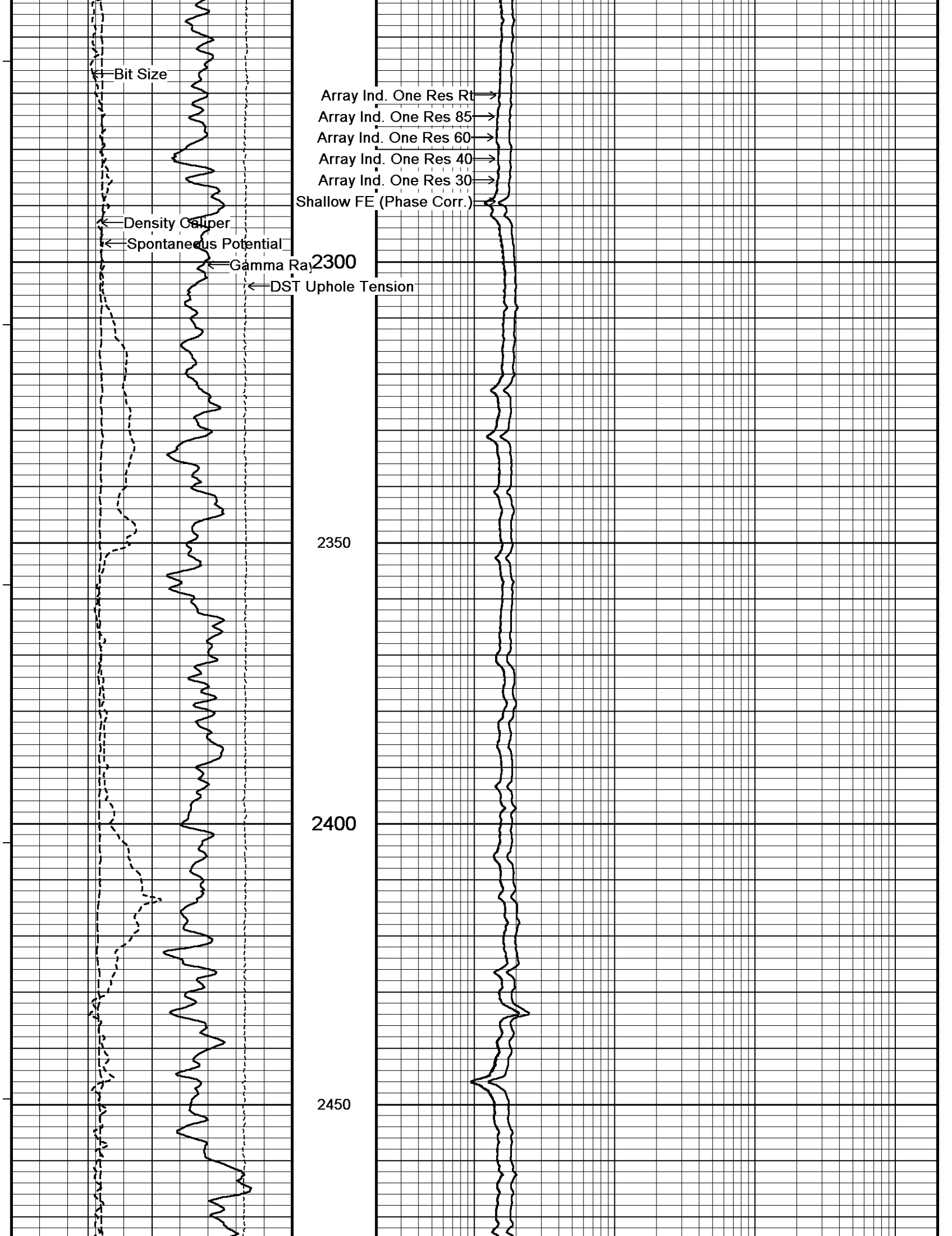
2100

2150

2200

2250







2500

2550

2600

2650

Array Ind. One Res Rt →

Array Ind. One Res 85 →

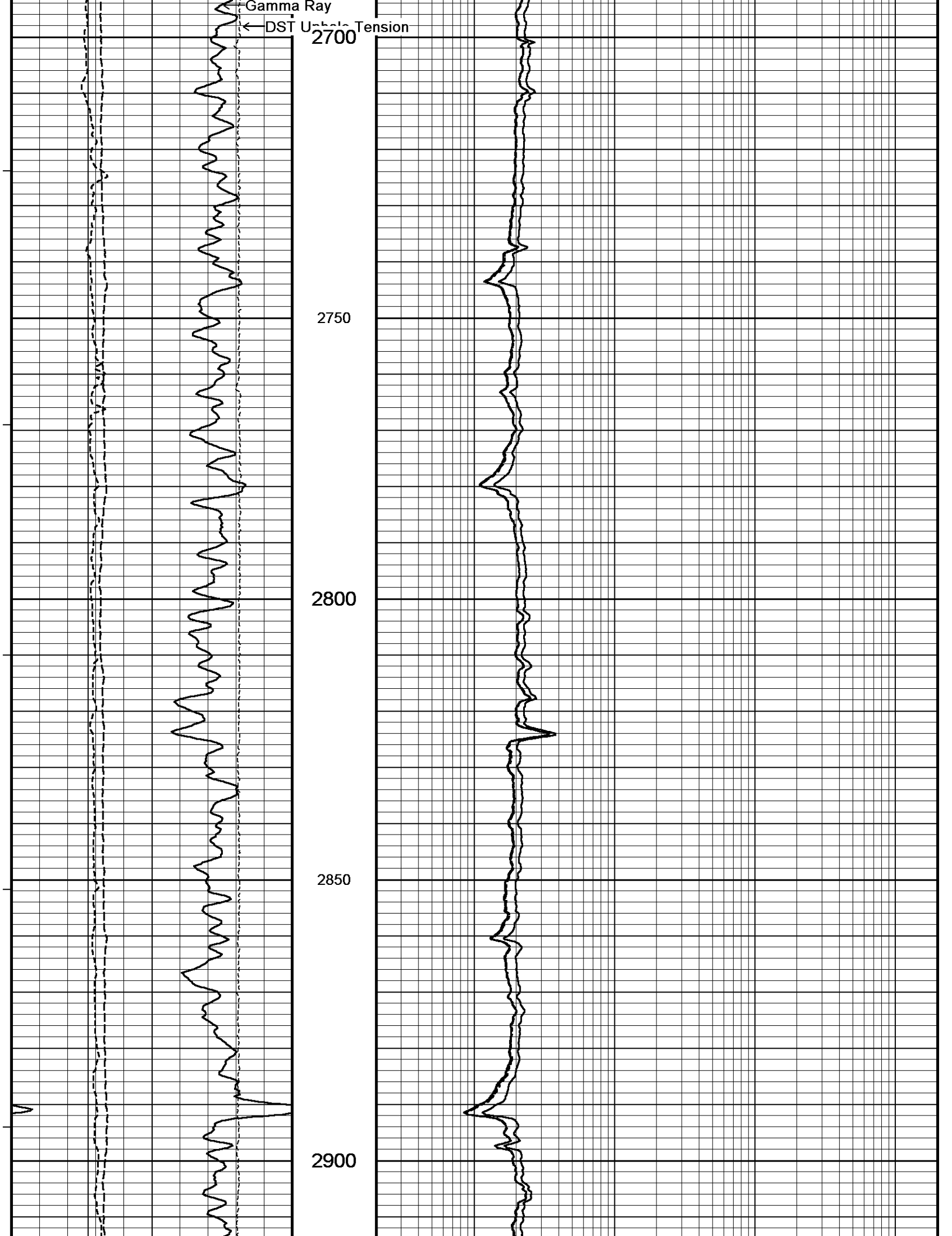
Array Ind. One Res 60 →

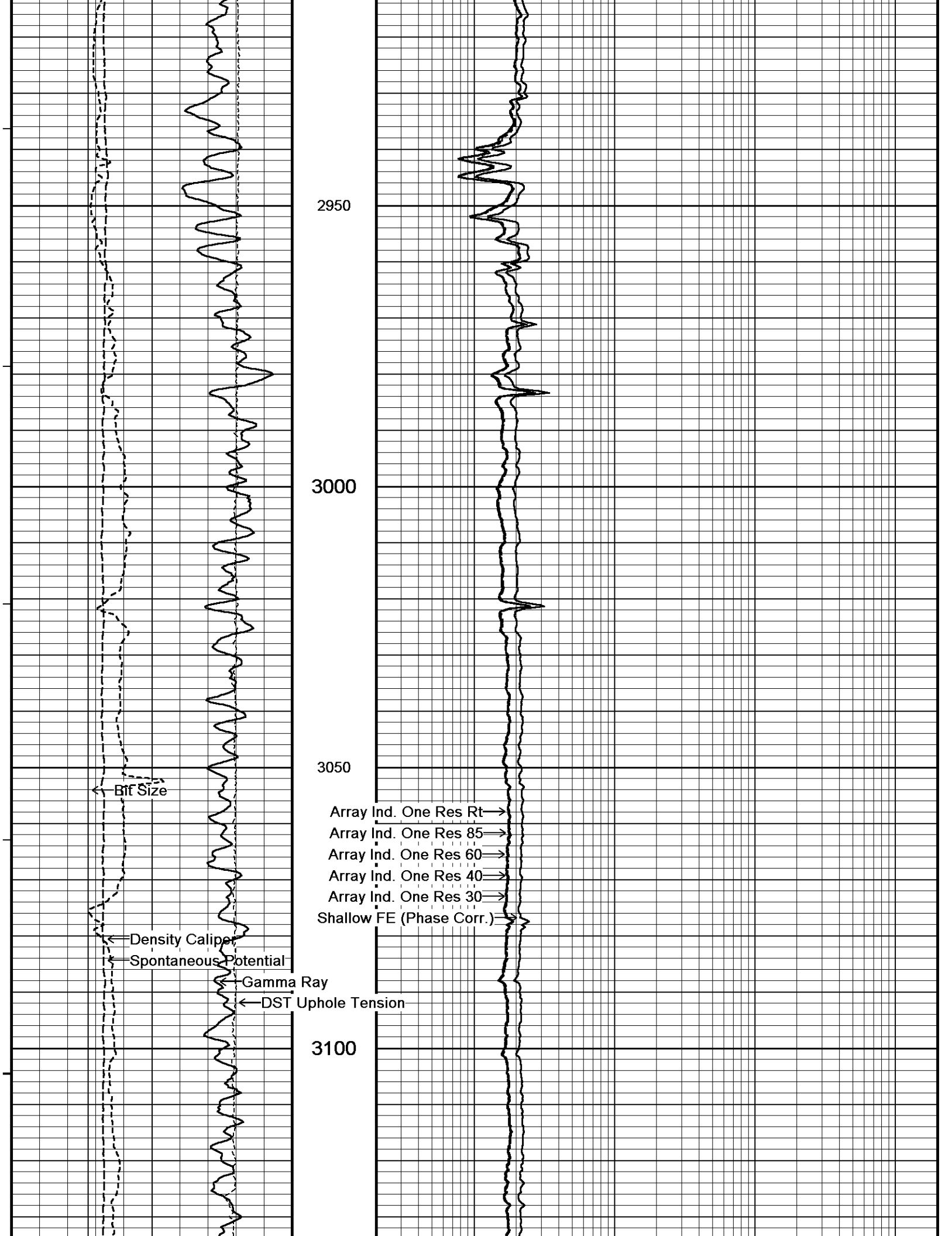
Array Ind. One Res 40 →

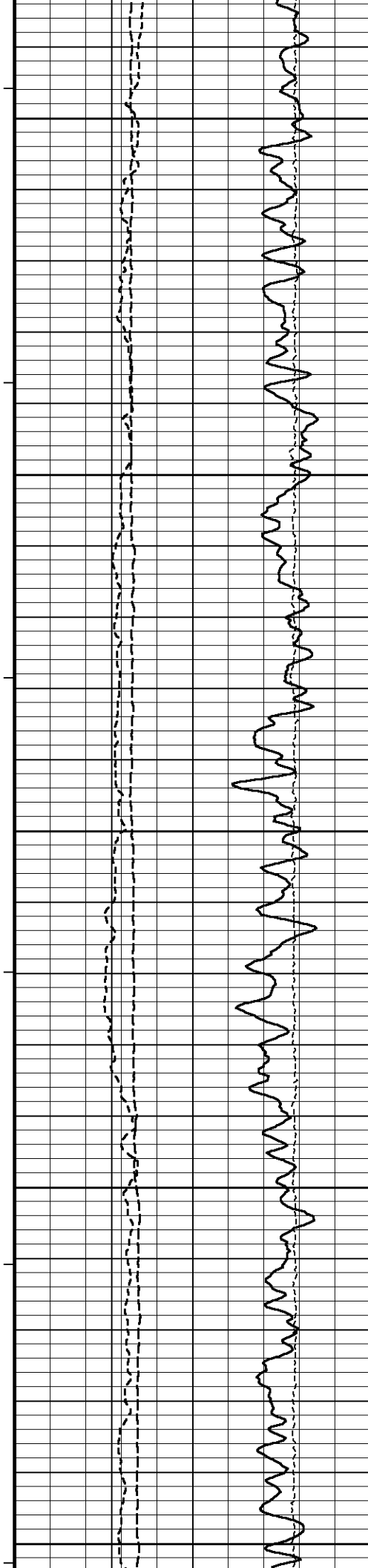
Array Ind. One Res 30 →

Shallow FE (Phase Corr.)









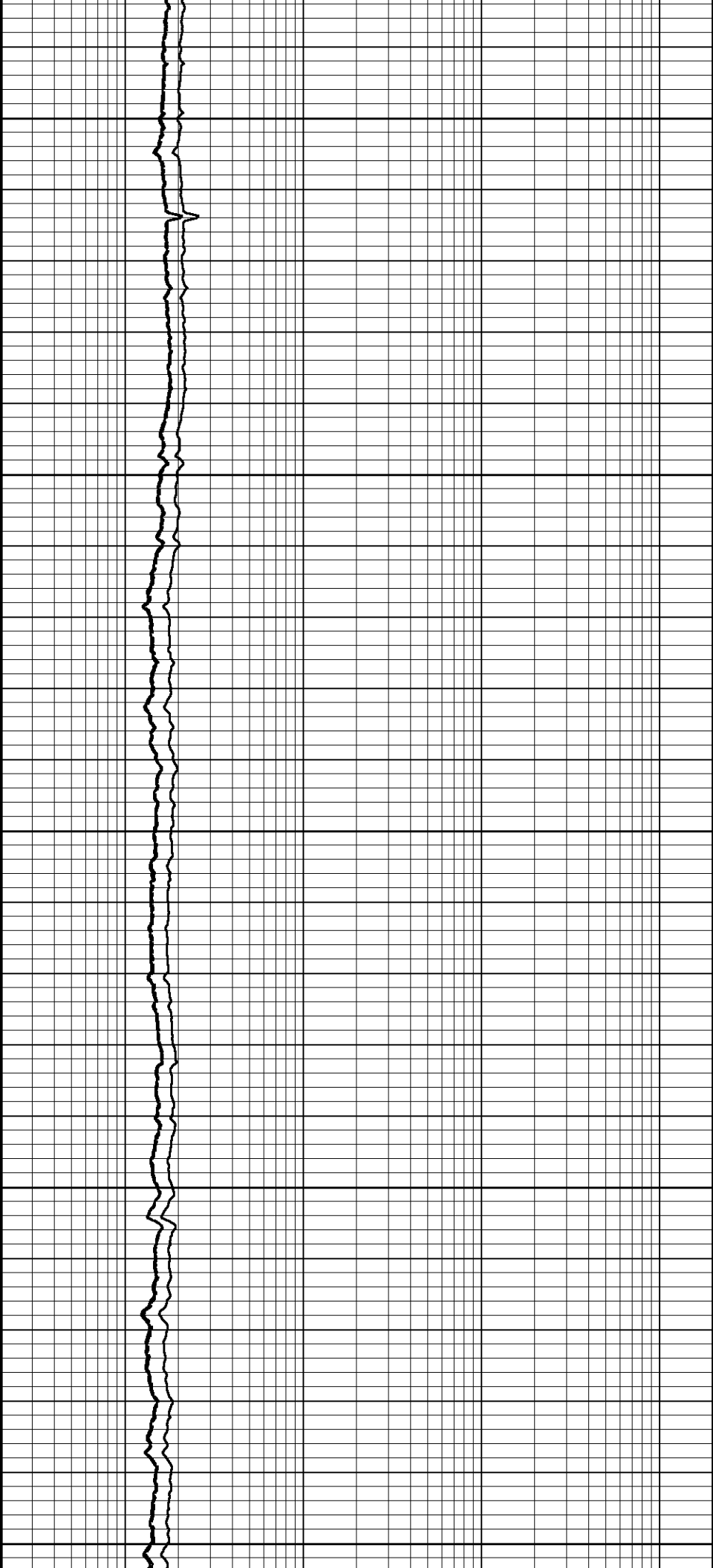
3150

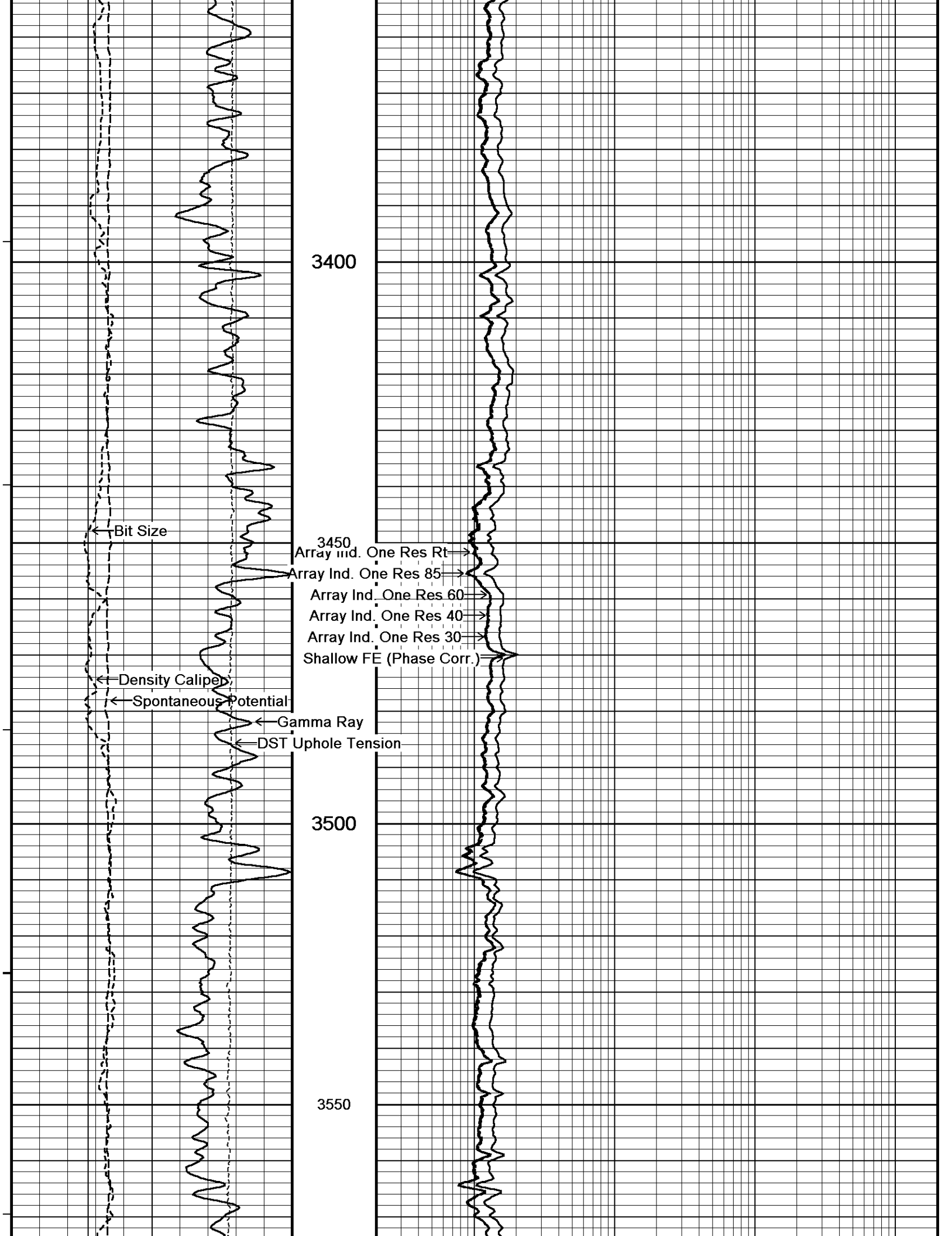
3200

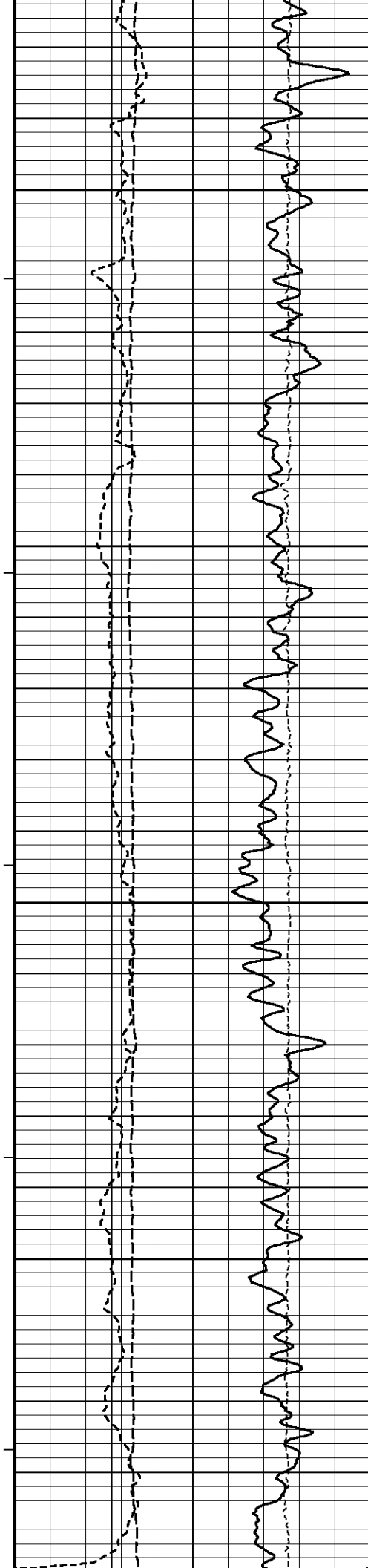
3250

3300

3350





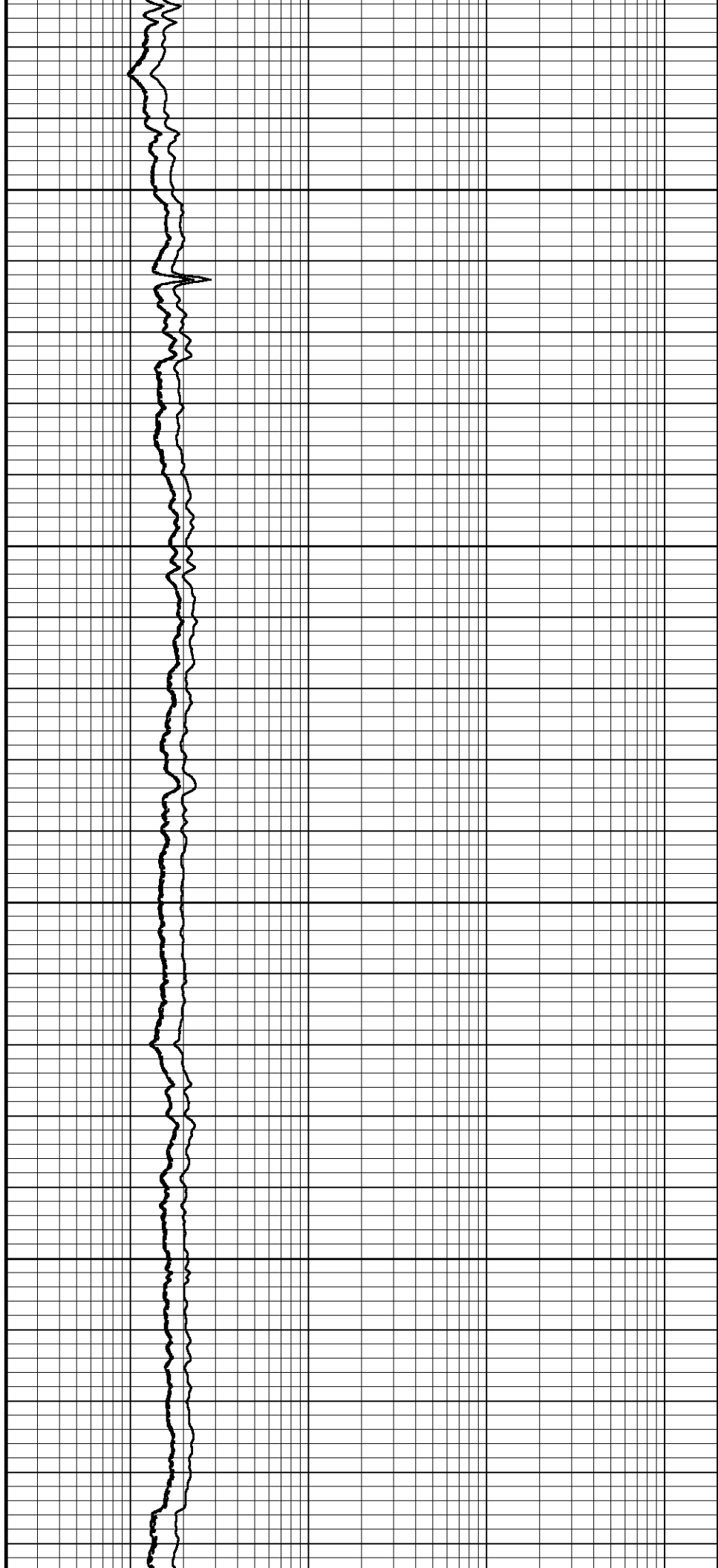


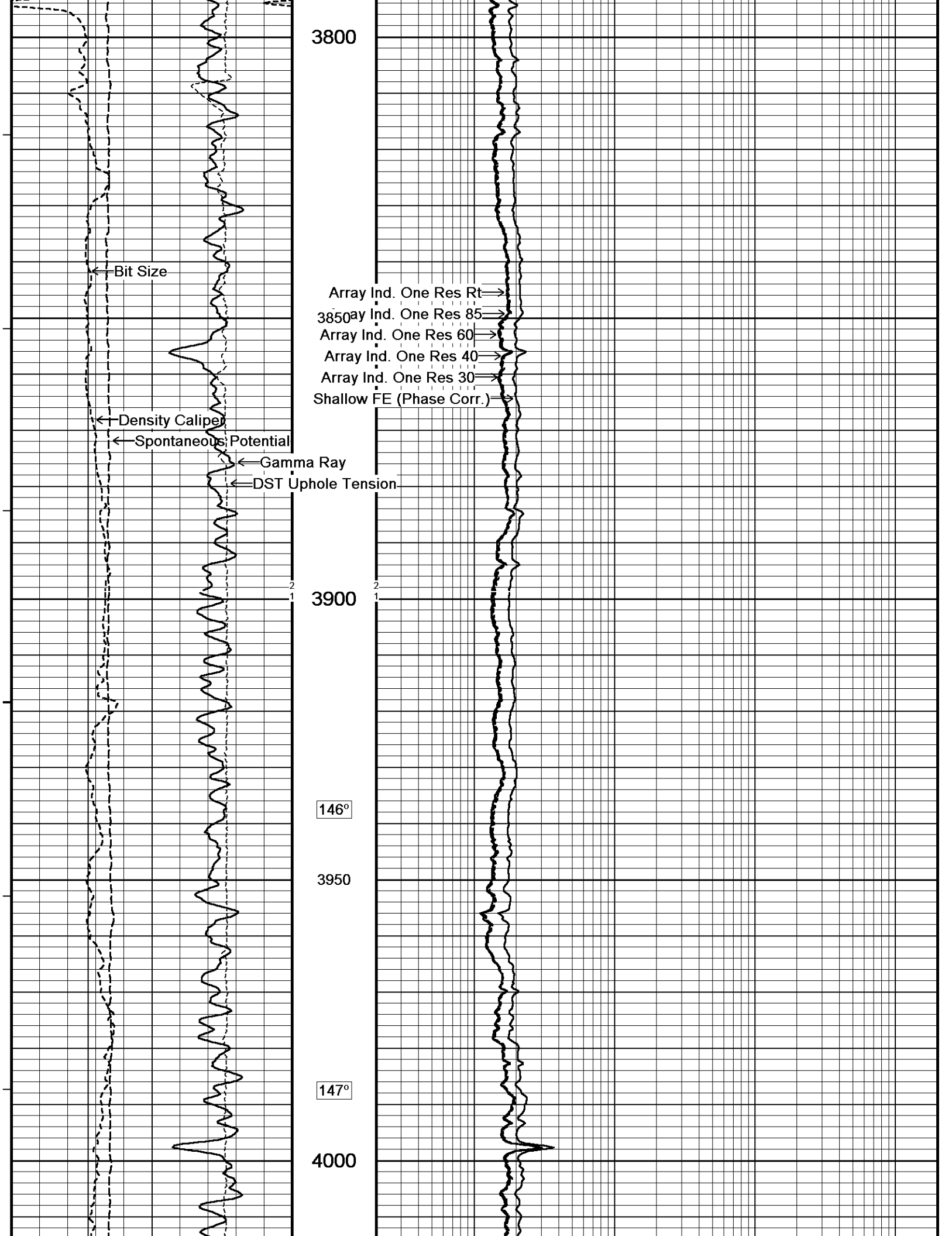
3600

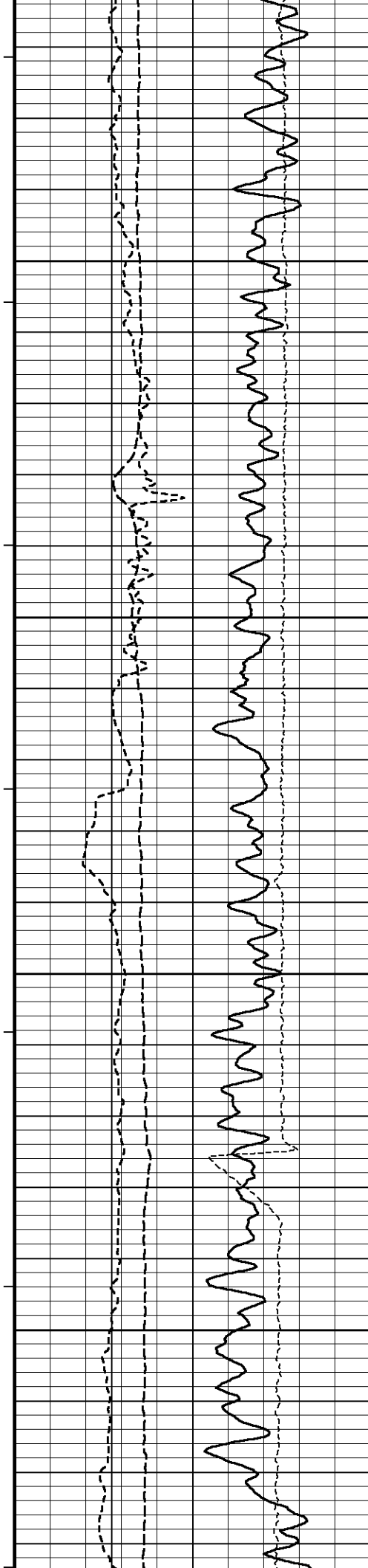
3650

3700

3750







147°

4050

148°

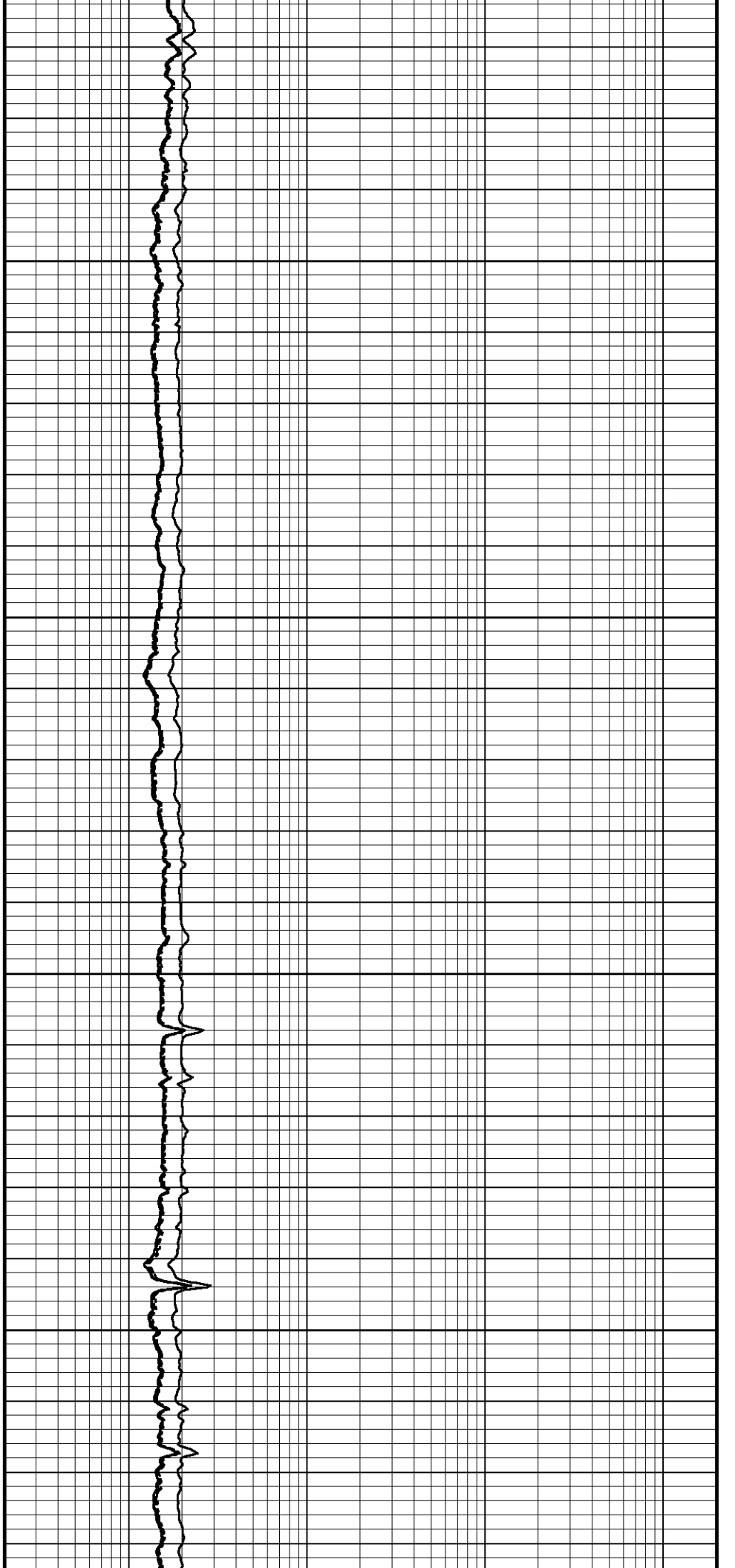
4100

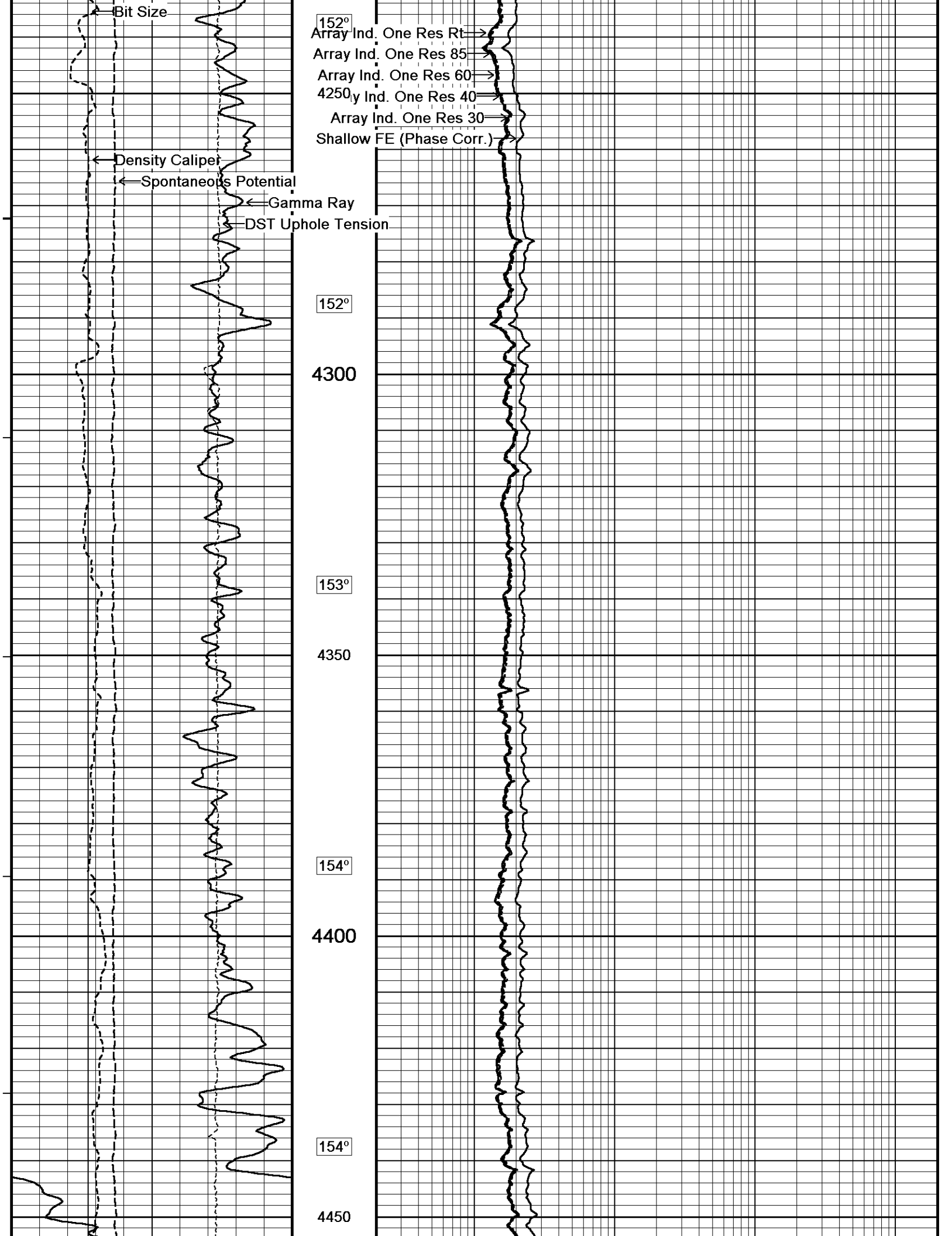
150°

4150

150°

4200





Bit Size

Density Caliper

Spontaneous Potential

Gamma Ray

DST Uphole Tension

152°

Array Ind. One Res Rt

Array Ind. One Res 85

Array Ind. One Res 60

4250y Ind. One Res 40

Array Ind. One Res 30

Shallow FE (Phase Corr.)

152°

4300

153°

4350

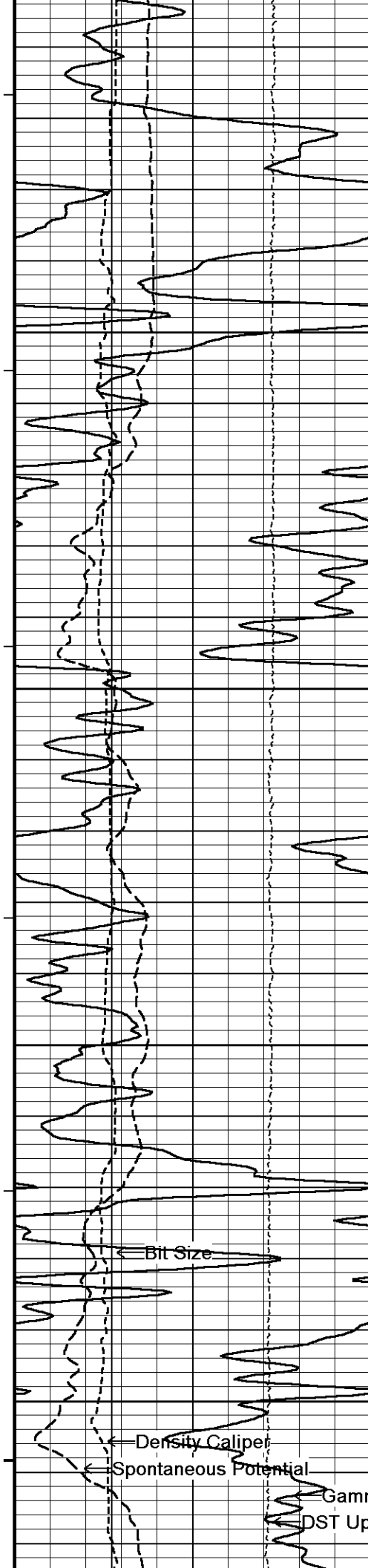
154°

4400

154°

4450





155°

4500

156°

4550

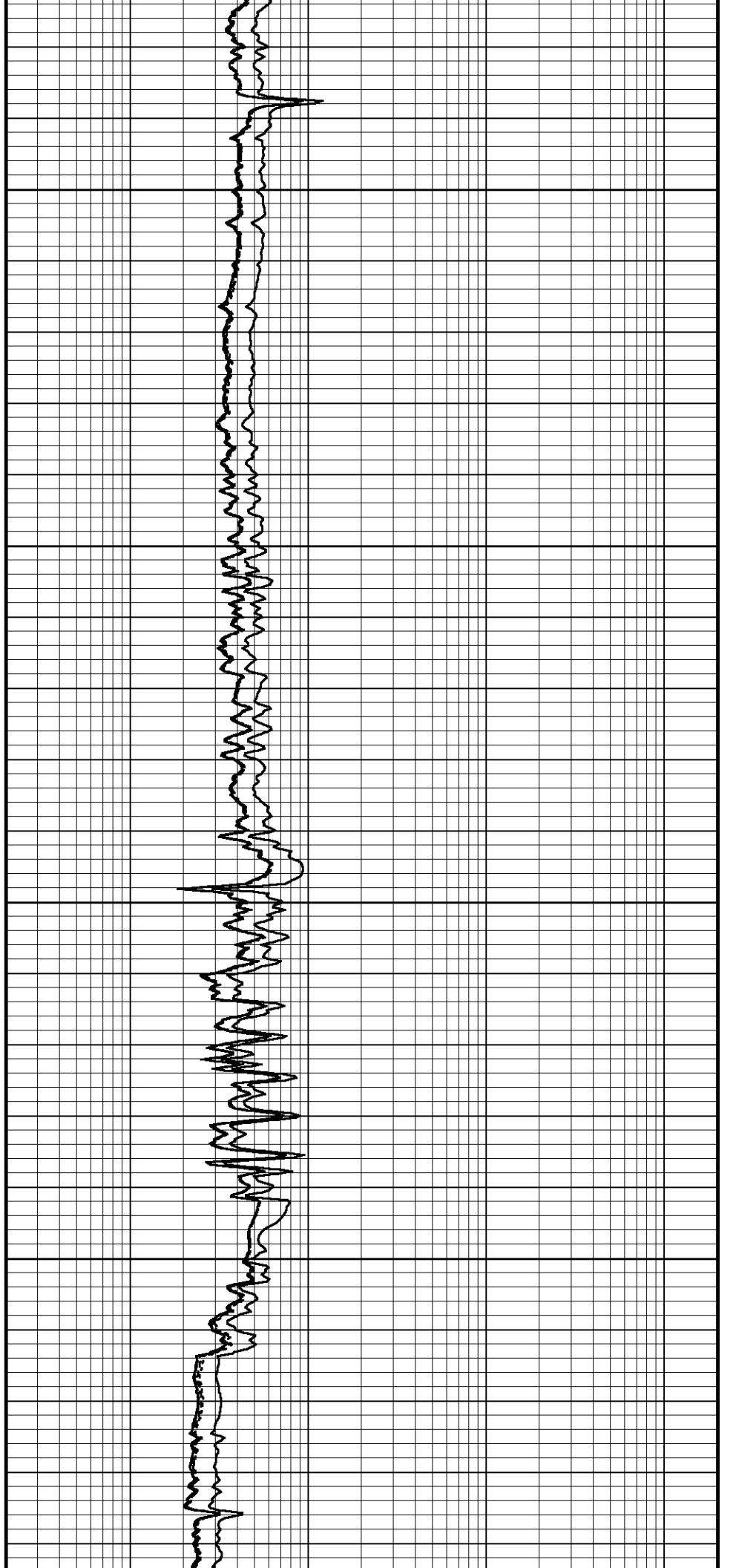
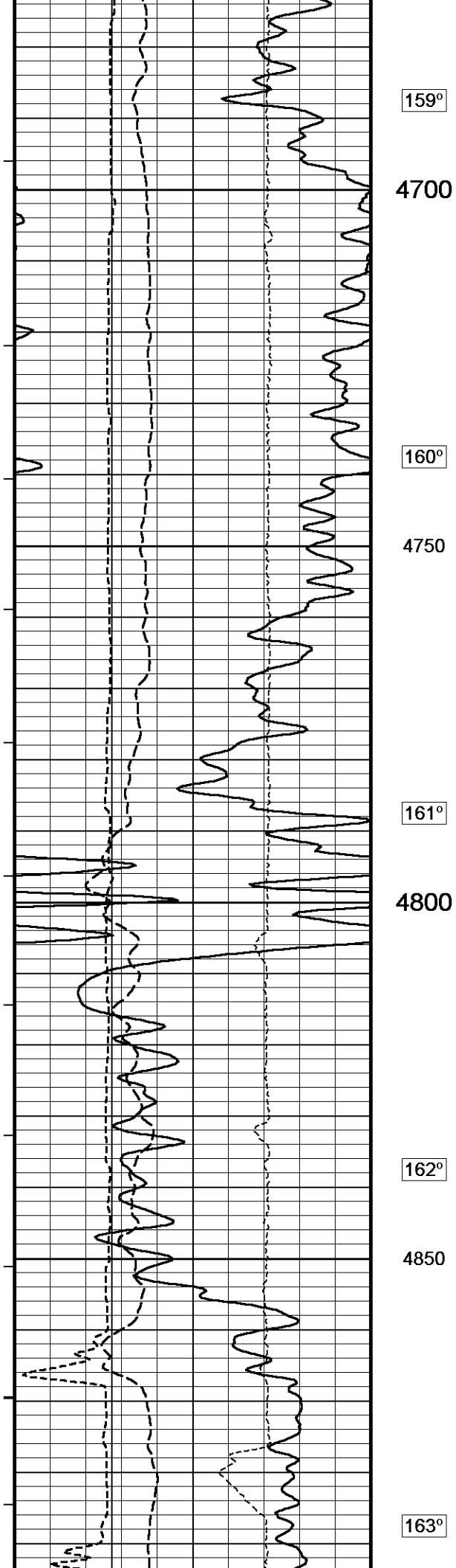
157°

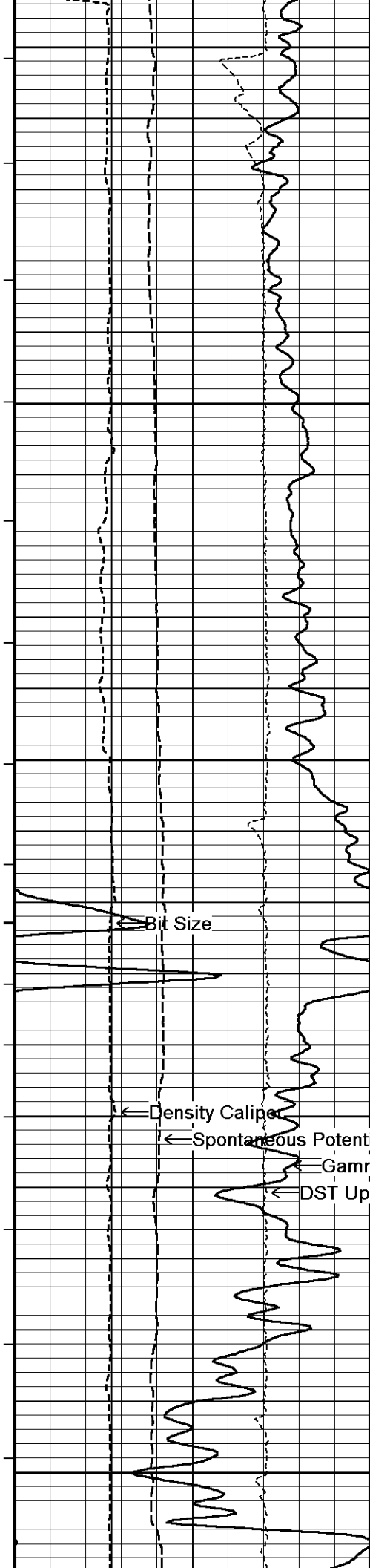
4600

158°

4650

Array Ind. One Res Rt  
Array Ind. One Res 85  
Array Ind. One Res 60  
Array Ind. One Res 40  
Array Ind. One Res 30  
Shallow FE (Phase Corr.)





4900

163°

4950

164°

5000

← Bit Size

← Density Caliper

← Spontaneous Potential

← Gamma Ray

← DST Uphole Tension

Array Ind. One Res Rt →

Array Ind. One Res 85 →

Array Ind. One Res 60 →

165° Array Ind. One Res 40 →

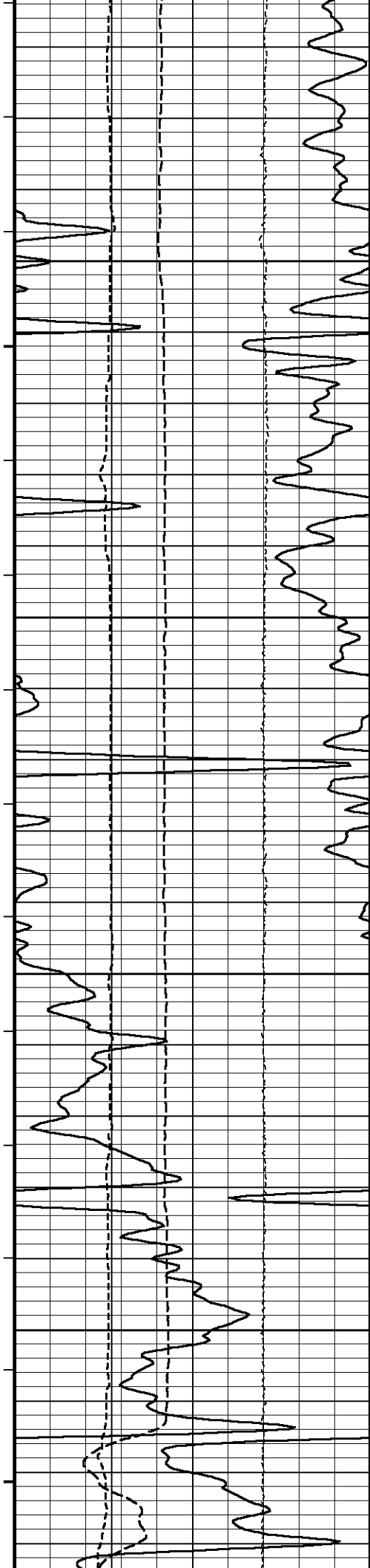
Array Ind. One Res 30 →

Shallow FE (Phase Corr.) →

5050

165°

5100



166°

5150

166°

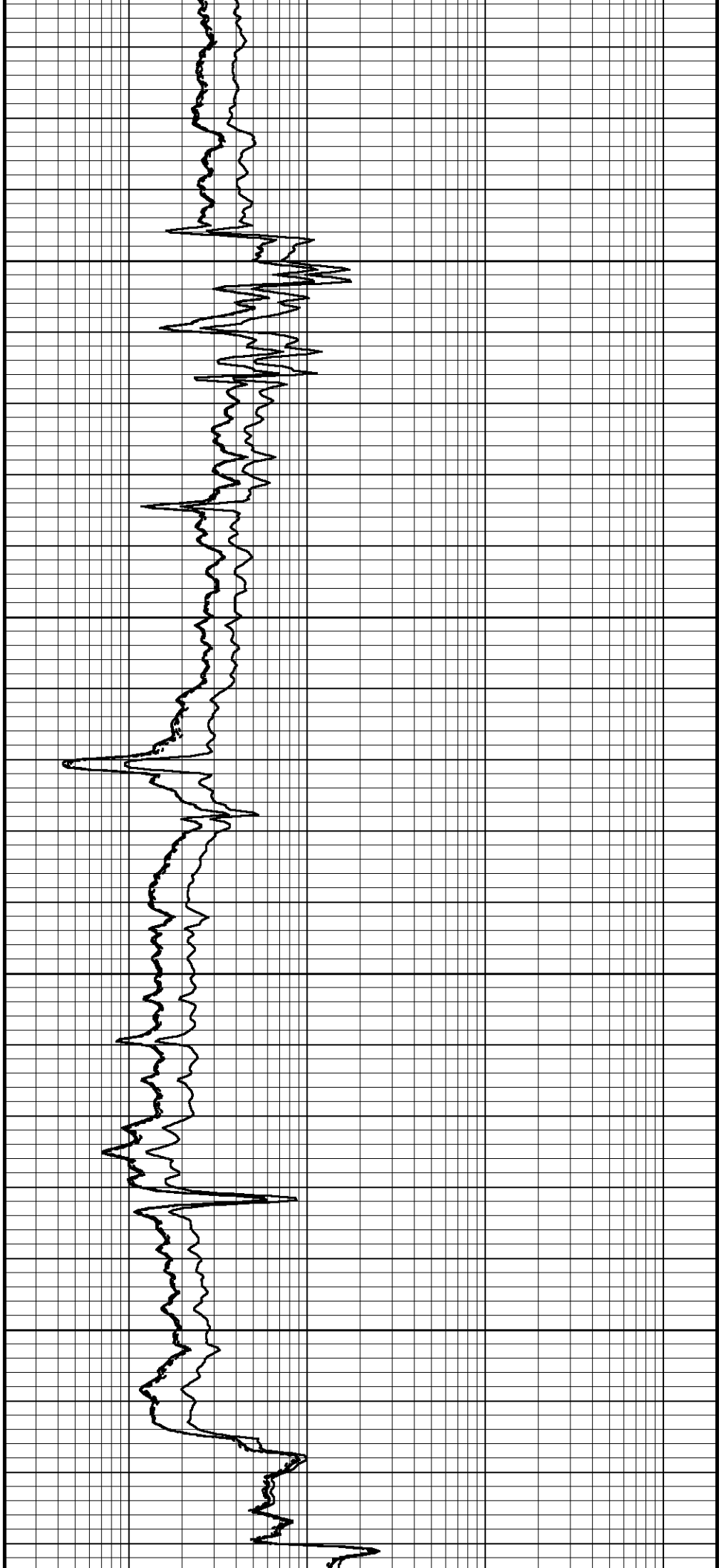
5200

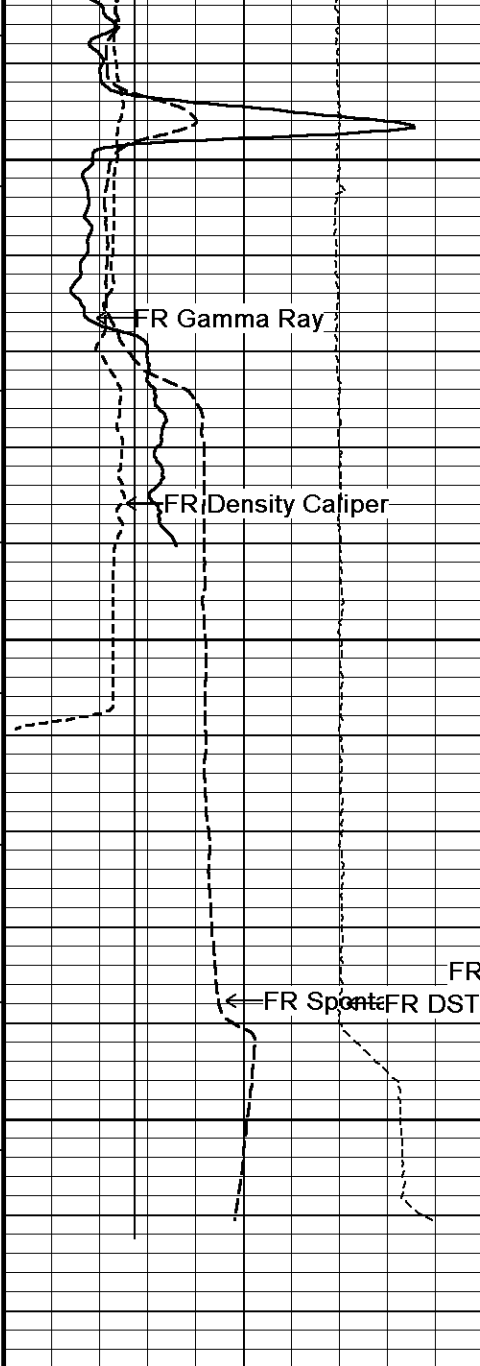
167°

5250

169°

5300





170°

5350

169°

5400 allow FE (Phase Corr.)

5450

Depth  
In  
Feet

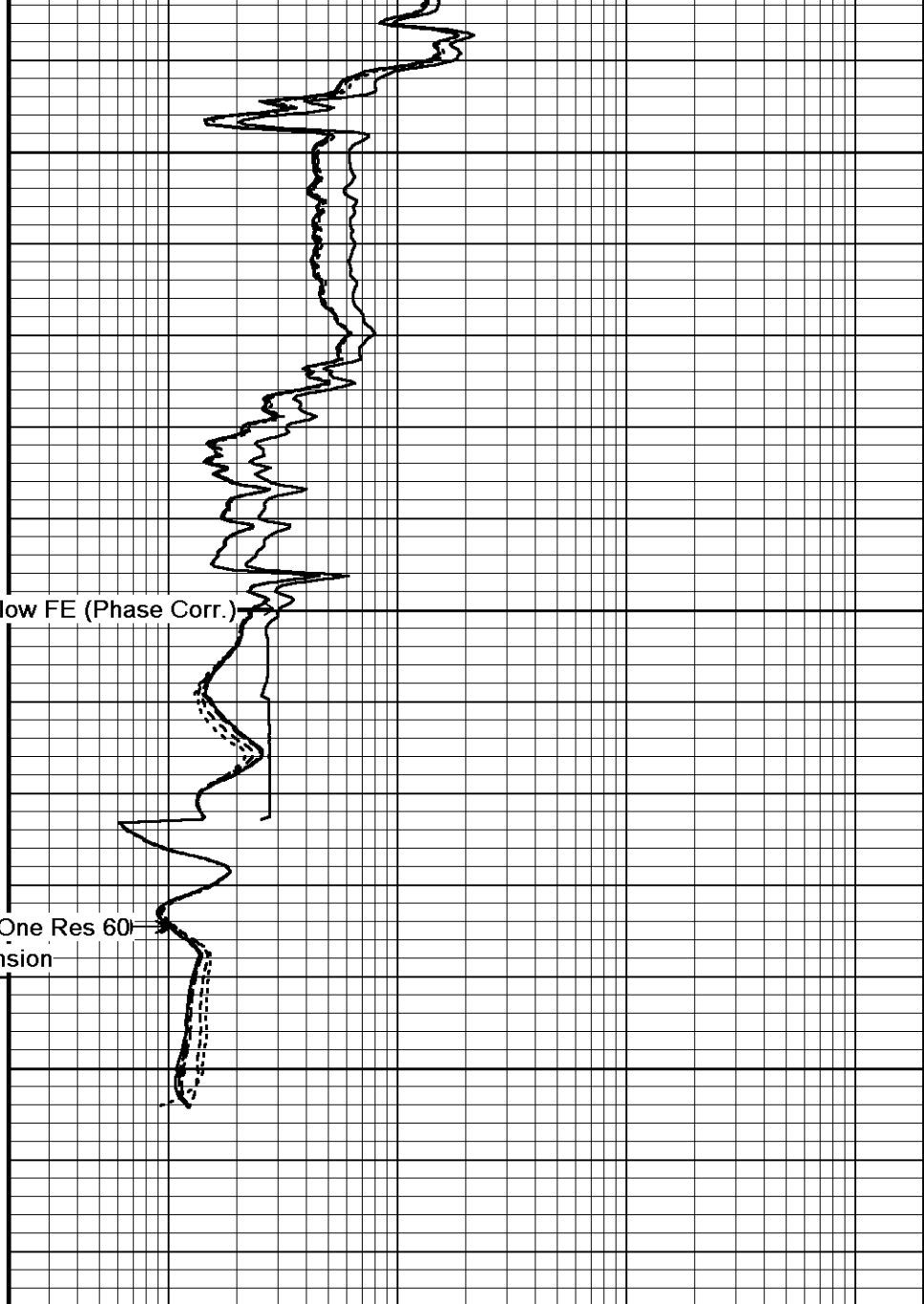
Timing Marks  
every 60.0 sec

DST Uphole Tension  
pounds  
10000 5000 0  
0 -5000 -10000

Gamma Ray  
API  
0 75 150

Spontaneous Potential  
millivolts  
- - - - - 20 - - - - - +

Borehole  
Temp in  
deg F

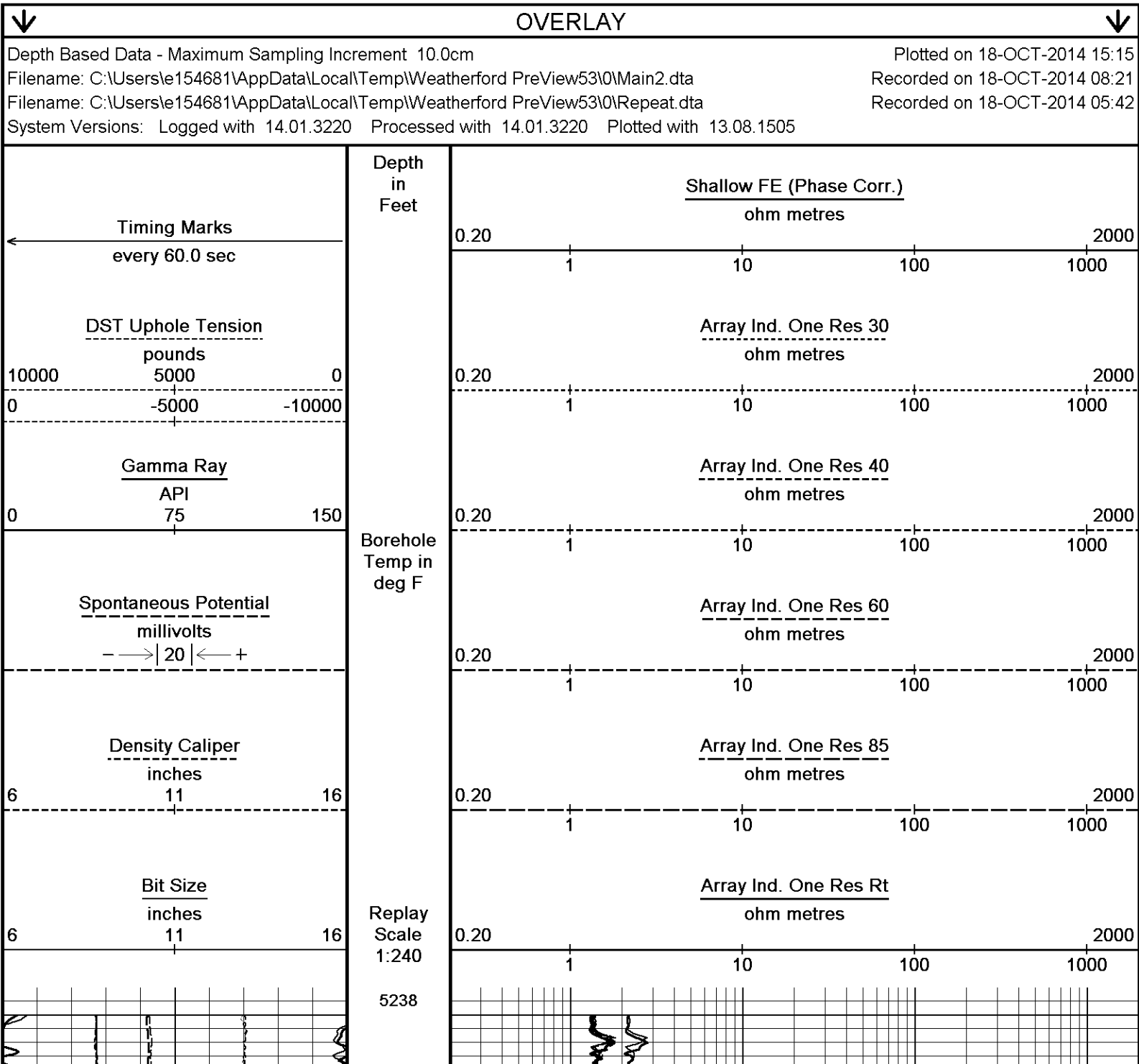
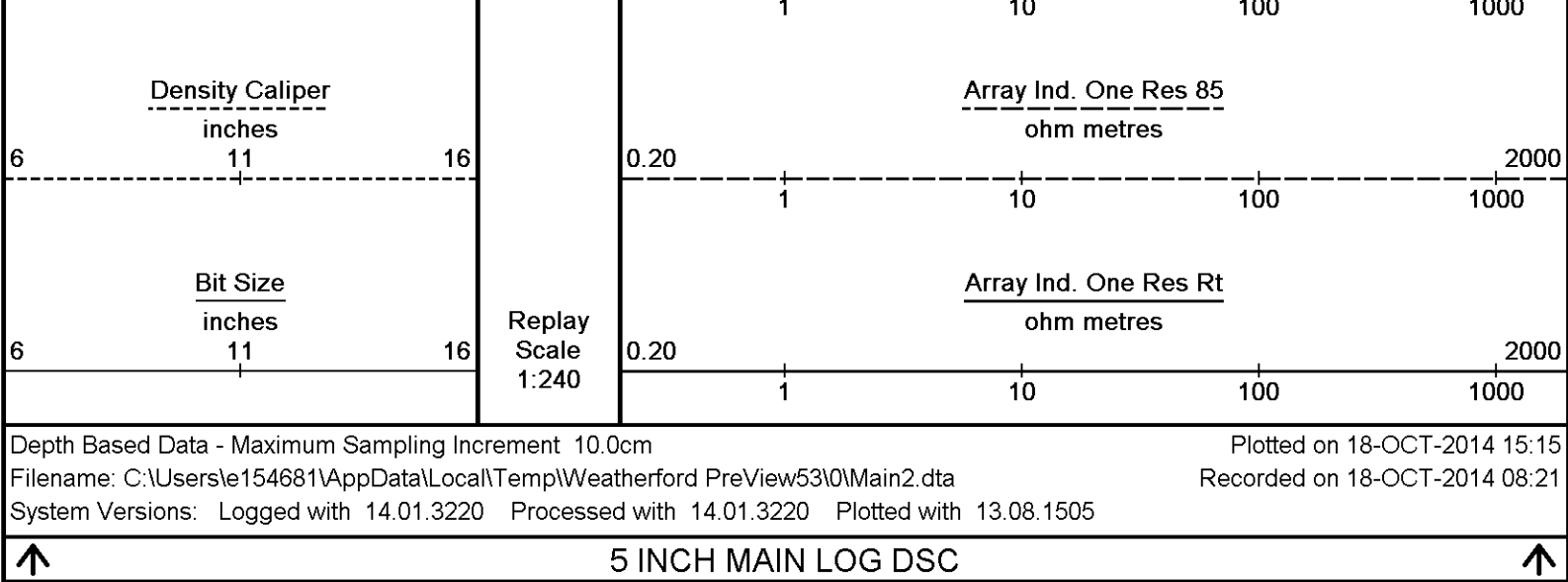


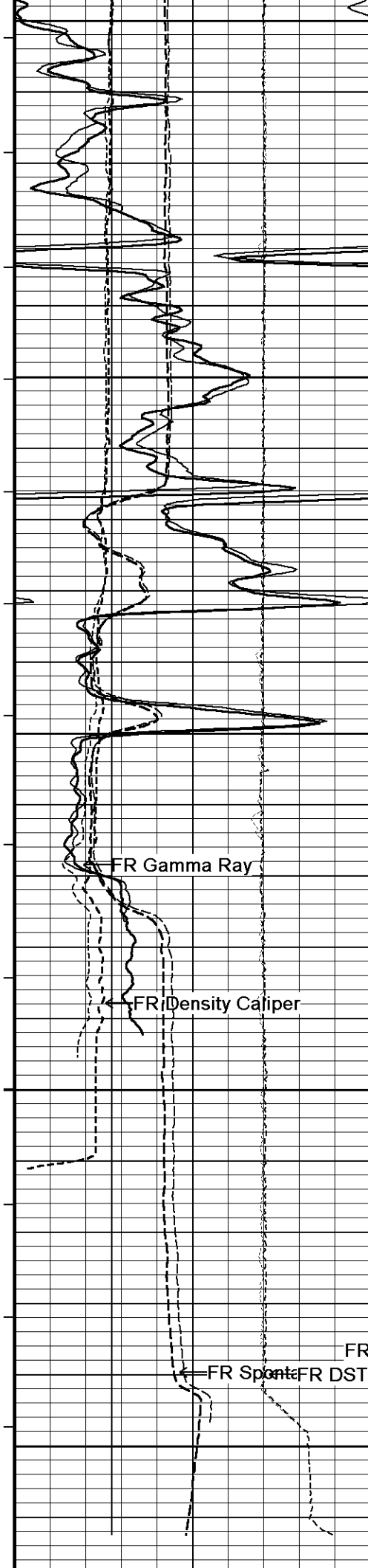
0.20 1 10 100 1000 2000

0.20 1 10 100 1000 2000

0.20 1 10 100 1000 2000

0.20 1 10 100 1000 2000





5250

169°

5300

170°

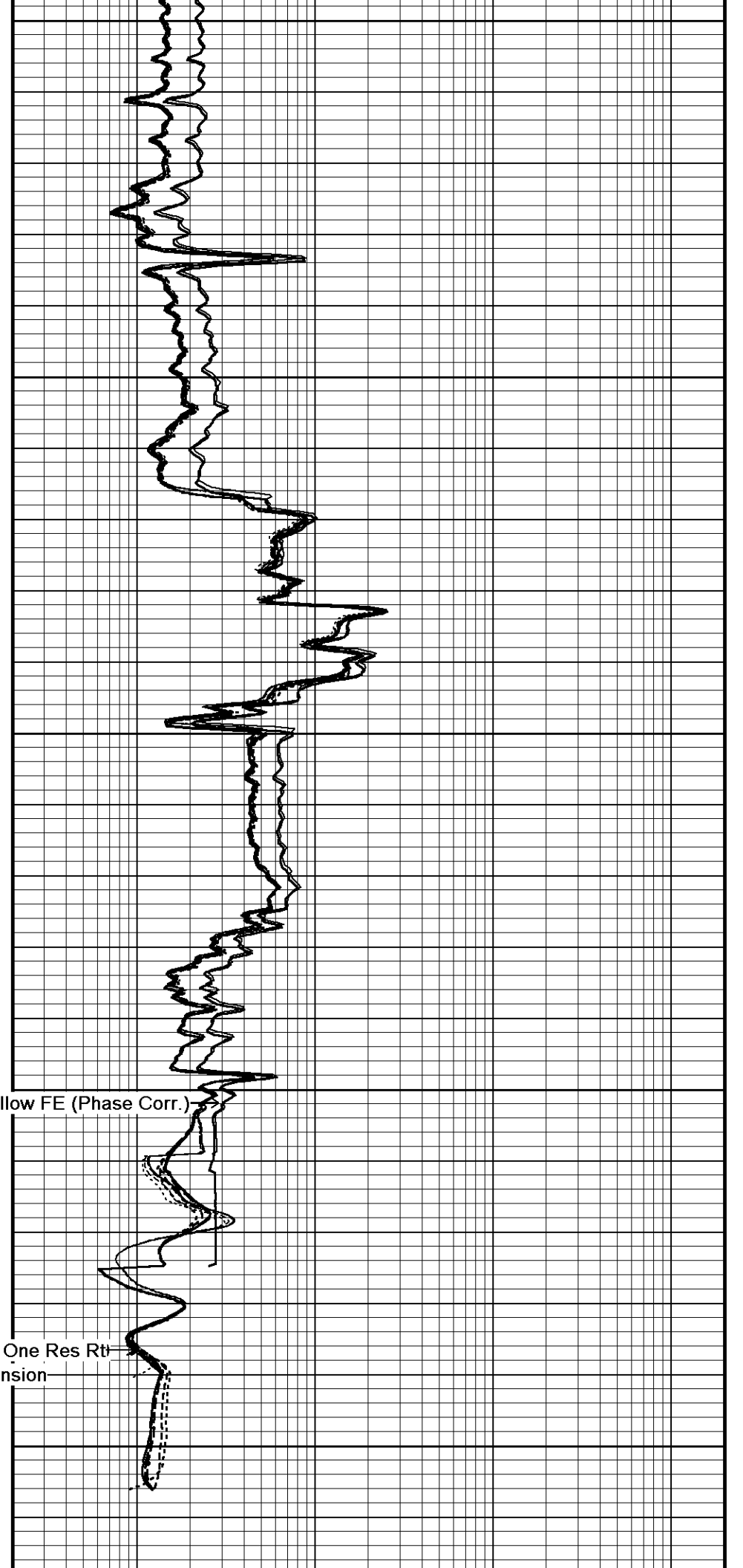
5350

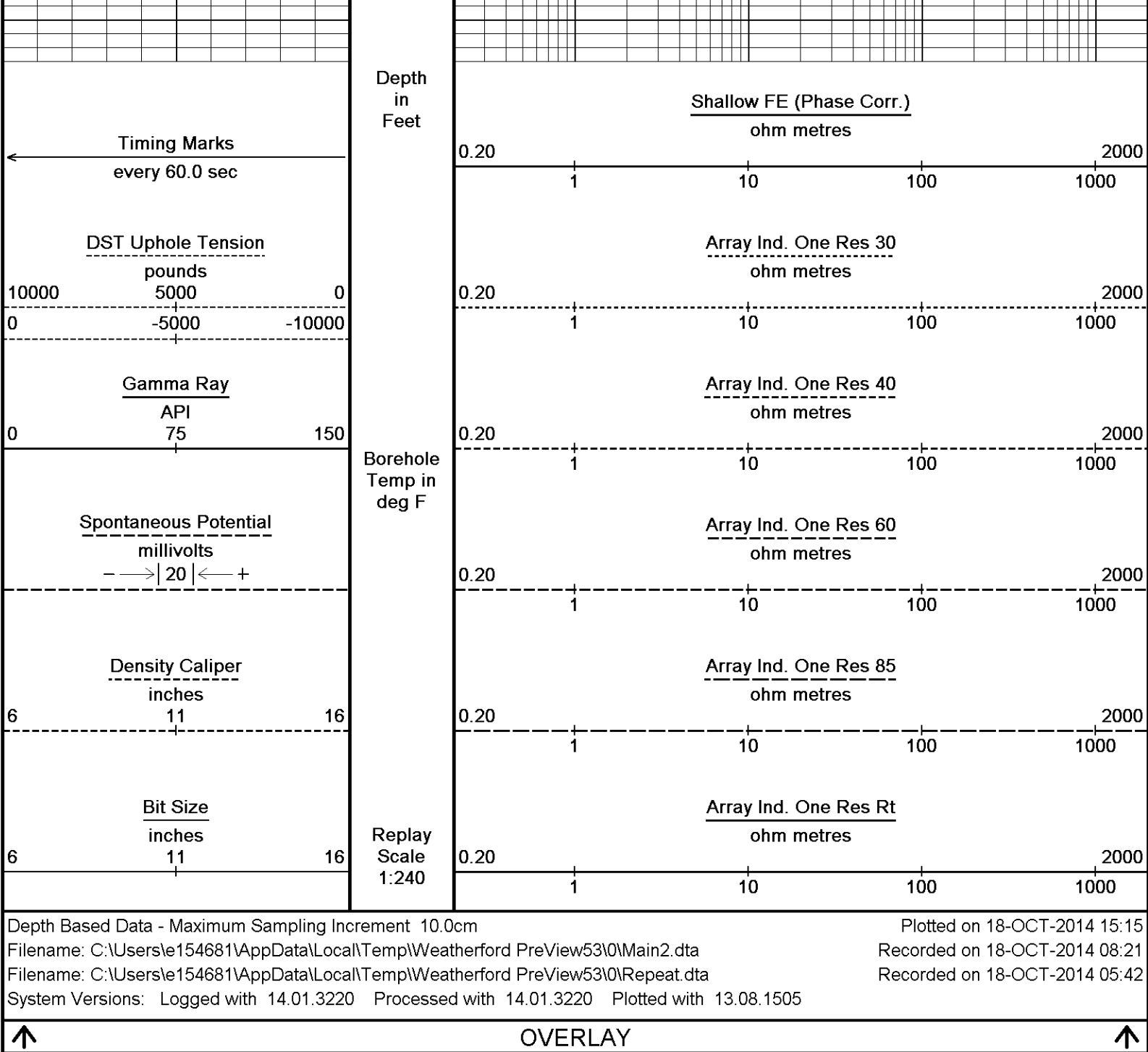
169°

5400

FR Array Ind. One Res Rt

5450





BEFORE SURVEY CALIBRATION		
C:\Users\le154681\AppData\Local\Temp\Weatherford PreView53\0\Main2.dta		
General Constants All 000		Last Edited on 18-OCT-2014,09:49
General Parameters		
Mud Resistivity	2.210	ohm-metres
Mud Resistivity Temperature	65.700	degrees F
Water Level	0.000	feet
Borehole Fluid Processing	Wet Hole	
Hole/Annular Volume and Differential Caliper Parameters		
HVOL Method	Single Caliper	
HVOL Caliper 1	Density Caliper	
HVOL Caliper 2	N/A	
Annular Volume Diameter	7.000	inches
Caliper for Differential Caliper	Density Caliper	
Rwa Parameters		
Porosity used	Base Density Porosity	



Resistivity used	Array Ind. One Res Rt		
RWA Constant A		0.610	
RWA Constant M		2.150	
SW/APOR Tool Source		0.000	
Gamma Calibration MCG-E.A 514			
			Field Calibration on 17-OCT-2014 21:37
	Measured	Calibrated (API)	
Background	158	108	
Calibrator (Gross)	1491	1020	
Calibrator (Net)	1333	912	
Gamma Constants MCG-E.A 514			
			Last Edited on 18-OCT-2014,09:49
Gamma Calibrator Number	GRC 72		
Mud Density	1.15	gm/cc	
Caliper Source for Processing	Density Caliper		
Tool Position	Eccentred		
Concentration of KCl		kppm	
K Mud Type	Chloride		
K Mud Concentration	0.09	%	
High Resolution Temperature Calibration MCG-E.A 514			
			Field Calibration on 18-OCT-2014,09:50
	Measured	Calibrated(Deg F)	
Lower	32.00	32.00	
Upper	100.00	100.00	
High Resolution Temperature Constants MCG-E.A 514			
			Last Edited on 18-OCT-2014,09:50
Pre-filter Length	11		
FE Calibration MFE-B.A 219			
			Base Calibration on 14-OCT-2014 11:10 Field Check on 17-OCT-2014 21:05
Base Calibration			
	Measured	Calibrated (ohm-m)	
Reference 1	0.0	0.0	
Reference 2	968.6	126.8	
Base Check		280.2	
Field Check		280.4	
FE Constants MFE-B.A 219			
			Last Edited on 18-OCT-2014,09:51
Running Mode	No Sleeve		
MFE K Factor	0.1268		
Caliper Source for FE correction	Density Caliper		
Caliper Value for FE correction	N/A	inches	
Rm Source for FE correction	Temperature Corr		
Temp. for Rm Corr.	MCG External Temperature		
Stand-off	Centred	inches	
Imager Pad Check MIE-A.J 244			
			Field Check on 14-OCT-2014 16:09
Pad 1	20/20 Buttons Verified	Pad 5	20/20 Buttons Verified
Pad 2	24/24 Buttons Verified	Pad 6	24/24 Buttons Verified
Pad 3	20/20 Buttons Verified	Pad 7	20/20 Buttons Verified
Pad 4	24/24 Buttons Verified	Pad 8	24/24 Buttons Verified
Compact Micro Imager Constants MIE-A.J 244			
			Last Edited on 07-JUN-2012 08:23
Sonde Configuration	Imager Mode		
Arm-Pad Kit	Normal Pads (12.25 in)		
Arm-Pad Kit Serial Number			
Centre Pad 1 Rotational Offset	0.00	degrees	
Image/Borehole Ovality Reference	Azimuth of Pad 1		
Non Active Buttons	Omit		
Search Angle	0.00	degrees	
Correlation Interval	3.28	feet	
Correlation Step	1.64	feet	
Current Offset	0.0000	mAmp	
Squasher Start	11111111.0000	mAmp	

## Navigation Constants MIE-A.J 244

Last Edited on 11-JUL-2012 12:21

Magnetic Declination	0.00	degrees	East
----------------------	------	---------	------

## Magnetometer Parameters MIE-A.J 244

Date Of Last Magnetometer Calibration	22-AUG-2013,09:56		
	X Magnetometer	Y Magnetometer	Z Magnetometer
Slope	-1.000000	-1.011965	-0.991340
Offset	0.010303	-0.015788	0.008269

## Magnetometer Constants MIE-A.J 244

Last Edited on

Magnetometer Calibrator Number	000
--------------------------------	-----

## Accelerometer Parameters MIE-A.J 244

Date Of Last Accelerometer Calibration	13-FEB-2013,14:31		
	X Accelerometer	Y Accelerometer	Z Accelerometer
Slope	-1.103572	-1.107641	-1.103778
Offset	-0.006989	0.006286	-0.003996

## Accelerometer Constants MIE-A.J 244

Last Edited on 14-OCT-2014,16:12

Accelerometer Calibrator Number	000
---------------------------------	-----

## Accelerometer Temperature Characterisation

## X Accelerometer

Serial Number	1016			
Calibration Date	12-Apr-2011			
	B0	B1	B2	B3
Bias(g)	0.00000e+000	1.93698e-005	-7.60293e-010	6.54727e-011
	SF0	SF1	SF2	SF3
Scale Factor(mA/g)	3.00000e+000	2.59257e-004	6.13375e-007	-3.90888e-010

## Y Accelerometer

Serial Number	973			
Calibration Date	19-Jan-2011			
	B0	B1	B2	B3
Bias(g)	0.00000e+000	1.95276e-005	-1.88058e-008	2.74122e-010
	SF0	SF1	SF2	SF3
Scale Factor(mA/g)	3.00000e+000	2.75268e-004	3.53140e-007	7.52116e-010

## Z Accelerometer

Serial Number	1032			
Calibration Date	18-Apr-2011			
	B0	B1	B2	B3
Bias(g)	0.00000e+000	-1.14960e-005	3.94288e-009	8.97135e-011
	SF0	SF1	SF2	SF3
Scale Factor(mA/g)	3.00000e+000	2.88058e-004	2.44833e-007	8.38007e-010

## Caliper Calibration MIE-A.J 244

Base Calibration on 14-OCT-2014 16:03

Field Calibration on 14-OCT-2014 16:04

## Base Calibration

Reading No	Pads 1-5 Meas.	Pads 3-7 Meas.	Calibrator Size (in)
1	24598	25678	5.96
2	34609	35979	7.97
3	44567	45592	9.84
4	55923	57146	11.91
5	0	0	0.00

Reading No	Pad 2 Meas.	Pad 4 Meas.	Pad 6 Meas.	Pad 8 Meas.	Calibrator Size (in)
1	24589	26958	24376	23838	5.96
2	33342	35325	33013	32430	7.97
3	41271	43620	41279	40227	9.84
4	51419	52989	50755	49959	11.91
5	0	0	0	0	0.00

## Field Calibration

Measured	Measured	Actual
Pads 1-5 Caliper(in)	Pads 3-7 Caliper(in)	Caliper(in)

	8.00		7.94		7.97
	Measured Pad 2 Caliper(in) 3.99	Measured Pad 4 Caliper(in) 3.99	Measured Pad 6 Caliper(in) 3.97	Measured Pad 8 Caliper(in) 3.98	Actual Caliper(in) 7.97
Caliper Constants MIE-A.J 244			Last Edited on 07-JUN-2012 08:23		
Caliper Difference for BRKT		0.120	inches		
Induction Calibration MAI-B.A 269			Base Calibration on 14-OCT-2014,11:18 Field Check on 17-OCT-2014 21:04		
Base Calibration					
Test Loop Calibration		Measured		Calibrated (mmho/m)	
Channel	Low	High	Low	High	
1	17.5	492.3	9.3	966.2	
2	5.8	384.1	7.6	821.4	
3	3.3	264.1	5.2	566.0	
4	2.7	135.6	2.6	279.2	
Array Temperature		27.0	Deg F		
Channel	Base Check (mmho/m)		Field Check (mmho/m)		
	Low	High	Low	High	
1			11.4	3698.6	
2			30.7	3519.3	
3			28.4	3006.1	
4			17.6	2057.6	
Deep			15.0	1925.1	
Medium			44.1	3990.6	
Shallow			48.9	5253.0	
Array Temperature			54.2	Deg F	
Induction Constants MAI-B.A 269			Last Edited on 18-OCT-2014,09:52		
Induction Model		RtAP-WBM			
Caliper for Borehole Corr.		Density Caliper			
Hole Size for Borehole Correction		N/A		inches	
Tool Centred		Yes			
Stand-off Type		N/A			
Stand-off		N/A		inches	
Number of Fins on Stand-off		N/A			
Stand-off Fin Angle		N/A			
Stand-off Fin Width		N/A			
Borehole Corr. Rm Source		Temperature Corr			
Temp. for Rm Corr.		MCG External Temperature			
Squasher Start		0.0020		mhos/metre	
Squasher Offset		N/A		mhos/metre	
Borehole Normalisation					
DRM1	0.0000	DRC1		0.0000	
DRM2	0.0000	DRC2		0.0000	
MRM1	0.0000	MRC1		0.0000	
MRM2	0.0000	MRC2		0.0000	
SRM1	0.0000	SRC1		0.0000	
SRM2	0.0000	SRC2		0.0000	
Calibration Site Corrections					
Channel 1		0.00	mmhos/metre		
Channel 2		0.00	mmhos/metre		
Channel 3		0.00	mmhos/metre		
Channel 4		0.00	mmhos/metre		
Apparent Porosity and Water Saturation Constants					
Archie Constant (A)		1.00			
Cementation Exponent (M)		2.00			
Saturation Exponent (N)		2.00			
Saturation of Water for Apor		100.00	percent		
Resistivity of Water for Apor and Sw		0.05	ohm-m		
Resistivity of Mud Filtrate for Sw		0.00	ohm-m		
Source for Rt		0.00			
Source for Dxo		0.00			

## Caliper Calibration MPD-D.A 460

Base Calibration on 14-OCT-2014 10:20

Field Calibration on 17-OCT-2014 21:07

## Base Calibration

Reading No	Measured	Calibrator Size (in)
1	18461	3.98
2	26997	5.96
3	35483	7.97
4	43651	9.84
5	53133	11.91
6	N/A	N/A

## Field Calibration

Measured Caliper (in)	Actual Caliper (in)
8.00	7.97

## DOWNHOLE EQUIPMENT

C:\Users\le154681\AppData\Local\Temp\Weatherford PreView53\0\Main2.dta

SHA-J.B Compact Swivel Head Adaptor

SHA-J.B 587 LG: 2.30 ft WT: 22.0 lb OD: 2.244 in

Compact Comms Gamma

MCG-E.A 514 LG: 8.70 ft WT: 63.9 lb OD: 2.244 in

Compact Neutron

MDN-B.A 296 LG: 5.04 ft WT: 50.7 lb OD: 2.244 in

MIS-D.B Compact Inline Bowspring sub

MIS-D.B 702 LG: 5.70 ft WT: 33.1 lb OD: 2.240 in

Compact Density/Caliper

MPD-D.A 460 LG: 9.59 ft WT: 90.4 lb OD: 2.449 in

SKJ-D.A Compact Knuckle Joint

SKJ-D.A 115 LG: 2.17 ft WT: 24.3 lb OD: 2.244 in

MIS-E.B Compact Inline Standoff sub

MIS-E.B 786 LG: 2.14 ft WT: 15.4 lb OD: 2.244 in

SKJ-D.A Compact Knuckle Joint

SKJ-D.A 88 LG: 2.17 ft WT: 24.3 lb OD: 2.244 in

Compact Focussed Electric

MFE-B.A 219 LG: 6.05 ft WT: 48.5 lb OD: 2.244 in

Compact MMI Memory Section

MIM-A.J 244 LG: 4.65 ft WT: 26.5 lb OD: 2.244 in

Compact MMI Electrode Section

MIE-A.J 244 LG: 13.96 ft WT: 99.2 lb OD: 4.094 in

MIS-D.B Compact Inline Bowspring sub

MIS-D.B 730 LG: 5.70 ft WT: 33.1 lb OD: 2.240 in

Compact Induction

MAI-B.A 269 LG: 10.81 ft WT: 48.5 lb OD: 2.240 in

Total Length: 78.96 ft Weight: 579.8 lb

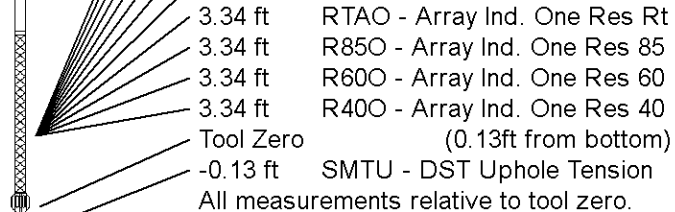


71.38 ft GRGC - Gamma Ray  
68.47 ft CGXT - MCG External Temperature

64.92 ft NPRD - Dolomite Neutron Por.  
64.92 ft NPRS - Sandstone Neutron Por.  
64.92 ft NPRL - Limestone Neutron Por.  
64.92 ft NPOR - Base Neutron Porosity

51.98 ft AVOL - Annular Volume  
51.98 ft HVOL - Hole Volume  
51.98 ft CLDC - Density Caliper  
50.05 ft DPRD - Dolomite Density Por.  
50.05 ft DPRS - Sandstone Density Por.  
50.05 ft DPRL - Limestone Density Por.  
50.05 ft DPOR - Base Density Porosity  
50.05 ft DEN - Compensated Density  
50.05 ft DCOR - Density Correction  
49.99 ft PDPE - PE

3.34 ft R60T - Array Ind. Two Res 60  
3.34 ft R40T - Array Ind. Two Res 40  
3.34 ft R30T - Array Ind. Two Res 30  
3.34 ft CTAT - Array Ind. Two Cond Ct  
3.34 ft R85T - Array Ind. Two Res 85  
3.34 ft R30O - Array Ind. One Res 30  
3.34 ft CTAO - Array Ind. One Cond Ct  
3.34 ft RTAT - Array Ind. Two Res Rt



COMPANY	EAST CHEYENNE GAS STORAGE LLC
WELL	ECGS No 6-21 WPD004-2
FIELD	WEST PEETZ
PROVINCE/COUNTY	LOGAN
COUNTRY/STATE	U.S.A / COLORADO

Elevation Kelly Bushing	4567.00	feet	First Reading	5437.00	feet
Elevation Drill Floor	4566.00	feet	Depth Driller	5440.00	feet
Elevation Ground Level	4557.00	feet	Depth Logger	5440.00	feet



**Weatherford®**

ARRAY INDUCTION-RTAP  
 SHALLOW FOCUSED ELECTRIC  
 LOG