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Project Shoal Area - Field Data Summary Report

prepared by

Todd Mihevc, Greg Pohll and Brad Lyles

submitted to

Nevada Operations Office
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ABSTRACT

Project Shoal was a 12-kiloton-yield nuclear test conducted by the United States Atomic Energy Commission on October 26, 1963, approximately 50 km southeast of Fallon, Nevada. This test took place in the Sand Springs Range, which is a north-south-trending mountain range within the Basin and Range Physiographic Province. Characterization of groundwater contamination at the Project Shoal Area (PSA) is being conducted by the U.S. Department of Energy under the Federal Facility Agreement and Consent Order (FFACO). The Corrective Action Investigation Plan, a requirement of the FFACO, for the Shoal site consists of flow and transport modeling to establish contaminant boundaries that are protective of human health and the environment. This report summarizes the hydrogeologic data collected at the PSA from the 1960s to the present and will be used to construct this model.

This report presents data for the individual wells and is organized in separate sections for each well. However, summary tables and figures are presented for some of the data, which include hydraulic conductivities, fracture analysis, water chemistry, and sorption properties of rock from the Shoal site. Data presented in the individual well sections consist of aquifer test analysis, fracture interpretation, water level measurements, and well logs. Logs for the wells that were drilled in the early 1960s were digitized from hard copy logs. All other well logs were obtained in electronic format and processed through WellCAD software to allow a consistent presentation of the data.

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LIST OF ACRONYMS

AEC	Atomic Energy Commission
CADD	Corrective Action Decision Document
CAIP	Corrective Action Investigation Plan
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
FFACO	Federal Facility Agreement and Consent Order
MSL	mean sea level
PSA	Project Shoal Area

Introduction

Since 1962, all United States nuclear tests have been conducted underground. The majority of this testing occurred on the Nevada Test Site, but a limited number of experiments were conducted in other locations. One of these is the subject of this report, the Project Shoal Area (PSA), located about 50 km southeast of Fallon, Nevada. The Shoal test consisted of a 12-kiloton-yield nuclear detonation (DOE, 1994), which occurred on October 26, 1963. Project Shoal was part of studies to enhance seismic detection of underground nuclear tests, in particular, in active earthquake areas.

Characterization of groundwater contamination at the PSA is being conducted by the U.S. Department of Energy (DOE) under the Federal Facility Agreement and Consent Order (FFACO) with the state of Nevada Department of Environmental Protection and the U.S. Department of Defense (DoD). This order prescribes a Corrective Action Strategy (Appendix VI), which, as applied to underground nuclear tests, involves preparing a Corrective Action Investigation Plan (CAIP), Corrective Action Decision Document (CADD), Corrective Action Plan, and Closure Report.

The CAIP for the PSA was approved in September 1996 and revised in 1998. The scope of the CAIP is flow and transport modeling to establish contaminant boundaries that are protective of human health and the environment. This report summarizes most of the hydrogeologic data collected at the PSA from the 1960s to the present. Additional PSA data can be found in DOE (1998), IT (2000) and University of Nevada (1965). The data presented in this report will be used to construct a flow and transport model at the PSA.

The PSA consists of a 10.4 km^2 area in the Sand Springs Range, located near Fallon, Nevada, in Churchill County (Figure 1). Ground zero of the underground nuclear test is located at North 1620170 (ft), East 557542 (ft) (Nevada Grid Coordinates), with a land elevation of 1,594 m (MSL). The nuclear device was emplaced 367 m below the land surface, at the end of a 305-m-long drift mined east from a vertical shaft. Figure 2 shows the area near ground zero looking northeast.

The Sand Springs Range is a north-south-trending range with a total relief between the range and valleys of about 500 m. A major intermittent drainage course in Ground Zero Canyon leads east to Fairview Valley. No permanent water bodies or streams exist. Sparse, low vegetation covers the area. The ground slopes steeply west to Fourmile Flat and east to Fairview Valley. Ground zero is near the crest of the range on a minor intramountain plateau named Gote Flat, which is about 800 m wide. At a depth of 367 m below the land surface, the Shoal working point is nearly at grade with the adjacent valley floors.

The Shoal site is in a sub-humid to semi-arid region of Nevada's Great Basin. Annual rainfall varies from about 13 cm in the valleys to about 30 cm in the high mountain ranges (Hardman and Mason, 1949). Most precipitation in the mountain ranges occurs as snow. The annual precipitation estimate for the Shoal site varies between 20 cm (Gardner and Nork, 1970) and 30 cm (Hardman and Mason, 1949). Using the relationship between precipitation and recharge described by Maxey and Eakin (1949), an estimated 3 to 7 percent (0.6 to 2.1 cm/yr) of the annual precipitation will infiltrate and become groundwater recharge. A vadose zone model (Pohll et al., 1999) provides a

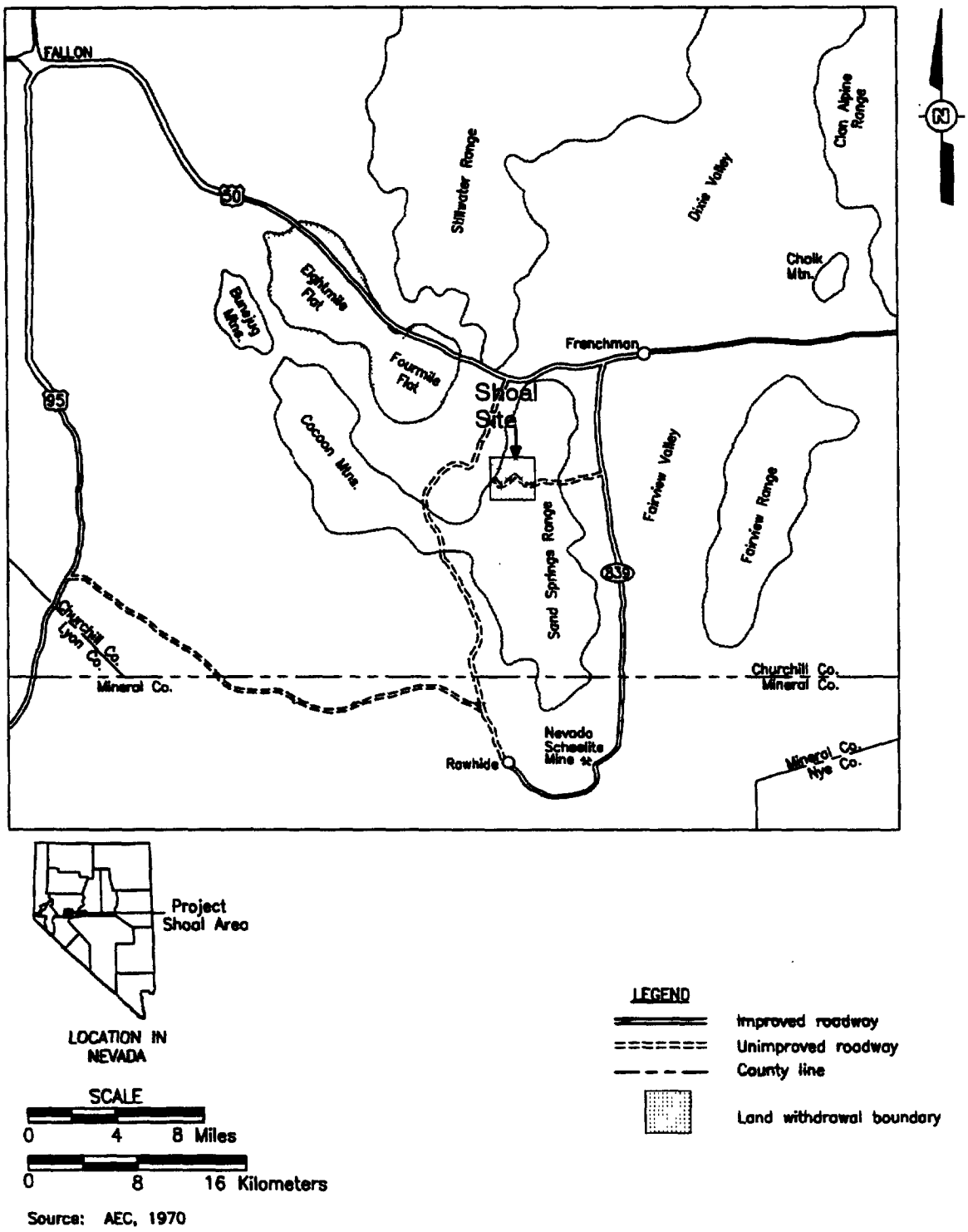

Figure 1. Study location.

Figure 2. Shoal site looking northeast (October 1999).

more rigorous estimate of surface recharge with a predicted median recharge rate of 0.055 cm/yr with a 95 percent confidence interval ranging from 0.0 to 0.159 cm/yr. Daily temperature fluctuations in excess of 10°C can occur. Maximum temperatures exceed 38°C in July and August and minimum temperatures of -18°C occur in December and January.

Figure 3 shows the location of the PSA boreholes, ground zero, emplacement shaft and surface fracture expressions. Table 1 provides the geographic and completion data for all wells at the PSA. This report provides the data shown in Table 2. These data are organized by well, with the exception being the summary information provided on hydraulic fracture and geochemical data.

Hydraulic Data Summary

Table 3 shows the available hydraulic data for the PSA. Figure 4 shows the distribution of hydraulic conductivity at the PSA. The Cooper and Jacob (1946) method was used to analyze all of the pumping test data, except HC-6. Numerical methods using Modflow (McDonald and Harbaugh, 1984) were used to properly determine the hydraulic conductivity and storage coefficient under unconfined conditions. Additional hydraulic data and anlaysis can be found in Pohll et al. (1998, Appendix 4) and University of Nevada (1965).

Fracture Data Summary

The PSA subsurface fractures were characterized with a combination of video, radar and acoustic televiewer logs. Table 4 summarizes the available video logs and associated depth intervals. Figures 5 and 6 show the distribution of strike and dip angles as derived from the 1999 acoustic televiewer logs (HC-5, HC-6, HC-7 and HC-8). Although acoustic televiewer logs were taken

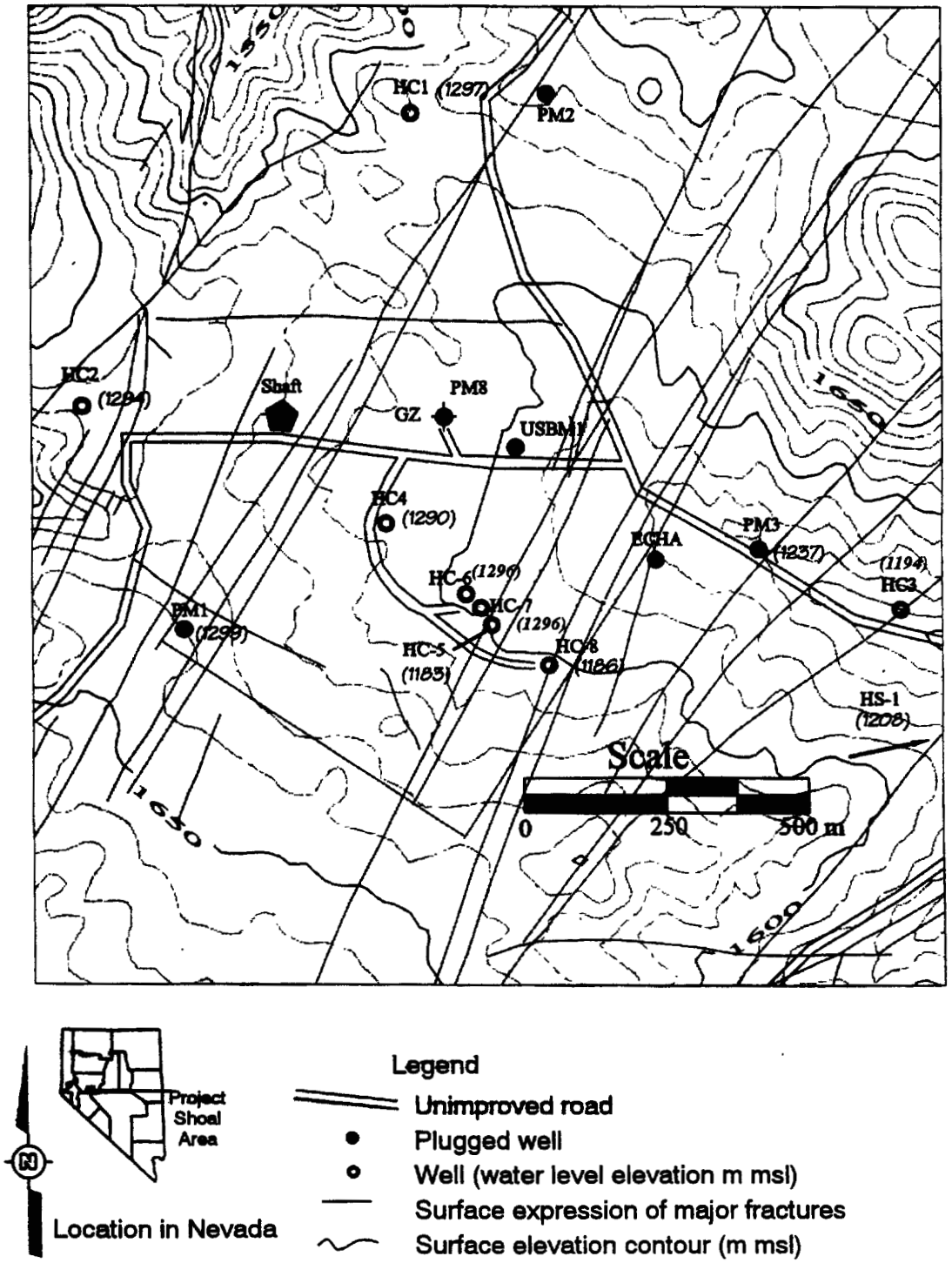

Figure 3. Project Shoal Area wells.

Table 1. Summary information for wells, ground zero, emplacement shaft and the Gote Flat benchmark at the PSA.

Well	Northing (ft)	Easting (ft)	Elevation Datum	Elevation (m)	Total Depth (m)	Screen Interval Depth Top (m)	Screen Interval Depth Bottom (m)	Current Condition	Water Table Elevation (m)
HS-1	1622141.28	576875.65	Ground Surface	1,293.19	213+	n/a	n/a	Operational	1,208.27
H-2	1631585.00	543132.00	Ground Surface	1,224.38	237.74	195	237.71	Operational	1,190.59
H-3	1627331.86	548884.86	Ground Surface	1,289.97	146.3	79.24	146.3	Operational	1,189.91
H-4	1622285.67	576814.39	Ground Surface	1,292.94	284.99	185.92	284.99	Abandoned	1,201.74
PM-1	1618717.83	556030.63	Ground Surface	1,633.13	408.13	n/a**	n/a**	Abandoned	1,299.46
PM-2	1621842.43	558120.94	Ground Surface	1,620.79	394.72	n/a**	n/a**	Abandoned	1,356.34
PM-3	1619192.76	559336.33	Ground Surface	1,563.65	334.37	n/a**	n/a**	Abandoned	1,237.23
PM-8	1619967.78	557532.73	Ground Surface	1,596.48	283.46	n/a**	n/a**	Abandoned	1,344.11
USBM-1	1619992.41	557949.92	Ground Surface	1,588.62	452.9	n/a**	n/a**	Abandoned	1,312.16
ECH-A	1619292.70	558740.30	Ground Surface	1,572.43	579.12	n/a	n/a	n/a	n/a
ECH-D	1619975.70	556545.50	Ground Surface	1,593.78	614.17	n/a**	n/a**	Abandoned	1,299.97
PS-1	1620186.00	557539.00	Ground Surface	n/a	n/a	n/a**	n/a**	Abandoned	n/a
Shaft	1620150.00	556549.00	Ground Surface	1,610.99	392.56	n/a	n/a	Abandoned	<1,300.58
Gote Flat Benchmark	1620166.26	557766.65	Ground Surface	1,600.89	n/a	n/a	n/a	n/a	n/a
Ground Zero	1620137.00	557494.00	Ground Surface	1,600.89	366.98	n/a	n/a	n/a	n/a
HC-1	1621927.00	557360.40	Top of 5" Steel Casing	1,618.25	405.38	n/a***	n/a	Operational	1,296.68
HC-2	1620208.30	555447.80	Top of 5" Steel Casing	1,629.80	369.42	n/a	n/a	Operational	1,294.02
HC-3	1618822.90	560114.70	Top of 5" Steel Casing	1,548.85	364.21	263.35	n/a	Operational	1,193.55
HC-4	1619650.16	557738.95	Top of 5" Steel Casing	1,603.46	375.20*	n/a	n/a	Operational	1,289.51
HC-5	1619056.07	558315.11	Top of PVC Access Tube	1,599.32	1,086.56	1,031.70	1,076.07	Operational	1,183.04
HC-6	1619312.58	558222.53	Top of 5" Steel Casing	1,593.63	377.93	340.13	375.59	Operational	1,295.49
HC-7	1619237.29	558291.68	Top of PVC Access Tube	1,593.94	377.93	337.24	372.94	Operational	1,295.78
HC-8	1618789.06	558642.91	Top of PVC Access Tube	1,603.14	771.11	699.30	734.81	Operational	1,185.91

*New total depth due to debris at bottom of borehole
**uncased hole
***open borehole in saturated zone
+constructed depth, current depth may be substantially less due to borehole deterioration

Table 2. Data from the Project Shoal Area presented in this report.

Activity	HC-1	HC-2	HC-3	HC-4	HC-5	HC-6	HC-7	HC-8	PM-1	PM-2	PM-3	PM-8	USBM-1	ECH-D
Current Water Level	X	X	X	X	X	X	X	X						
Historic Water Level									X		X	X	X	X
Slug Test									X		X		X	X
Pumping Test	X	X		X	X	X	X	X						
Stressed Thermal Flow	X	X		X										
Gross Chemistry	X	X		X	X	X	X	X	X		X		X	X
Isotope Chemistry	X	X		X	X	X	X	X						
Chemtool	X	X		X										
^{14}C	X	X		X	X	X	X	X						
Radar		X			X	X	X	X						
ATV					X	X	X	X						
Video*	X			X	X		X	X						
Fracture Interpretation	X	X	X	X	X	X	X	X	X	X	X		X	
Caliper	X	X	X	X	X	X	X	X	X	X	X		X	X
Density	X	X	X	X	X	X	X	X						
Neutron	X	X	X	X	X	X	X	X	X	X	X		X	X
Temperature	X	X		X	X	X	X	X	X					
Natural Gamma	X	X	X	X	X	X	X	X	X	X	X		X	X
Spectral Gamma	X	X	X	X	X	X	X							X
Deviation	X	X	X	X	X	X	X	X						
Resistivity		X		X	X	X	X	X	X	X	X			X
Spontaneous Potential									X	X	X			X

Video data are not available in report; refer to Table 4 for availability of borehole video logs.

Table 3. Summary of hydraulic testing at Project Shoal

Well	Test	Date	Top Elev. (m)	Bottom Elev. (m)	Thickness (m)	K (cm/sec)	S_Y (dimensionless)
HC-1	Pumping Test	2/19/1997	1,293.70	1,212.70	81.00	1.5E-05	-----
HC-1	Pumping Test	2/20/1997	1,293.70	1,212.70	81.00	2.6E-05	-----
HC-1	Stressed Thermal Flow	7/9/1997	1,242.26	1,232.62	9.64	5.3E-05	-----
HC-1	Stressed Thermal Flow	7/9/1997	1,232.62	1,225.86	6.76	7.1E-05	-----
HC-2	Pumping Test	2/24/1997	1,292.70	1,260.08	32.62	2.7E-06	-----
HC-2	Recovery Analysis	2/25/1997	1,292.70	1,260.08	32.62	1.3E-06	-----
HC-4	Pumping Test	2/23/1997	1,285.50	1,225.09	60.41	4.0E-06	-----
HC-4	Recovery Analysis	2/24/1997	1,285.50	1,225.09	60.41	9.0E-06	-----
HC-4	Stressed Thermal Flow	8/7/1997	1,292.04	1,286.04	6.00	1.0E-05	-----
HC-4	Stressed Thermal Flow	8/7/1997	1,286.04	1,274.04	12.00	3.4E-06	-----
HC-4	Stressed Thermal Flow	8/7/1997	1,274.04	1,267.04	7.00	2.3E-06	-----
HC-4	Stressed Thermal Flow	8/7/1997	1,267.04	1,255.04	12.00	1.5E-06	-----
HC-4	Stressed Thermal Flow	8/7/1997	1,255.04	1,246.04	9.00	3.6E-06	-----
HC-4	Stressed Thermal Flow	8/7/1997	1,246.04	1,236.04	10.00	1.0E-06	-----
HC-4	Stressed Thermal Flow	8/7/1997	1,236.04	1,228.04	8.00	4.4E-06	-----
HC-5	Pumping Test	10/4/1999	568.58	532.00	36.58	2.3E-04	-----
HC-5	Pumping Test	10/11/1999	568.58	532.00	36.58	1.6E-04	-----
HC-6	Pumping Test	10/25/1999	1,292.26	1,255.68	36.58	1.6E-05	-----
HC-6	Pumping Test (while pumping HC-7)	10/28/1999	1,292.26	1,255.68	36.58	1.7E-04	0.01
HC-7	Pumping Test	10/28/1999	1,292.26	1,221.00	36.58	2.7E-05	-----
HC-8	Pumping Test	11/11/1999	762.00	762.00	36.58	9.6E-07	-----
HC-8	Recovery Analysis	11/14/1999	762.00	762.00	36.58	1.1E-06	-----
USBM-1	Slug Test	7/30/1963	1,312.16	1,135.72	176.44	1.2E-05	-----
PM-1	Slug Test	3/24/1963	1,299.46	1,225.00	74.46	1.9E-05	-----
PM-3	Slug Test	4/22/1963	1,287.50	1,229.28	58.22	2.3E-06	-----
ECH-D	Slug Test	7/19/1962	1,300.00	979.61	320.39	5.6E-07	-----

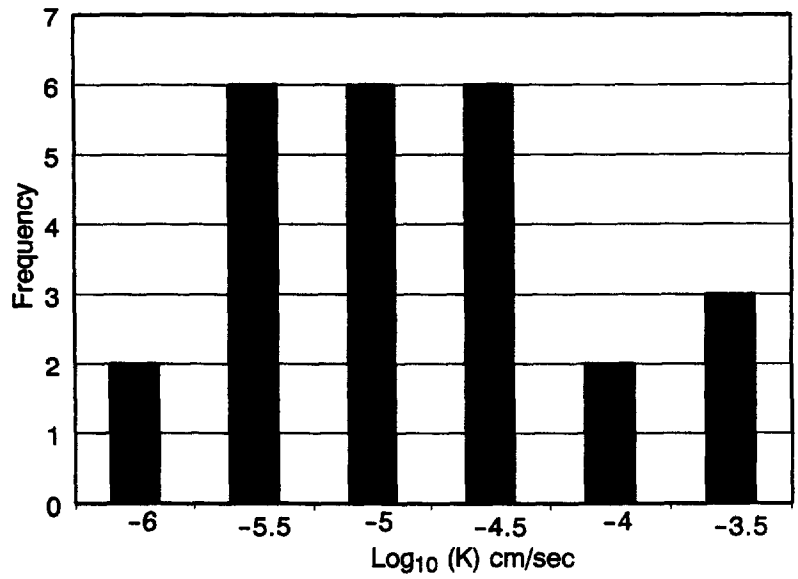

Figure 4. Histogram of hydraulic conductivity for the PSA.

during the 1996 drilling effort (HC-1, HC-2, HC-3, and HC-4), poor borehole conditions did not allow for an accurate determination of fracture strikes and dips.

Table 4. Summary of video logs.

				Depth Range (ft bgs)	
Video #	Well #	Date	Tape #	Unsaturated	Saturated
1	HC-1	10/4/1996	1 of 1	0-890	
2	HC-1	10/4/1996	1 of 1	0-900	
3	HC-4	10/8/1999	1 of 3	0-1,142	
4	HC-4	10/8/1999	2 of 3	0-1,142	
5	HC-4	10/8/1999	3 of 3	0-1,142	
6	HC-5	8/24/1999	1 of 2	0-1,363	1,363-2,696
7	HC-5	8/24/1999	2 of 2	0-1,363	1,363-2,696
19	HC-7	10/6/1999	1 of 2	0-1,102	1,102-1,150
8	HC-7	10/6/1999	2 of 2	0-1,102	1,102-1,150
9	HC-8	8/26/1999	1 of 2	0-1,272	1,272-1,276
10	HC-8	8/16/1999	2 of 2	0-1,272	
11	HC-8	8/28/1999	1 of 2	0-1,450	
12	HC-8	8/28/1999	2 of 2	0-1,450	
13	HC-8	9/9/1999	1 of 1	0-747	
14	Shoal shaft	5/21/1996	1 of 2	0-42	
15	Shoal shaft	5/21/1996	2 of 2	0-42	
16	Shoal shaft	5/31/1996	1 of 2	0-1,015	
17	Shoal shaft	5/31/1996	2 of 2	0-1,015	
18	HC-6	9/29/1999	1 of 1	972-1,155	1,155-1,230

Geochemical Data Summary

The waters from the Project Shoal Area are a mixed-cation and mixed-anion-type water. The samples from the site fall into three general groupings, where wells HC-1, HC-2, and HC-4 are one

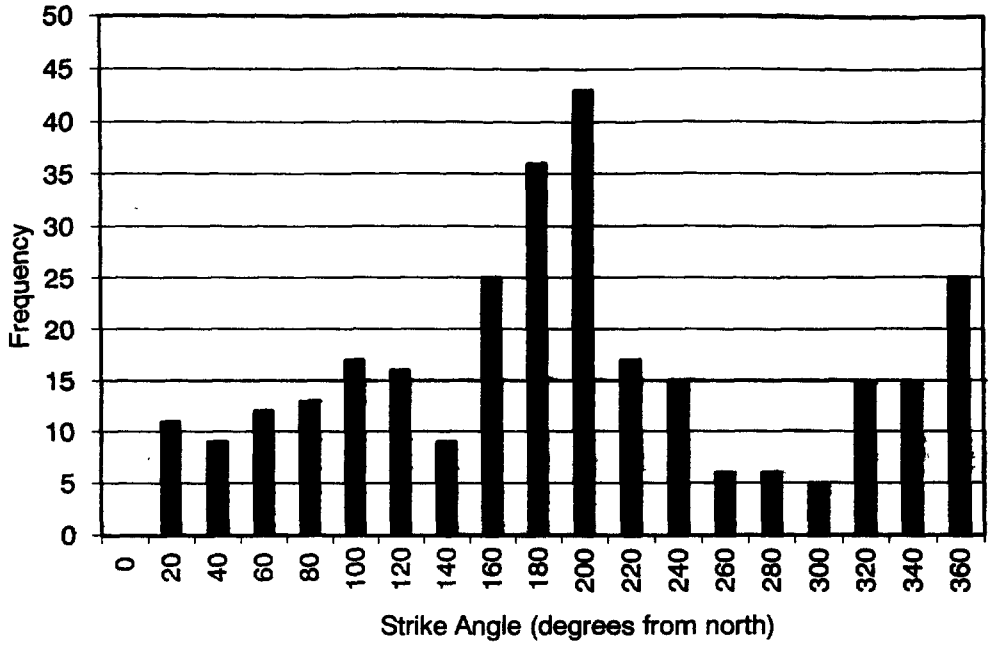

Figure 5. Distribution of strike angles as determined from acoustic televiewer analysis (HC-5, HC-6, HC-7 and HC-8).

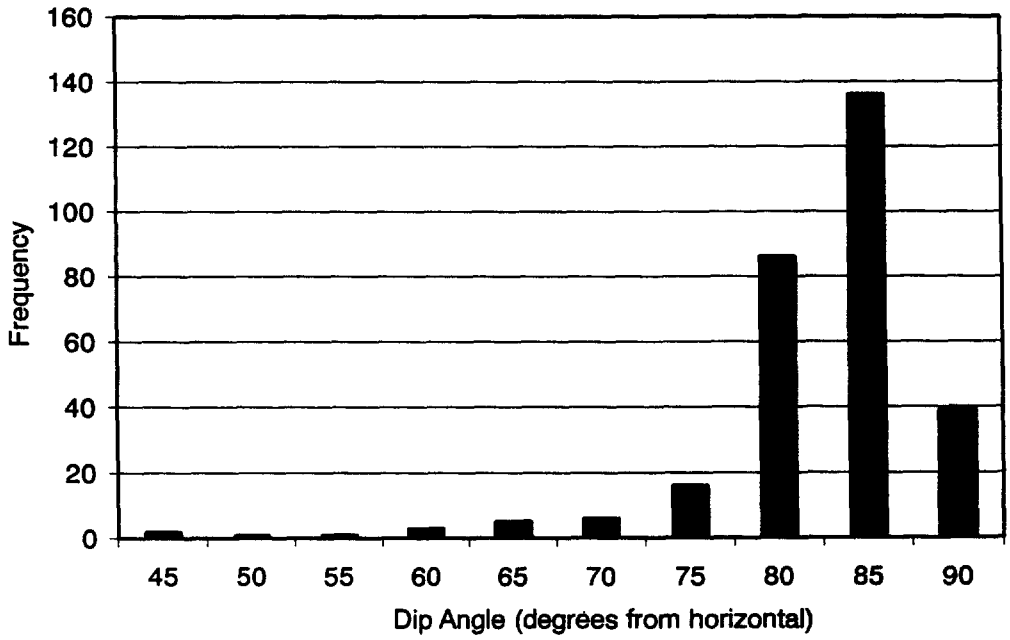

Figure 6. Distribution of dip angles as determined from acoustic televiewer analysis (HC-5, HC-6, HC-7 and HC-8).

group, wells HC-6 and HC-7 are a second group and wells HC-5 and HC-8 comprise a third group (see Figure 7). The waters from HC-1, HC-2, and HC-4 are a calcium-sodium mixed-anion water with specific conductance values that range from 467 to 727 microsiemiens (See Table 5). The waters from HC-6 and HC-7 are a calcium-sodium mixed-anion water with sulfate being the dominant anion. The specific conductance from these wells is the highest seen at the site and ranges from 1,060 to 1,380 microsiemiens. The waters from HC-5 and HC-8 are a sodium mixed anion water with specific conductance values that are intermediated of the other two groupings and they range from 799 to 948 micromhos.

In 1996, batch-type sorption experiments were performed to estimate the affinity of a strong and a weak binding cation (selenite and chromate, respectively) for aquifer material (granite) from the PSA (Pohll et al., 1998). Table 6 shows the estimated distribution coefficients for strontium and cesium.

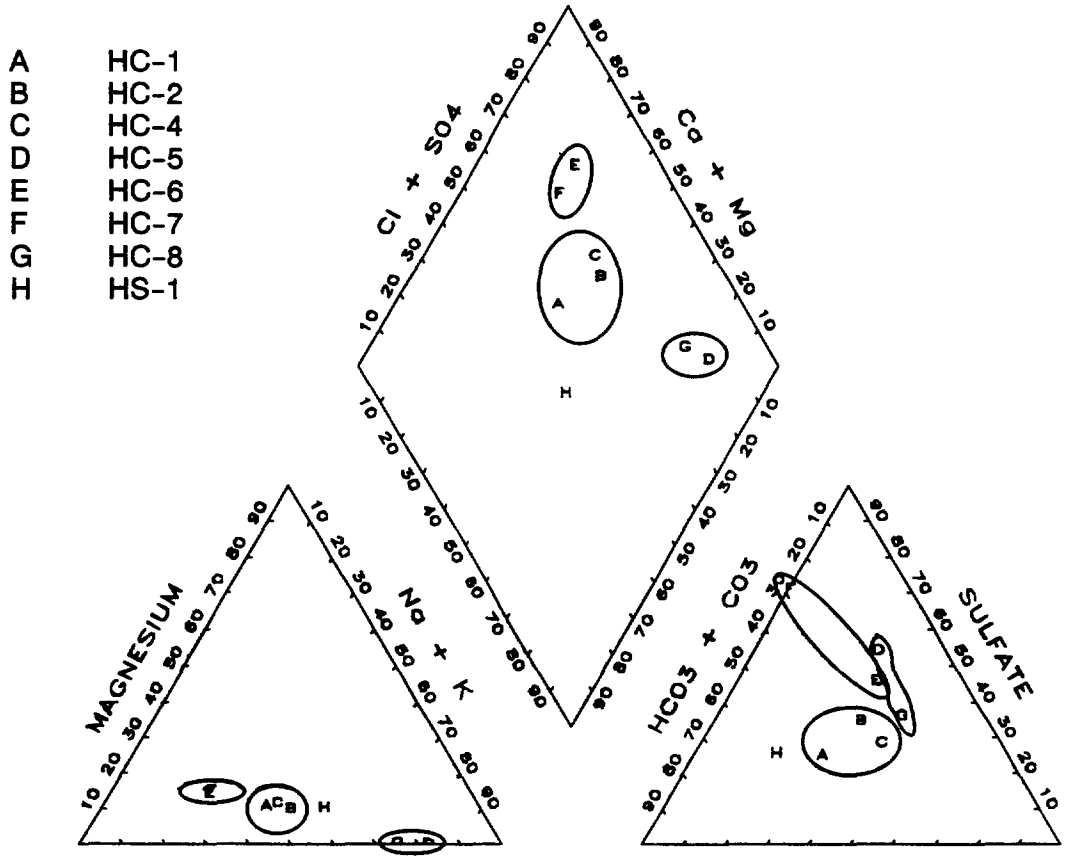

Figure 7. Trilinear diagram of borehole fluids.

Table 5a. Chemical analyses of water samples collected from the HC wells at the Shoal Site, along with analyses of groundwater from other wells in the area of the Sand Springs Range (from Chapman *et al.,* 1994). All units are mg/L unless noted otherwise.

Well	Depth (m)	Date	T (°C)	pH[1] (S.U.)	EC[1] (µS/cm)	SiO_2 (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)	CO_3 (mg/L)	NO_3 (mg/L)	Br (mg/L)
HC-1	336	2-21-1997	13.6	8.00/8.01	423/467	19.8	45.7	6.01	38.7	2.79	47.7	52.2	116	na	11.1	0.7
HC-2	347	3-19-1997	na	na/8.03	na/670	20.8	58.1	7.87	64.8	3.48	80.8	108.0	118	na	0.44	0.59
HC-4	327	2-24-1997	13.7	7.20/8.04	658/727	22.7	66.4	9.87	63.7	3.67	101.0	90.3	113	na	26.8	1.67
HC-5	476	1-12-2000	31.5	8.26	948	32.2	31.6	0.20	170	2.24	92.1	228	83.5	na	0.31	
HC-6	371	10-6-1999	24.0	7.72	1,060	26.1	139	19.6	58.5	4.43	126	235	133	na	16.7	0.4
HC-7	371	11-3-1999	20.5	7.75	1,380	24.4	178	26.4	77	5.18	189	329	165	na	0.58	0.6
HC-8	610	10-29-1999	26.6	8.16	799	30.0	37.6	0.44	130	3.12	120	133	91.5	na	0.04	0.3
HS-1	92	3-30-1992	na	7.72/8.14	428/438	68.7	31.5	5.37	47.2	7.11	29.3	51.5	110/140	na	3.99	<0.1
PM-1+	340++	5-29-1963	na	8.4	2,200*	19	112	49	271	9	702	130	149	0.6	na	na
PM-2+	270++	5-29-1963	na	7.3	1,055*	3	87	11	70	9	78	78	437	3.6	na	na
PM-3+	330++	5-29-1963	na	8.2	1,050*	54	71	5	411	18	23	61	92	1.2	na	na
ECH-D	300++	7-16-1962	na	8.5	657*	49	62	10	86	9	100	92	243	9.0	na	na
USBM#1	280++	7-2-1963	na	8.0	785*	31	55	5	104	4	100	161	156	0.6	na	na

[1]First number is a measurement in the field at the time of sample collection. Second number is a laboratory measurement. If there is only one number, it is a laboratory measurement.
*Based on TDS measurements
+Probable analyses error
++Approximate depth of bailed sample

Table 5b. Isotopic analyses for groundwater samples from the Shoal site.

Well	^{14}C Percent Modern Carbon	δD (‰)	$\delta^{13}C$ (‰)	$\delta^{18}O$ (‰)	Tritium (pCi/L)
HC-1	48.68 ± 0.83	-114	-10.8	-14.5	<5
HC-2	22.13 ± 0.51	-115	-10.4	-14.5	<5
HC-4	5,408 ± 51.9++	-113	-11.2	-14.2	1,130±15
HC-5	pending	pending	pending	pending	pending
HC-6	12.26 ± .18	-113	-11.2	-13.8	pending
HC-7	7.45 ± .15	-115	-9.8	-13.9	pending
HC-8	9.61 ± .15	-117	-12.0	-14.4	pending
HS-1	8.3 ± 0.9	-123	-9.9	-16.3	<10

++Percent modern carbon affected by nuclear device

Table 6. Linear and Freundlich isotherm parameters for Well HC-4 (Pohll et al., 1998).

pH	K_d (m^3/g)	K_F $(g/g)(g/m^3)^{1/n}$	1/n (-)
Lead Sorption			
6.0	7.33×10^{-4}	2.11×10^{-4}	0.79
8.0	4.9×10^{-4}	4.9×10^{-3}	1.00
Cesium Sorption			
5.0	3.07×0^{-5}	4.56×10^{-5}	0.85
6.0	2.75×10^{-5}	3.88×10^{-5}	0.88
7.0	3.11×10^{-5}	3.62×10^{-5}	0.98
8.0	4.29×10^{-5}	3.88×10^{-5}	1.07
9.0	5.45×10^{-5}	4.14×10^{-5}	1.13
Chromate Sorption			
9.0	4.25×10^{-6}	2.49×10^{-7}	0.47
Selenite Sorption			
4.0	1.51×10^{-5}	6.32×10^{-7}	0.57
5.0	4.12×10^{-5}	6.17×10^{-7}	0.44
6.0	2.13×10^{-4}	1.80×10^{-4}	0.98
7.0	1.00×10^{-4}	2.84×10^{-5}	0.84
8.0	4.32×10^{-5}	1.89×10^{-6}	0.58
9.0	2.08×10^{-5}	1.66×10^{-7}	0.34

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HC-1

Available Data

- Pumping Test
- Water Level vs. Time
- Stressed Thermal Flow
- Borehole Deviaiton
- Chemtool (temperature, EC, pH)
- Fracture Interpretation Log
- Natural Gamma Log
- Caliper Log
- Density Log
- Neutron Log
- Spectral Gamma Ray Log (thorium, uranium, potassium)
- Temperature Log

Analysis	
Date:	2/19/1997
ΔS (m):	0.24
Q (m^3/day):	1.36
Screen Thickness (m):	81
Transmissivity (m^2/day):	1.039593
Hydraulic Conductivity (cm/sec):	1.496E-05

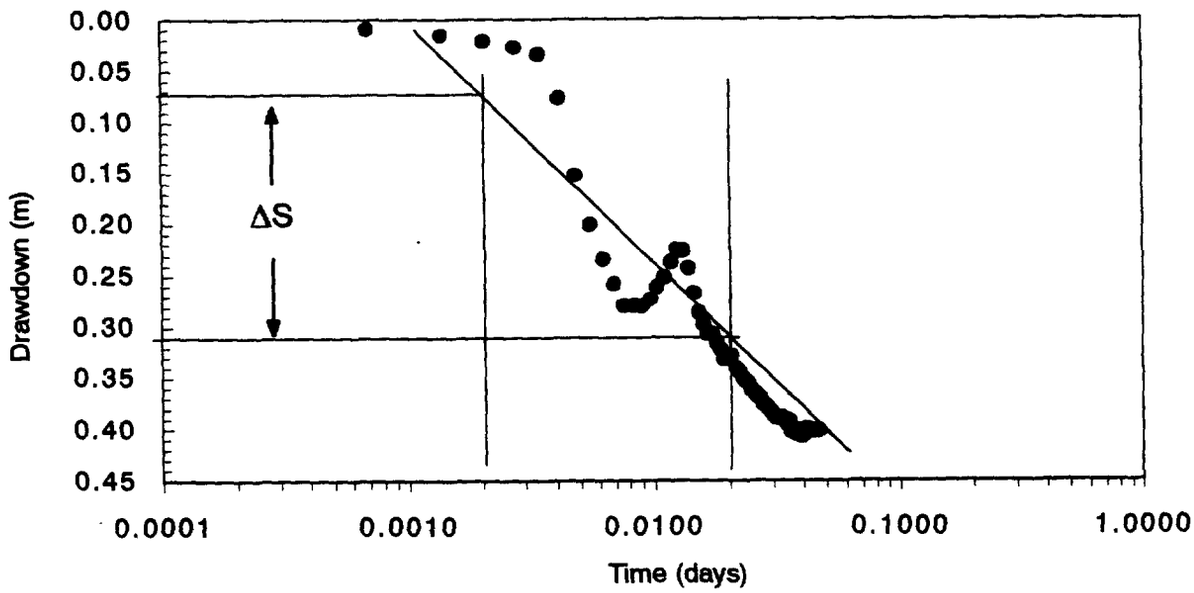

Figure HC-1.1. HC-1 pumping test analysis (1997).

Analysis	
Date:	2/20/1997
ΔS (m):	0.24
Q (m^3/day):	2.34
Screen Thickness (m):	81
Transmissivity (m^2/day):	1.7881
Hydraulic Conductivity (cm/sec):	2.56E-05

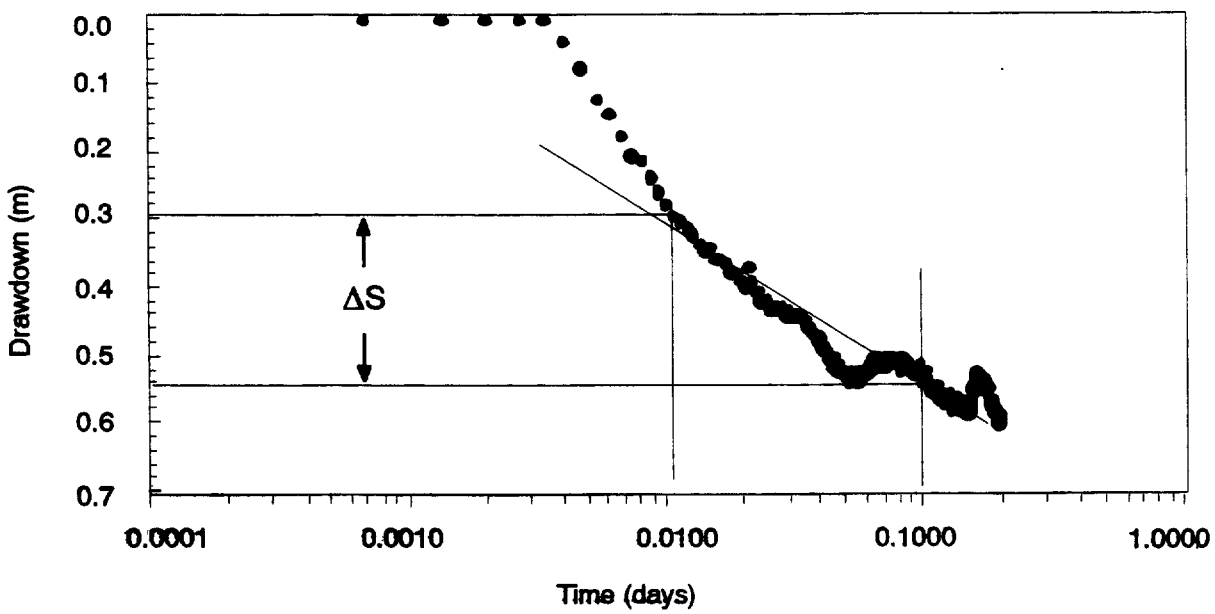

Figure HC-1.2. HC-1 pumping test analysis (1997).

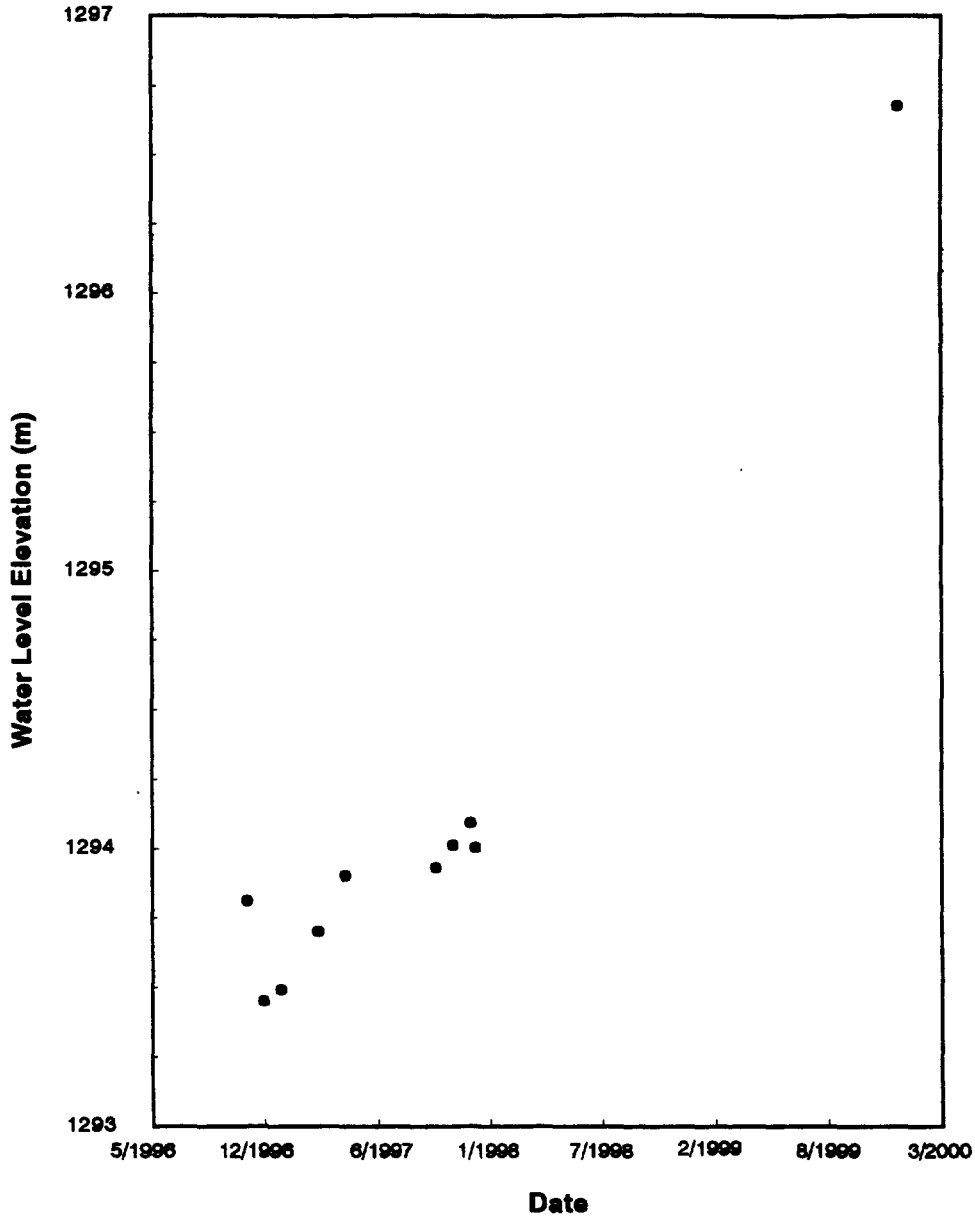

Figure HC-1.3. HC-1 water level vs. time.

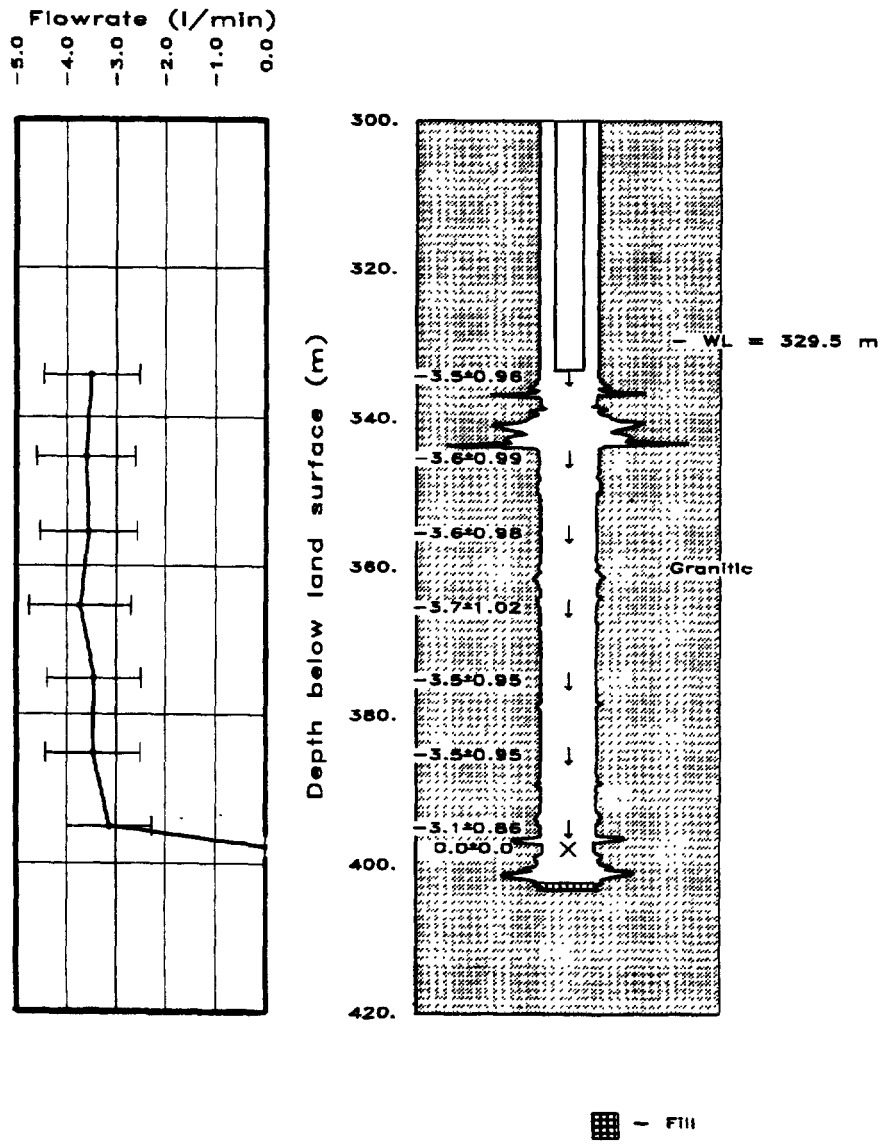

Figure HC-1.4. HC-1 well schematic and stressed thermal flowmeter results.

Table HC-1.1. HC-1 Measured and simulated borehole deviation.

Cable Depth (m)	True Depth (m)	Regression True Depth (m)	Absolute Error (m)
0.03	0.03	0.03	0.0018
7.62	7.62	8.05	0.4320
15.24	15.24	16.06	0.8195
22.86	22.86	24.02	1.1666
30.48	30.47	31.95	1.4748
38.10	38.07	39.83	1.7543
45.72	45.66	47.67	2.0094
53.34	53.25	55.47	2.2230
60.96	60.84	63.24	2.3995
68.58	68.42	70.97	2.5523
76.20	75.99	78.66	2.6734
83.82	83.55	86.32	2.7732
91.44	91.11	93.95	2.8438
99.06	98.66	101.55	2.8956
106.68	106.20	109.12	2.9237
114.30	113.74	116.66	2.9263
121.92	121.27	124.18	2.9046
129.54	128.80	131.66	2.8629
137.16	136.32	139.12	2.8055
144.78	143.83	146.56	2.7336
152.40	151.32	153.98	2.6545
160.02	158.81	161.37	2.5604
167.64	166.30	168.75	2.4494
175.26	173.78	176.10	2.3227
182.88	181.26	183.44	2.1877
190.50	188.73	190.77	2.0394
198.12	196.19	198.07	1.8823
205.74	203.65	205.37	1.7174
213.36	211.10	212.65	1.5430
220.98	218.55	219.92	1.3665
228.60	225.98	227.18	1.1920
236.22	233.41	234.43	1.0209
243.84	240.81	241.67	0.8604
251.46	248.20	248.91	0.7057
259.08	255.58	256.14	0.5549
266.70	262.95	263.37	0.4185
274.32	270.30	270.59	0.2946
281.94	277.63	277.81	0.1844
289.56	284.94	285.04	0.0954
297.18	292.23	292.26	0.0316
304.80	299.51	299.49	0.0177
312.42	306.77	306.72	0.0483
320.04	313.93	313.95	0.0171
327.66	321.19	321.19	0.0031
335.28	328.44	328.44	0.0007
342.90	335.69	335.70	0.0068
350.52	342.95	342.96	0.0118
358.14	350.23	350.24	0.0032
365.76	357.54	357.52	0.0148
373.38	364.87	364.83	0.0407
381.00	372.22	372.14	0.0797
388.62	379.60	379.47	0.1242
396.24	386.99	386.82	0.1670
403.86	394.38	394.19	0.1916
404.16	394.68	394.48	0.1921

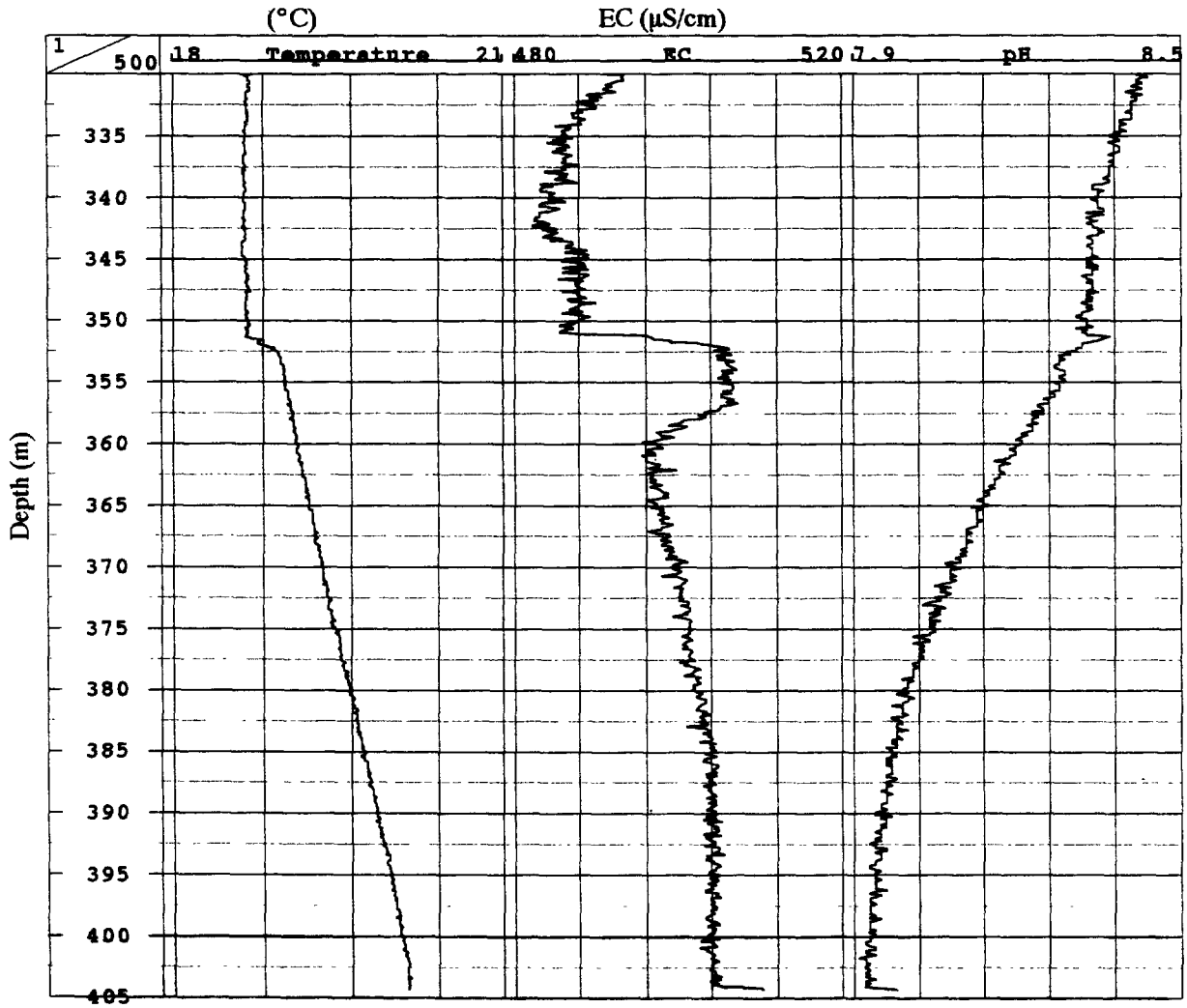

Figure HC-1.5. HC-1 chemlog containing temperature, electrical conductivty and pH.

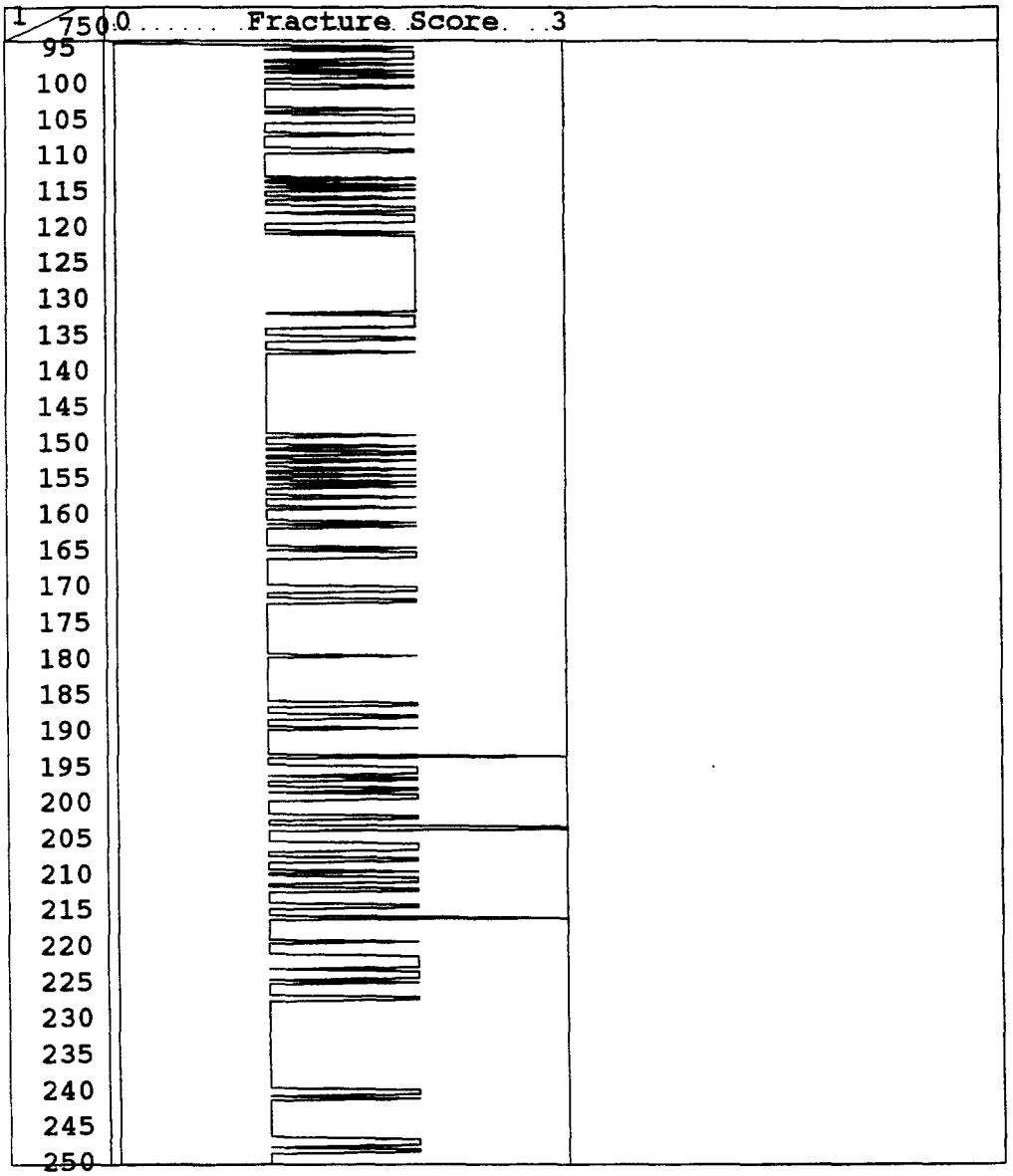

Figure HC-1.6. HC-1 fracture interpretation scores (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault).

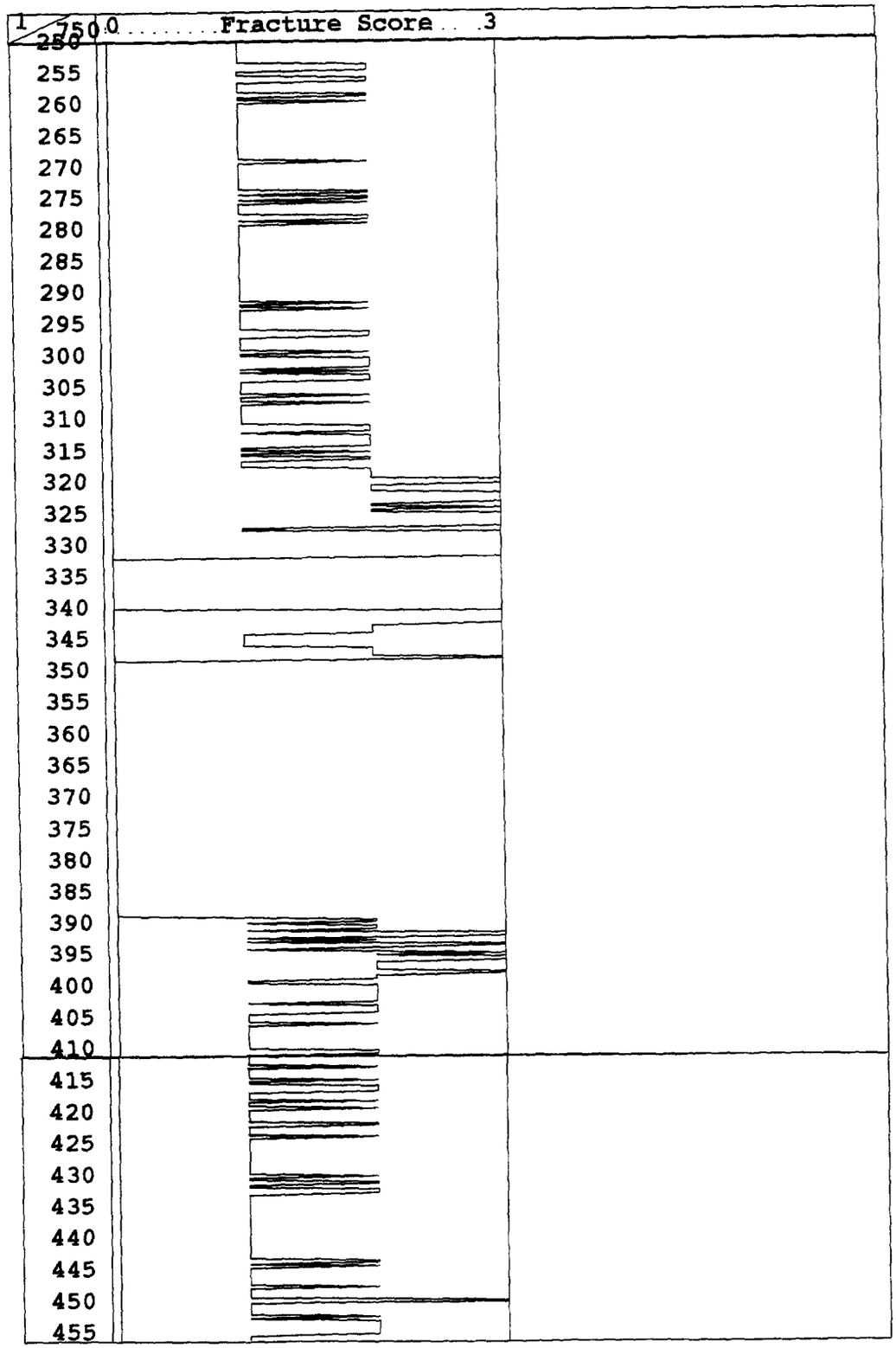

Figure HC-1.6. HC-1 fracture interpretation scores (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) (continued).

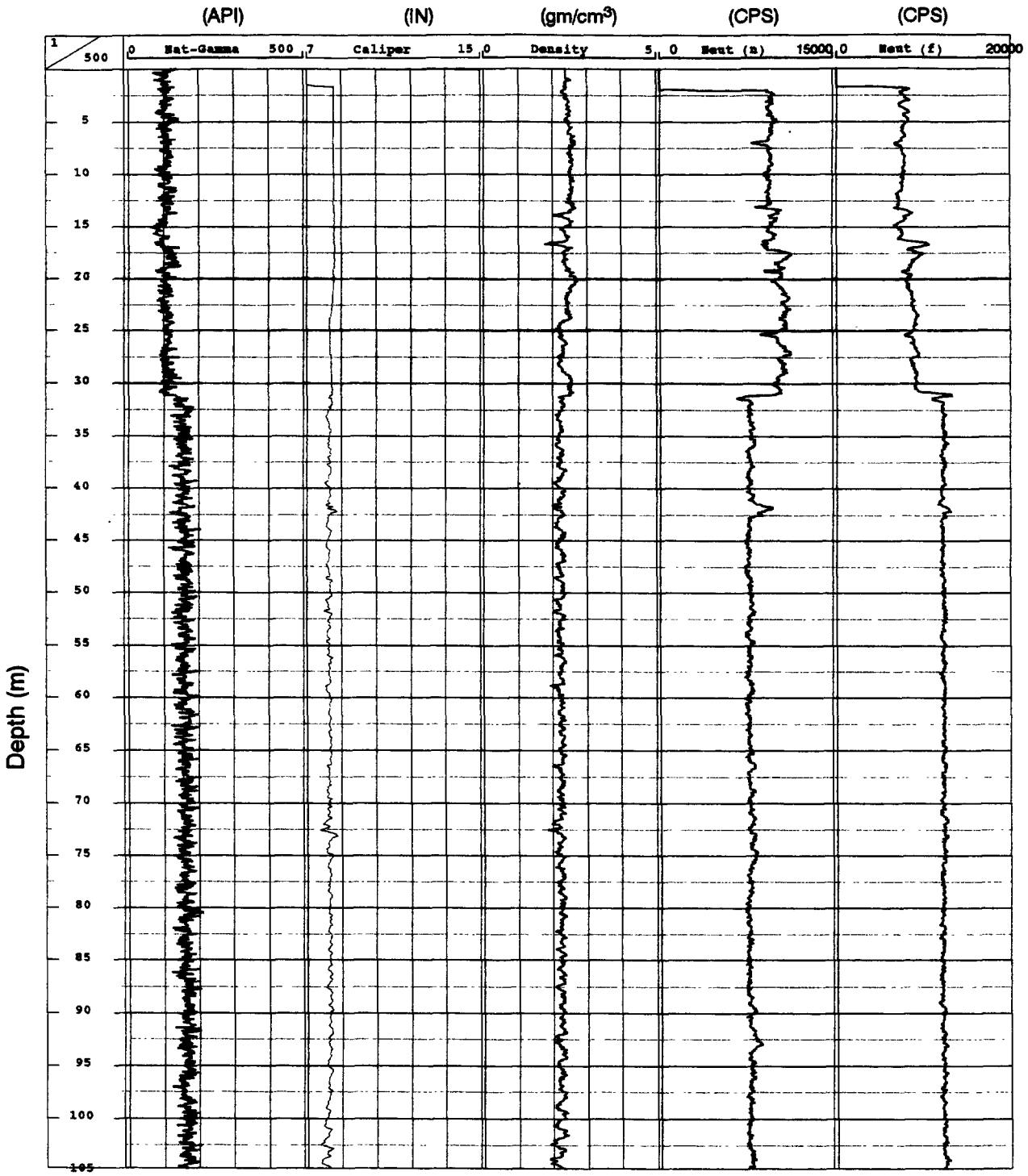

Figure HC-1.7. HC-1 natural gamma, caliper, density, and neutron logs.

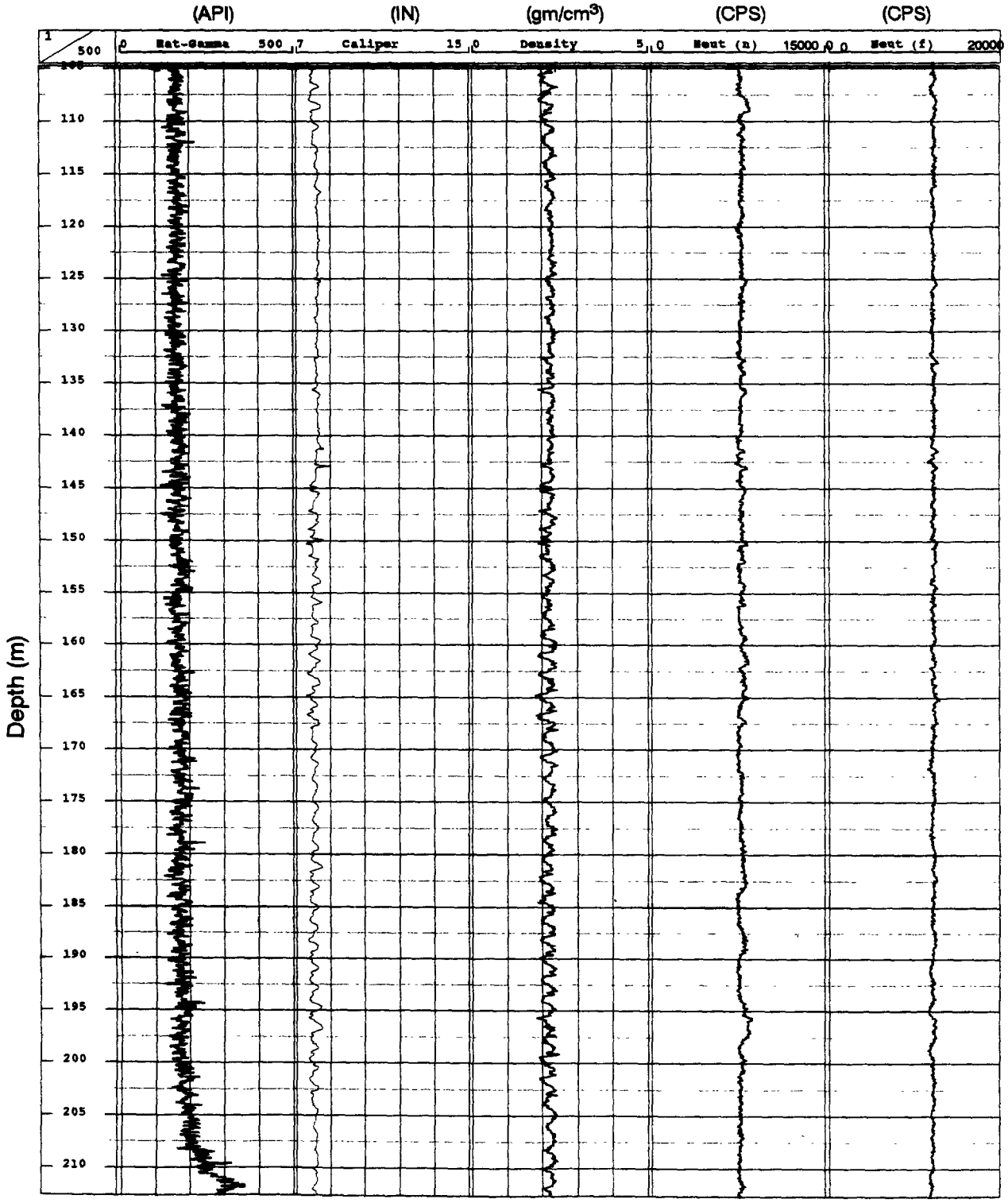

Figure HC-1.7. HC-1 natural gamma, caliper density, and neutron logs (continued).

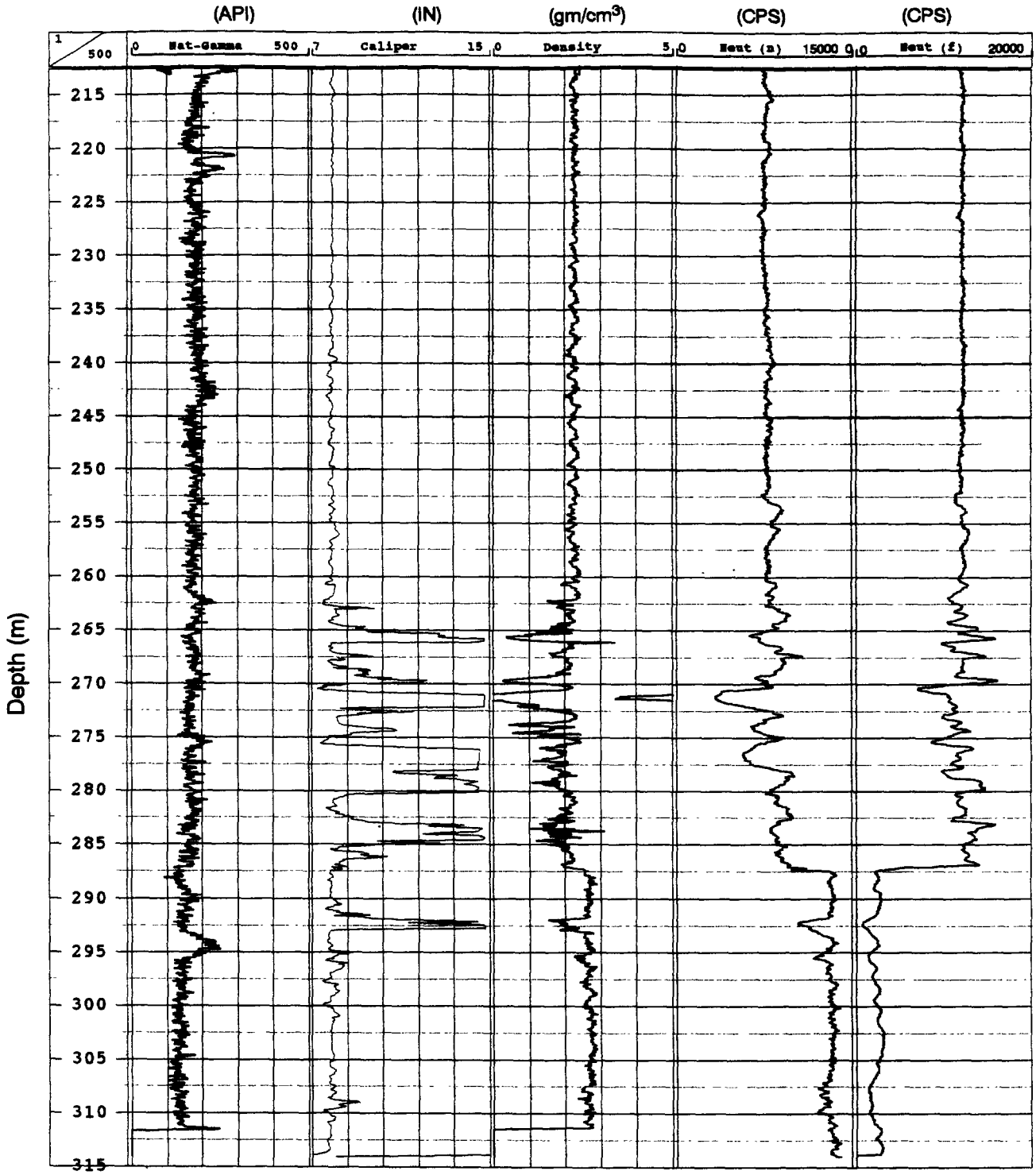

Figure HC-1.7. HC-1 natural gamma, caliper, density, and neutron logs (continued).

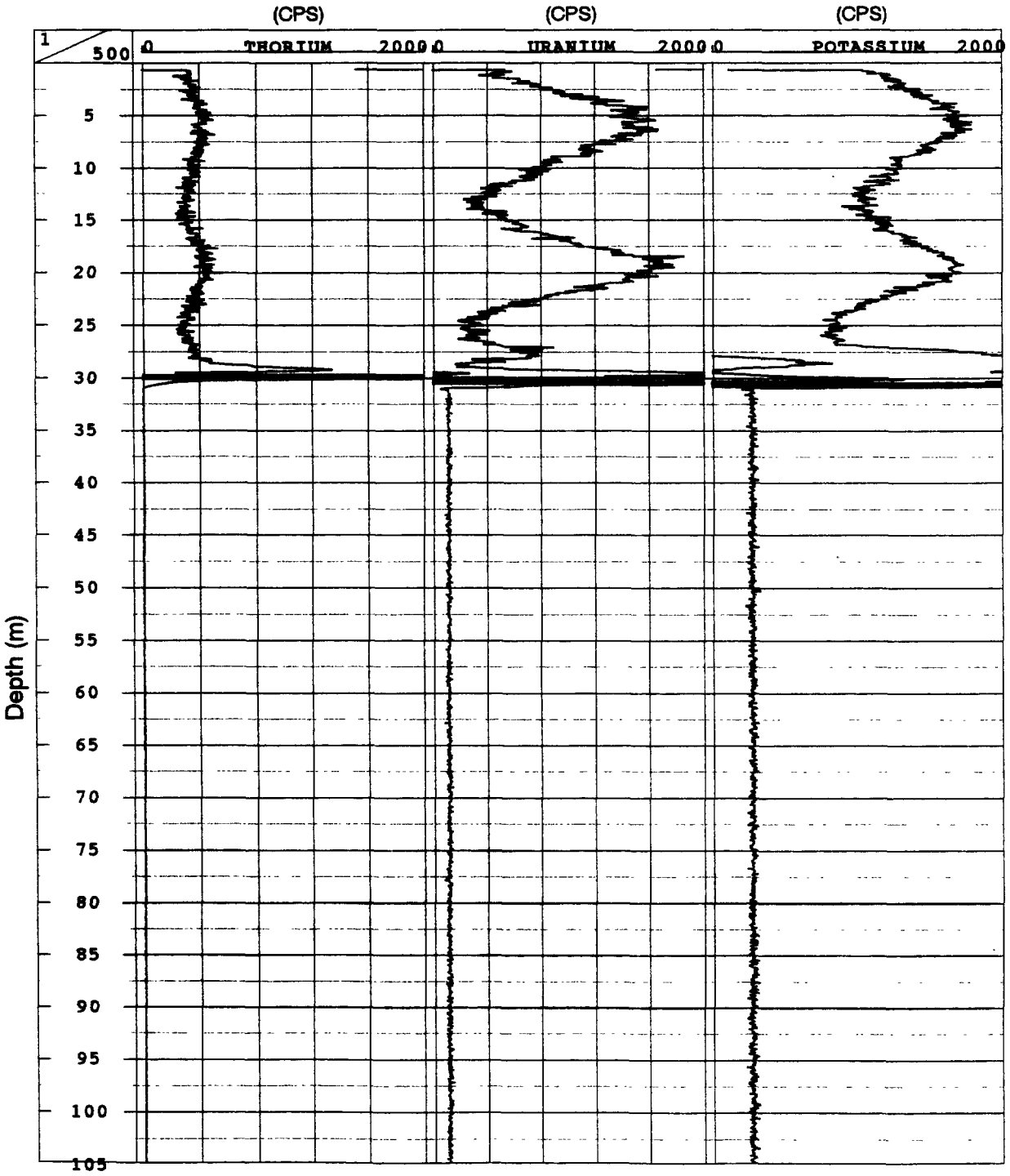

Figure HC-1.8. HC-1 spectral gamma logs.

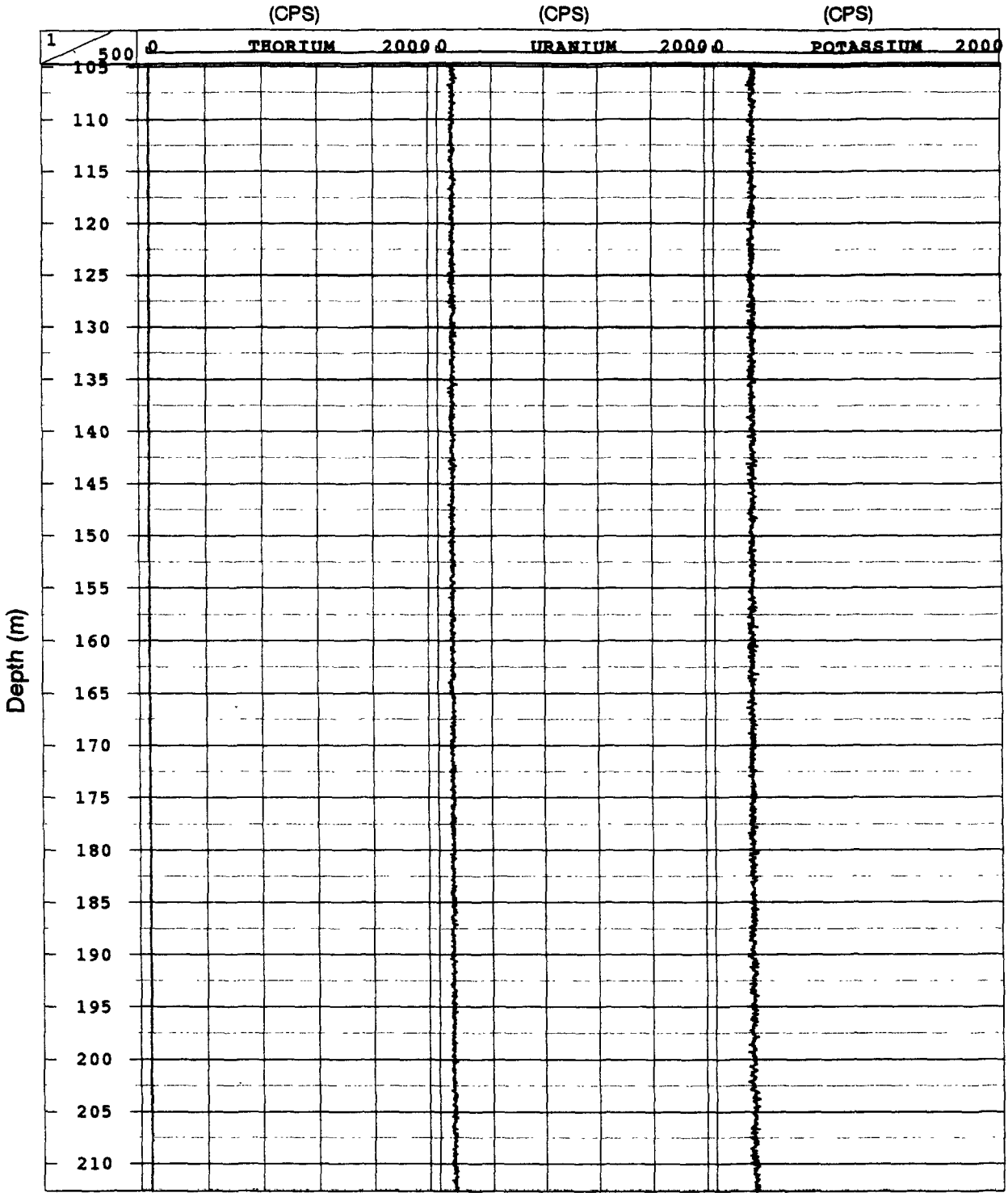

Figure HC-1.8. HC-1 spectral gamma logs (continued).

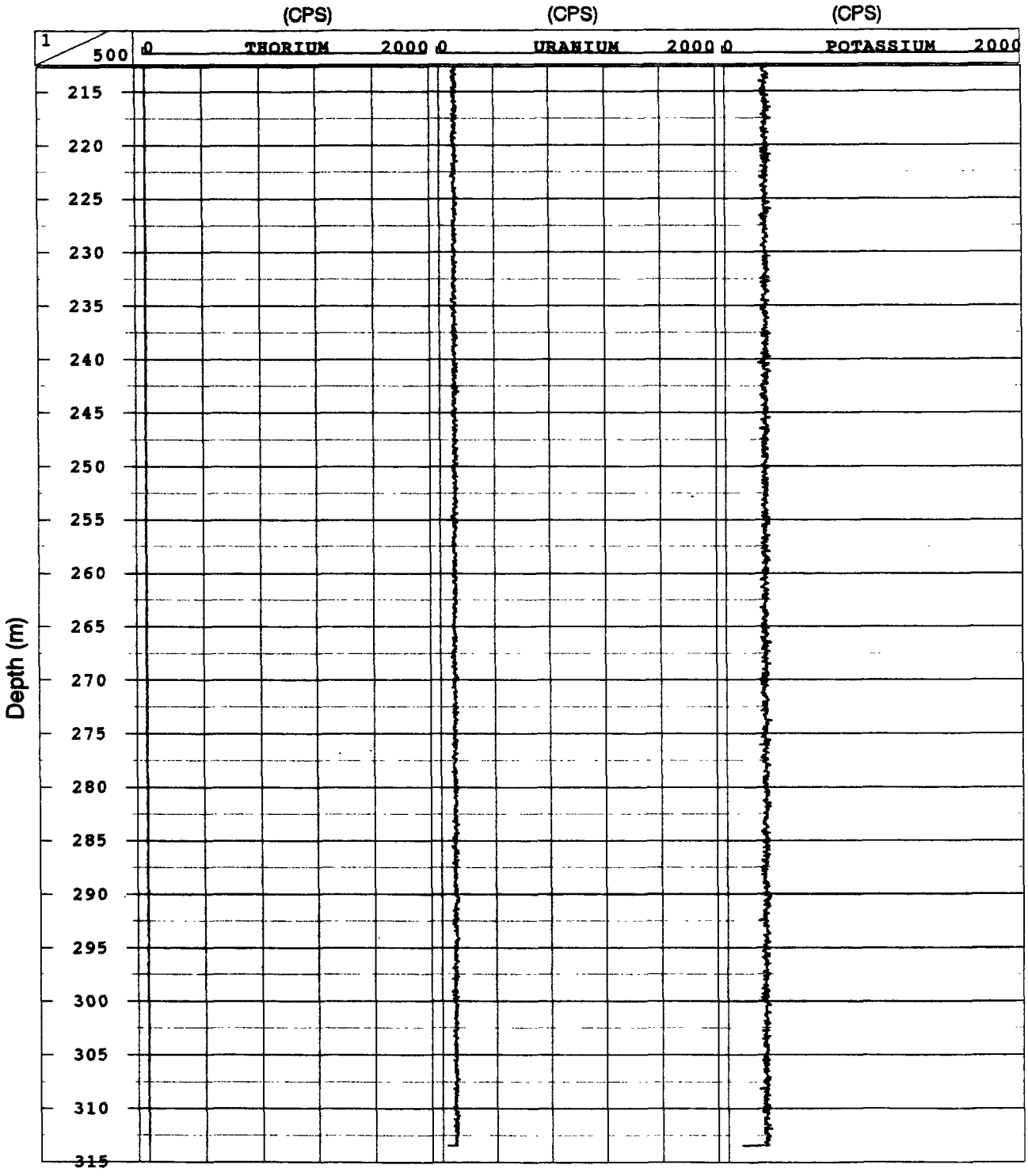

Figure HC-1.8. HC-1 spectral gamma logs (continued).

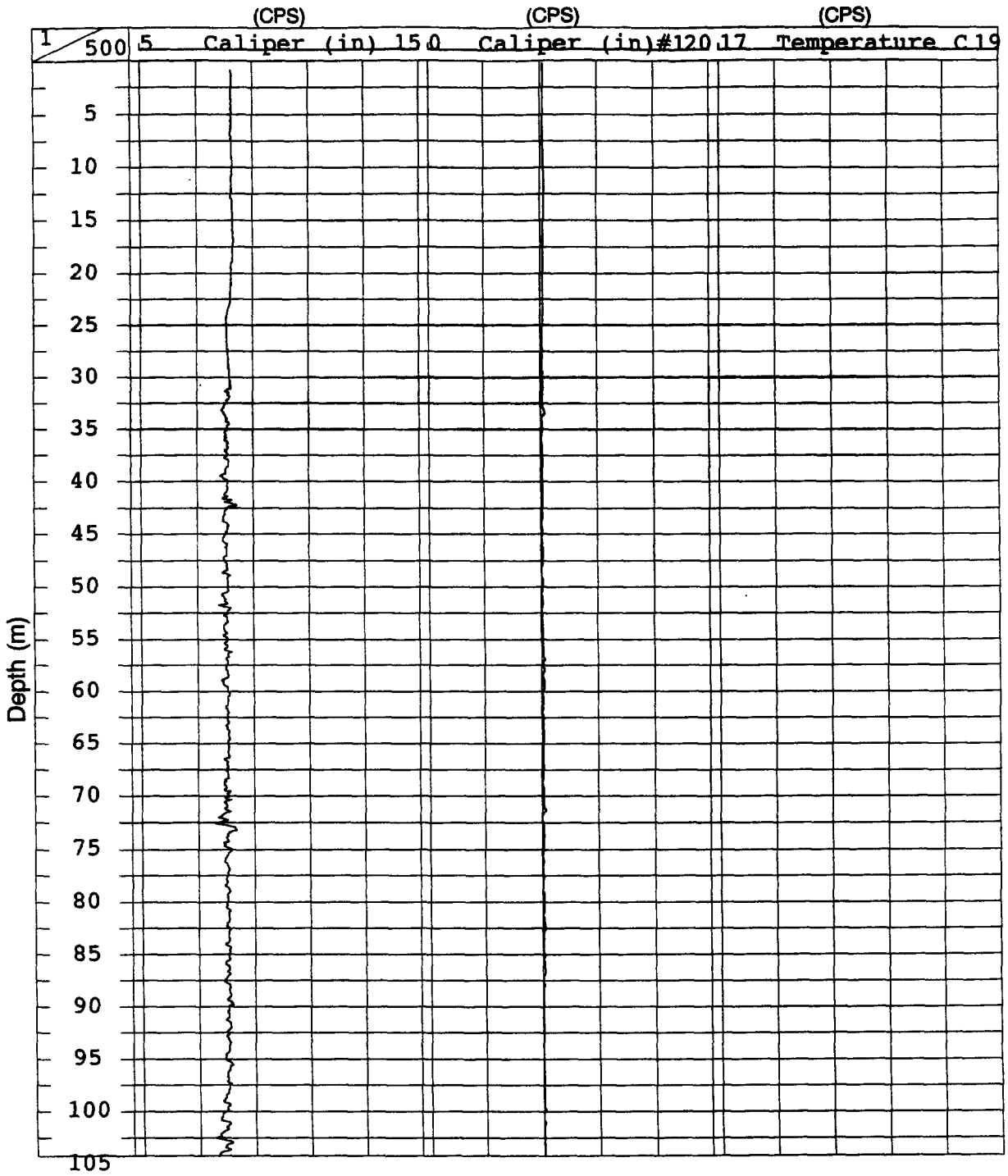

Figure HC-1.9. HC-1 caliper and temperature logs.

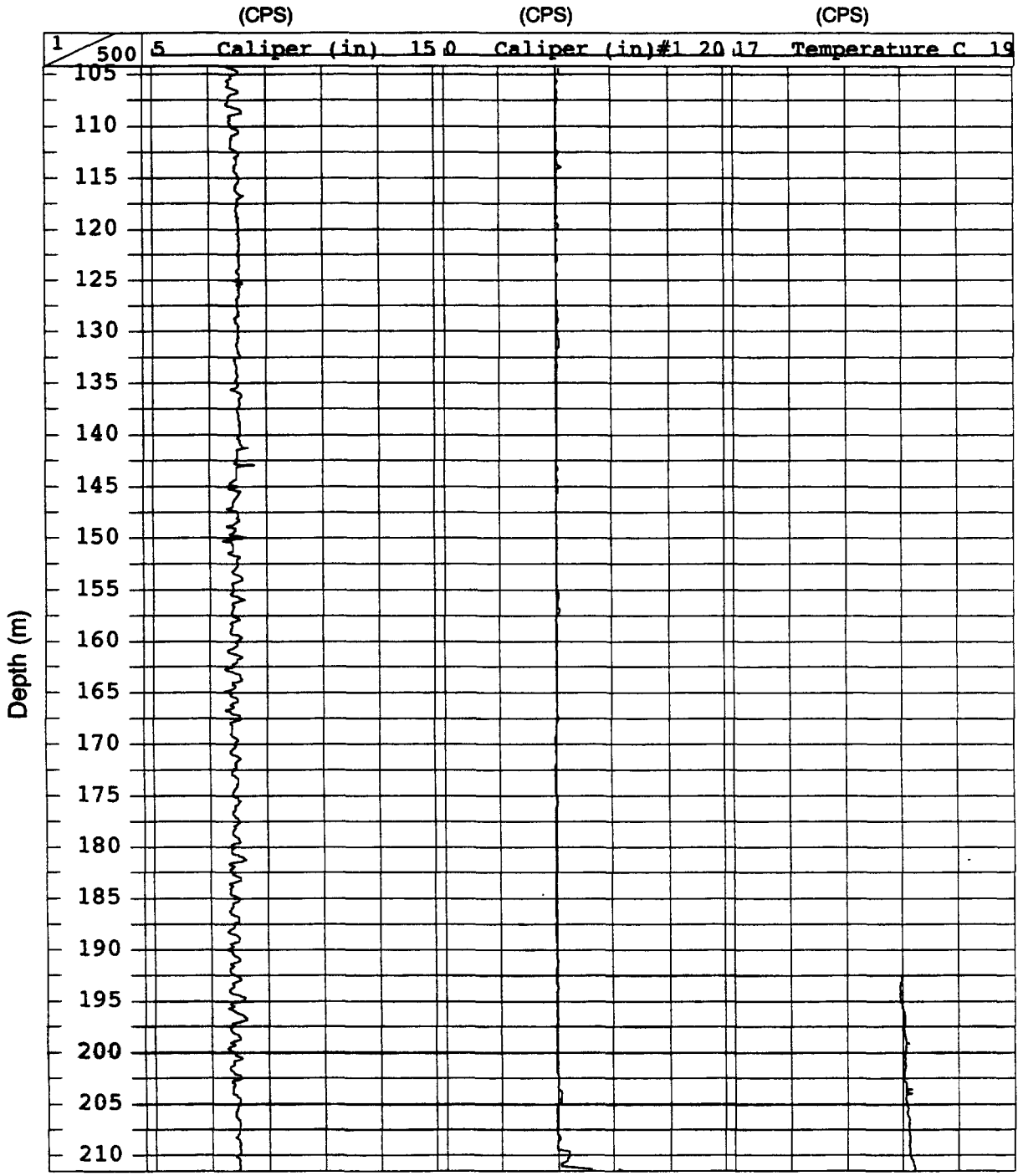

Figure HC-1.9. HC-1 caliper and temperature logs (continued).

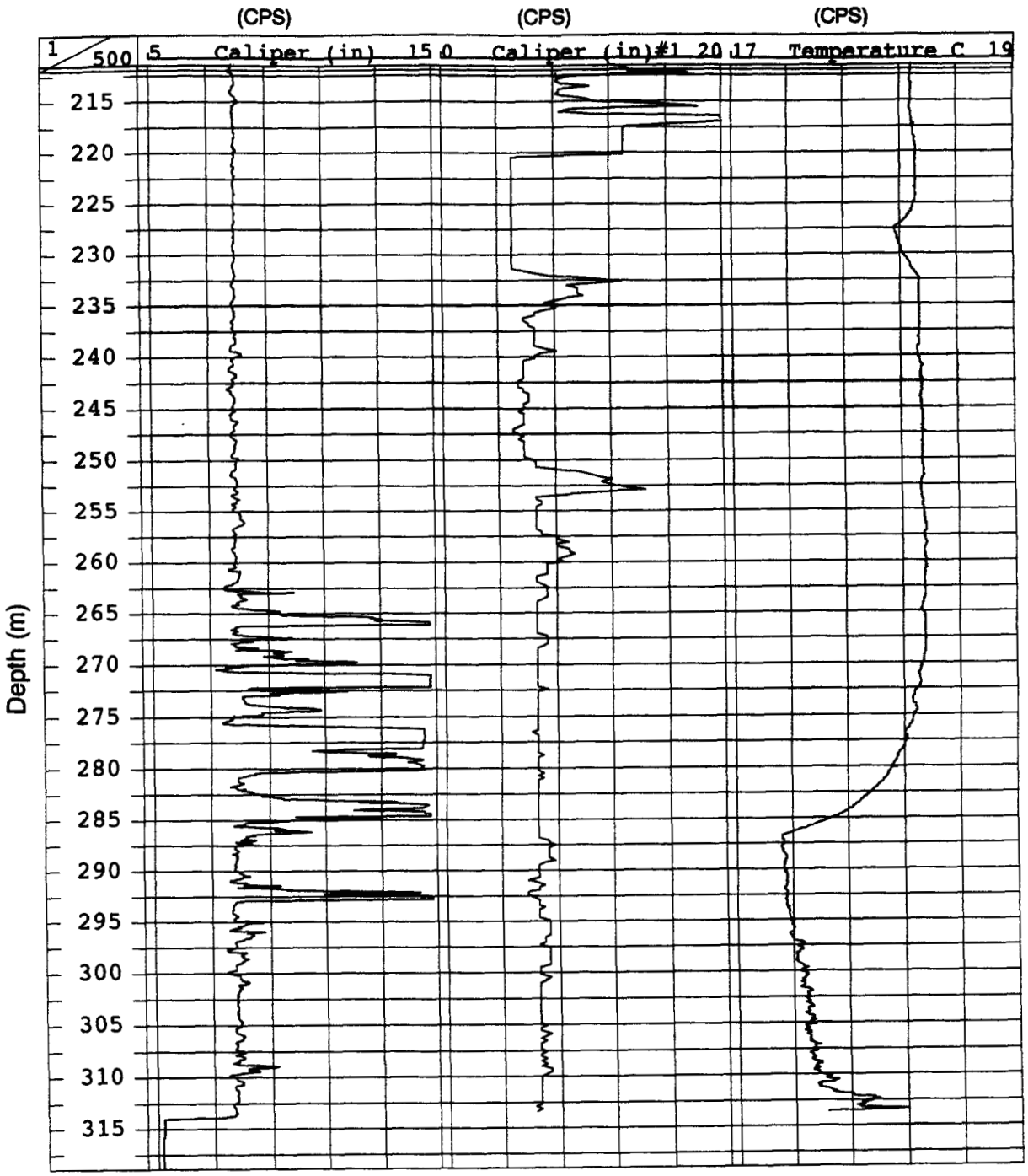

Figure HC-1.9. HC-1 caliper and temperature logs (continued).

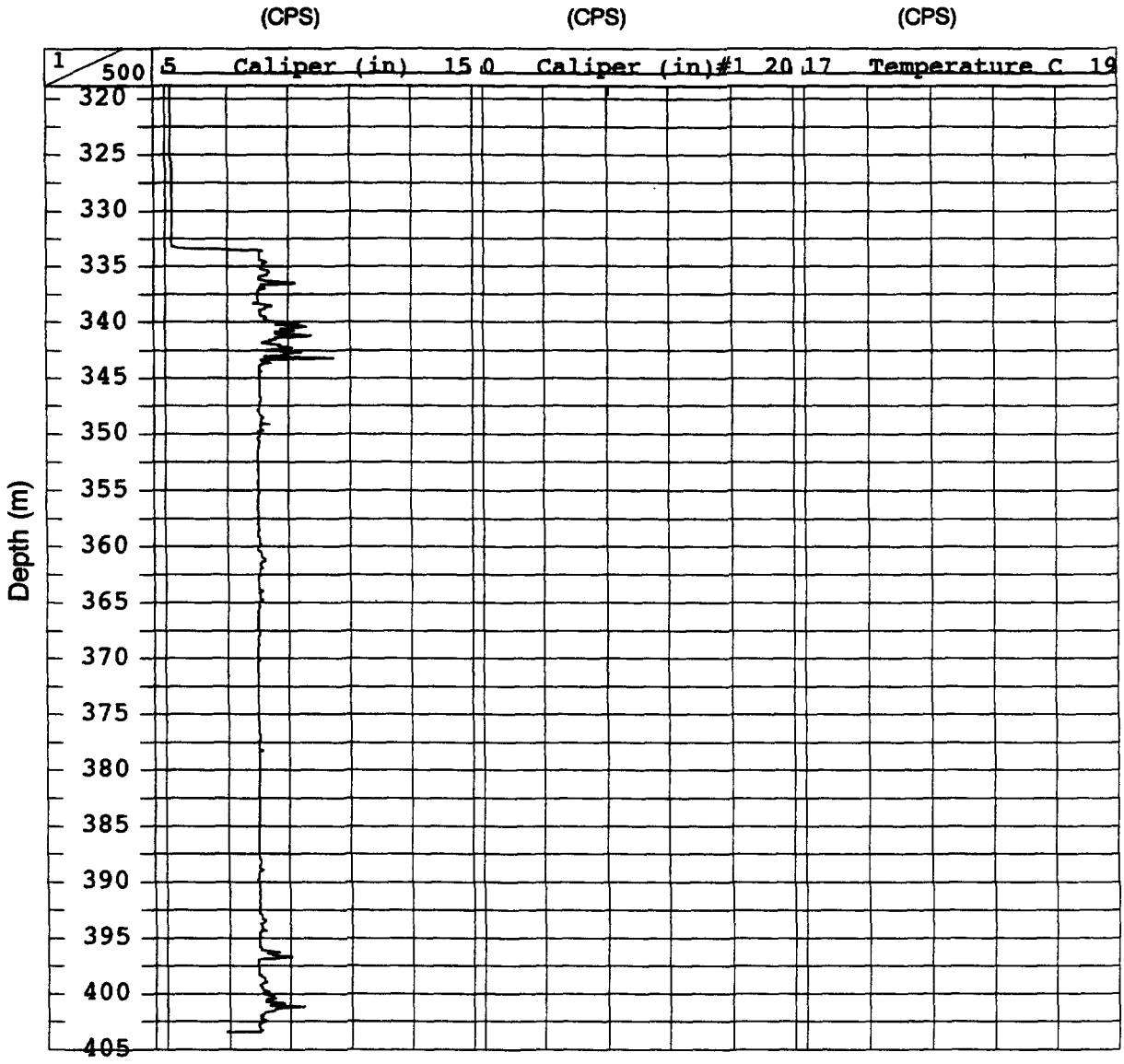

Figure HC-1.9. HC-1 caliper and temperature logs (continued).

HC-2

Available Data

- Pumping Test
- Water Level vs. Time
- Stressed Thermal Flow
- Borehole Deviaiton
- Chemtool Log (temperature, EC, pH)
- Radar Log
- Fracture Interpretation Log
- Natural Gamma Log
- Resistivity Log
- Caliper Log
- Density Log
- Porosity Log (derived from neutron)
- Spectral Gamma Ray Log (thorium, uranium, potassium)

Analysis	
Date:	2/24/1997
ΔS (m):	5.95
Q (m^3/day):	2.45
Screen Thickness (m):	32.62
Transmissivity (m^2/day):	1.7881
Hydraulic Conductivity (cm/sec):	2.68E-06

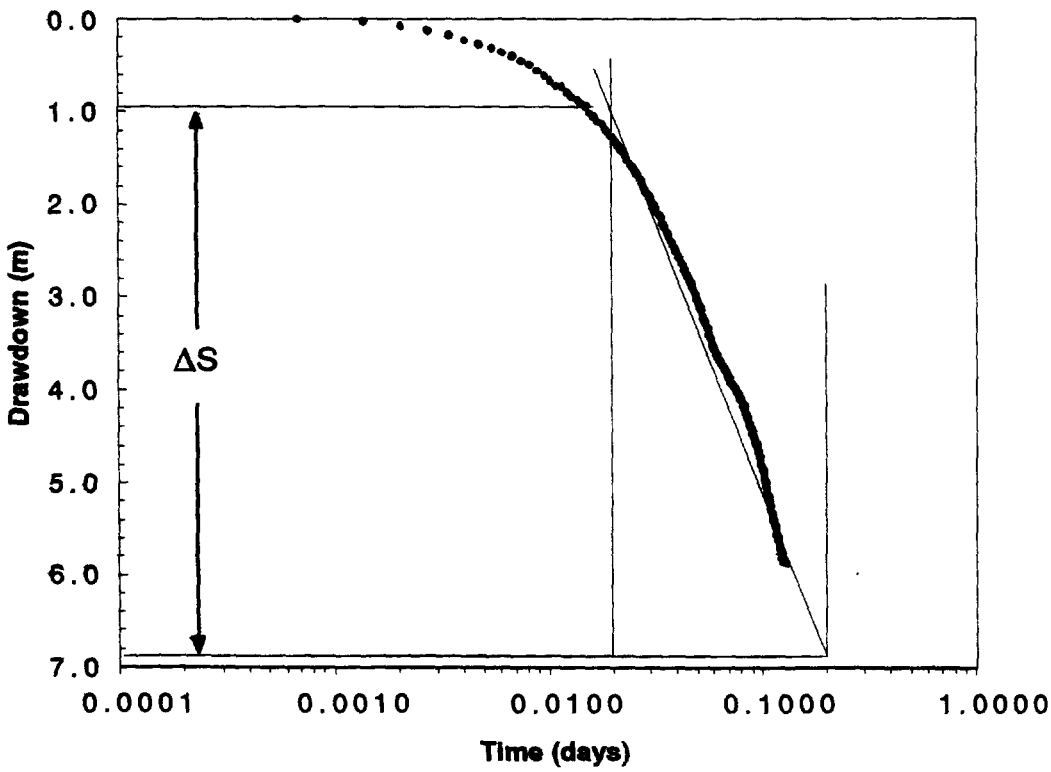

Figure HC-2.1. HC-2 pumping test analysis (1997).

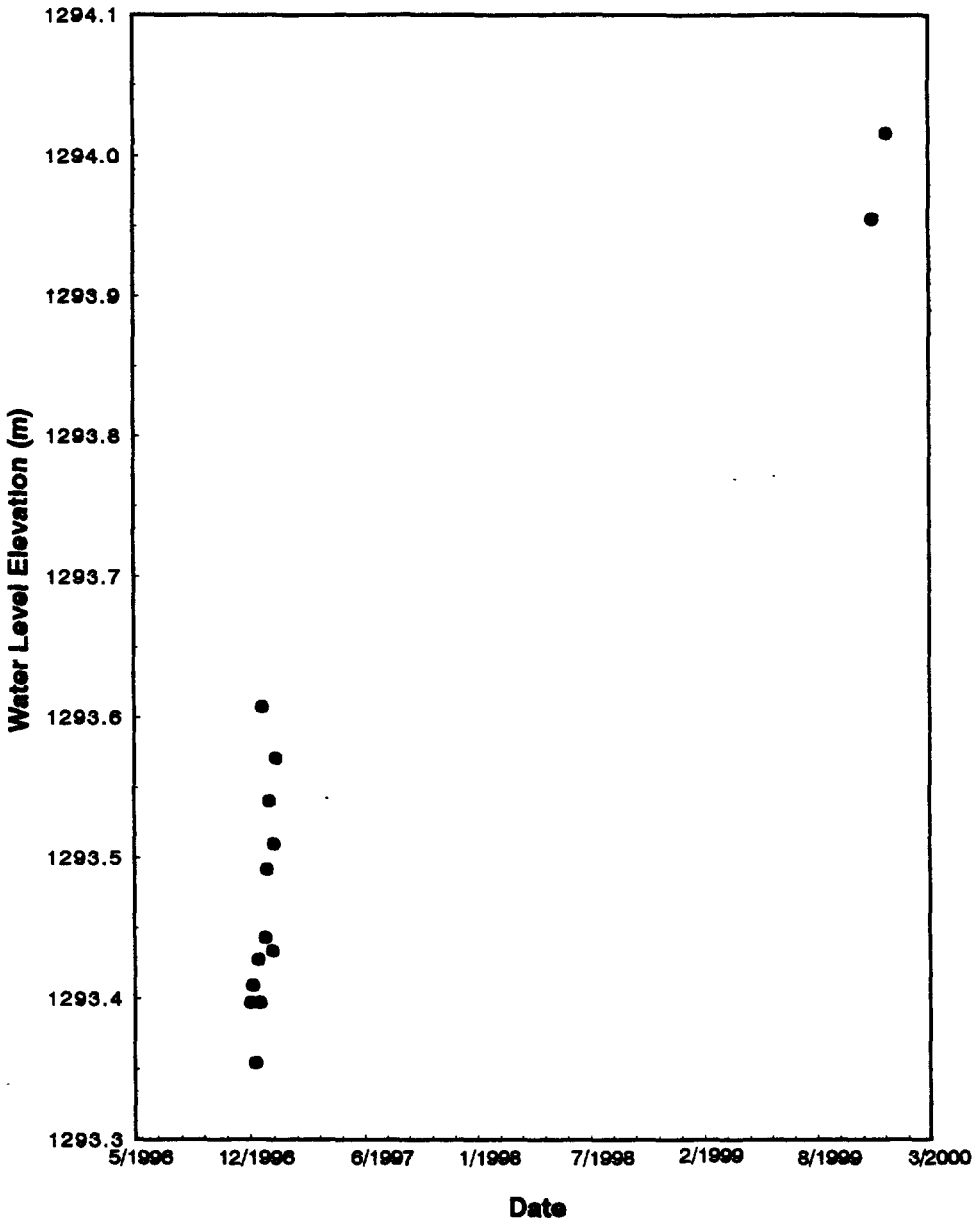

Figure HC-2.2. HC-2 water level vs. time.

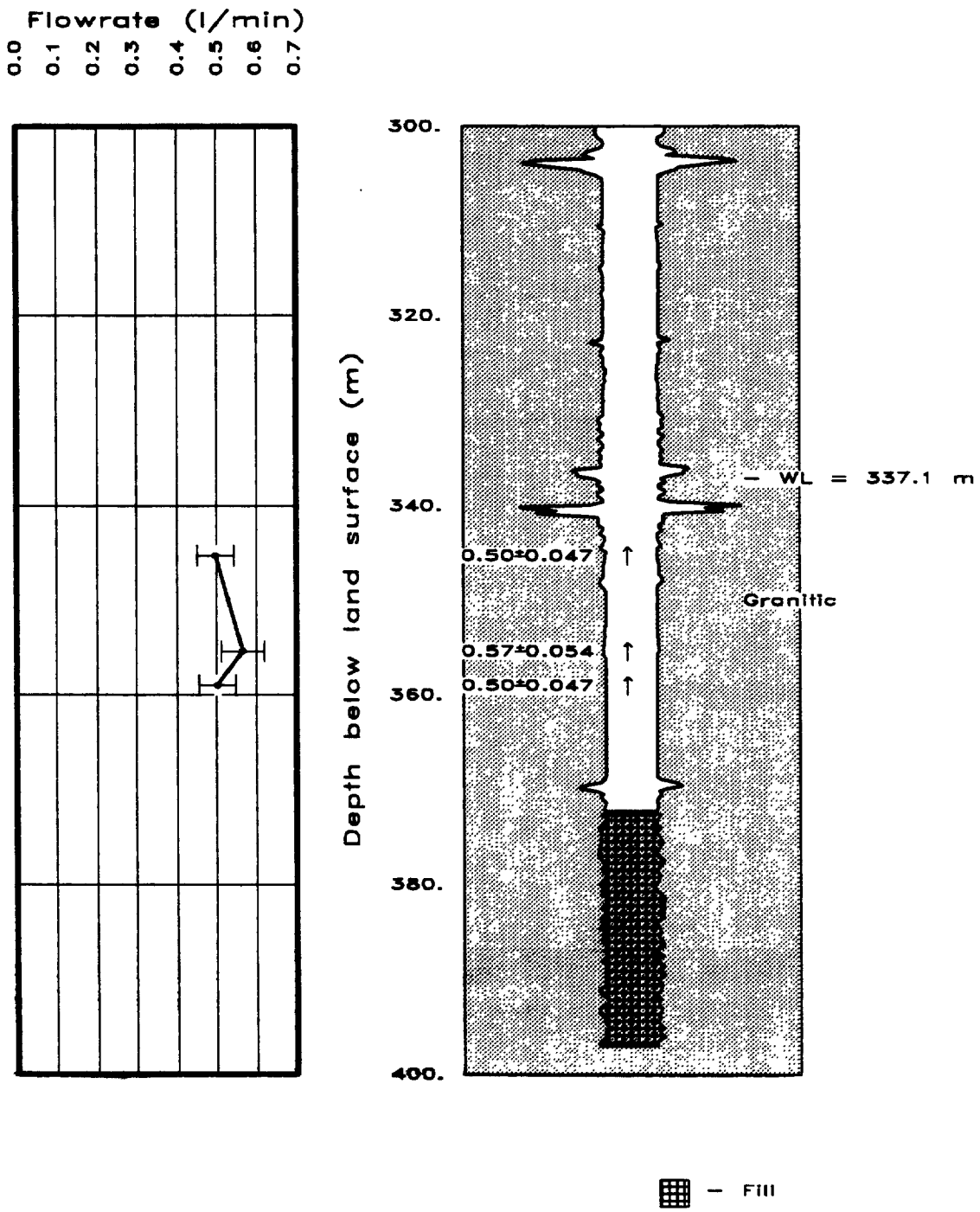

Figure HC-2.3. HC-2 well schematic and stressed thermal flowmeter results. Borehole geometry is based on caliper logs. Casing bottom is at a depth of 292 m.

Table HC-2.1. HC-2 measured and simulated borehole deviation.

Cable Depth (m)	True Depth (m)	Regression True Depth (m)	Absolute Error (m)
274.32	274.21	274.21	0.0004
281.94	281.83	281.83	0.0013
289.56	289.44	289.45	0.0009
297.18	297.06	297.06	0.0004
304.80	304.68	304.68	0.0001
312.42	312.30	312.29	0.0004
320.04	319.91	319.91	0.0004
327.66	327.53	327.53	0.0000
335.28	335.15	335.15	0.0009
342.90	342.77	342.76	0.0009
350.52	350.38	350.38	0.0003
358.14	358.00	358.00	0.0006
365.76	365.62	365.62	0.0011
370.12	369.97	369.97	0.0006

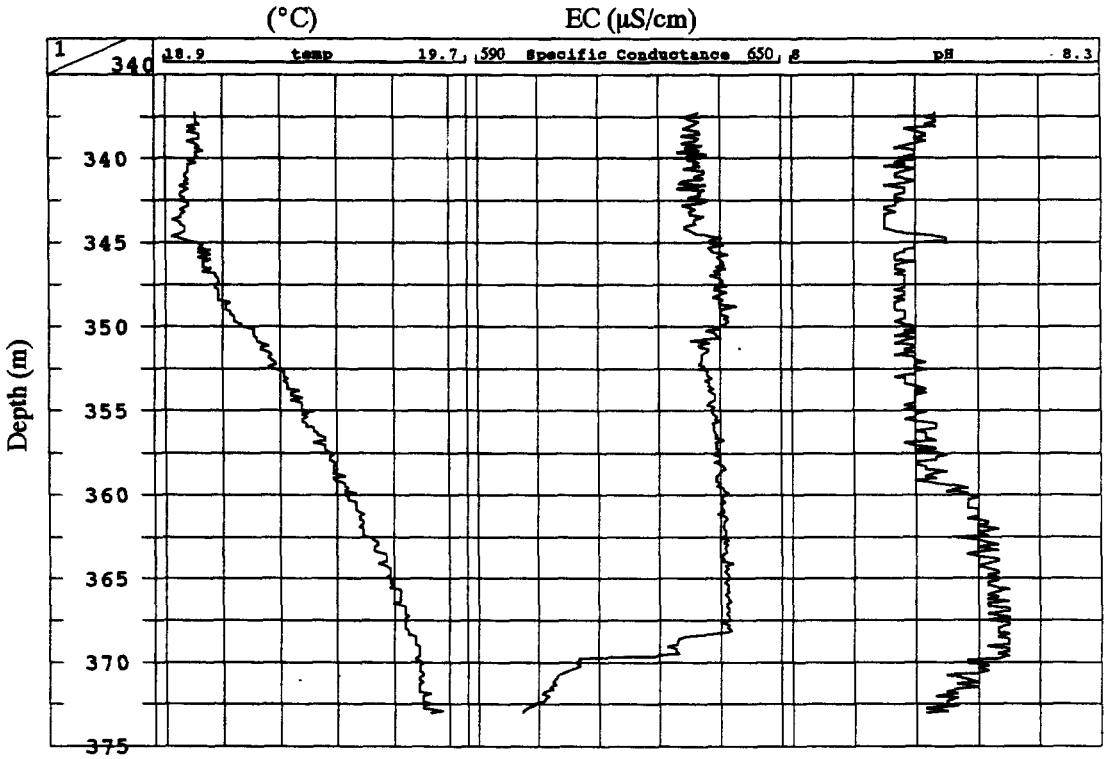

Figure HC-2.3. HC-2 chemlog containing temperature, EC and pH.

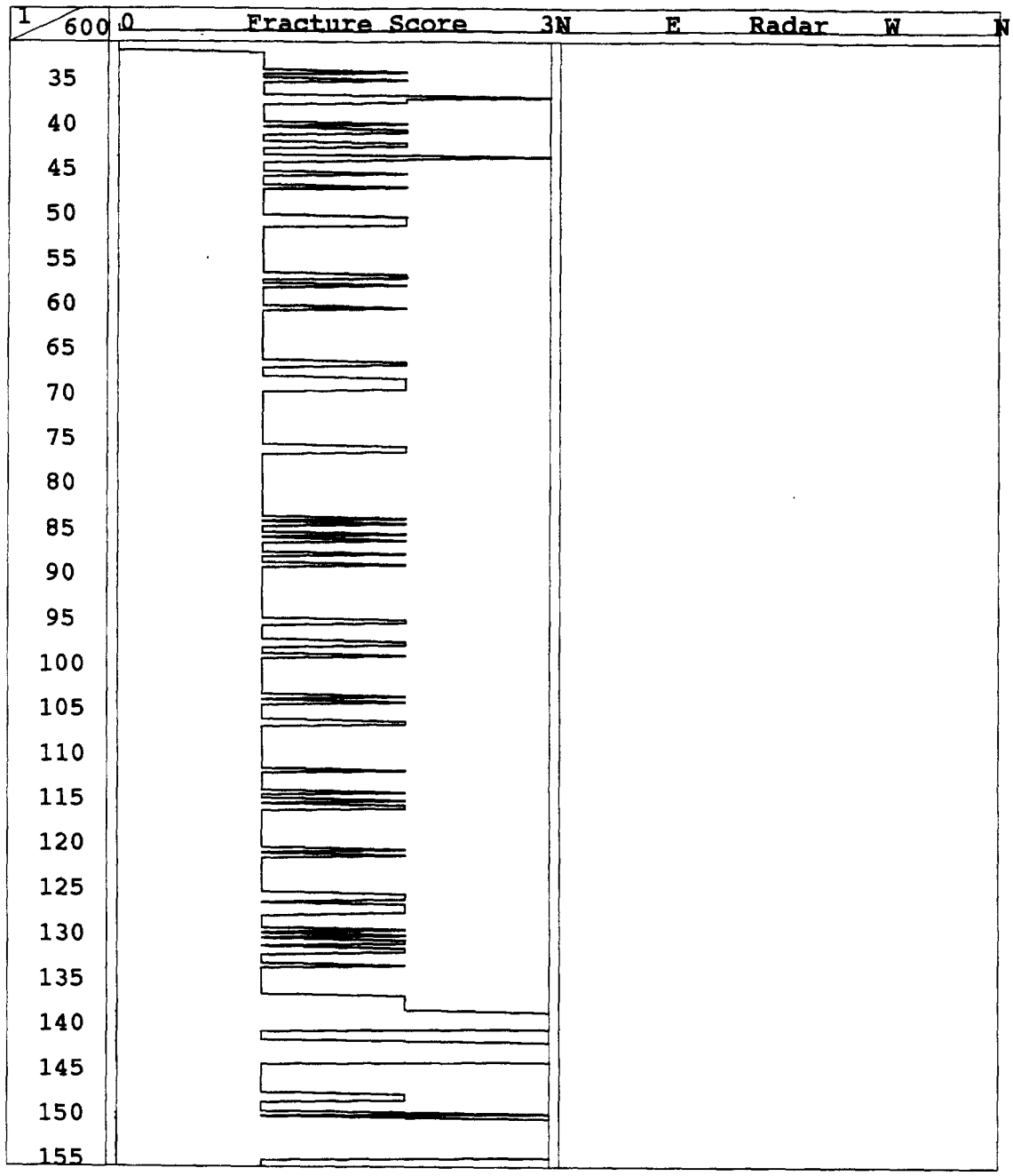

Figure HC-2.4. HC-2 fracture interpretation scores (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault).

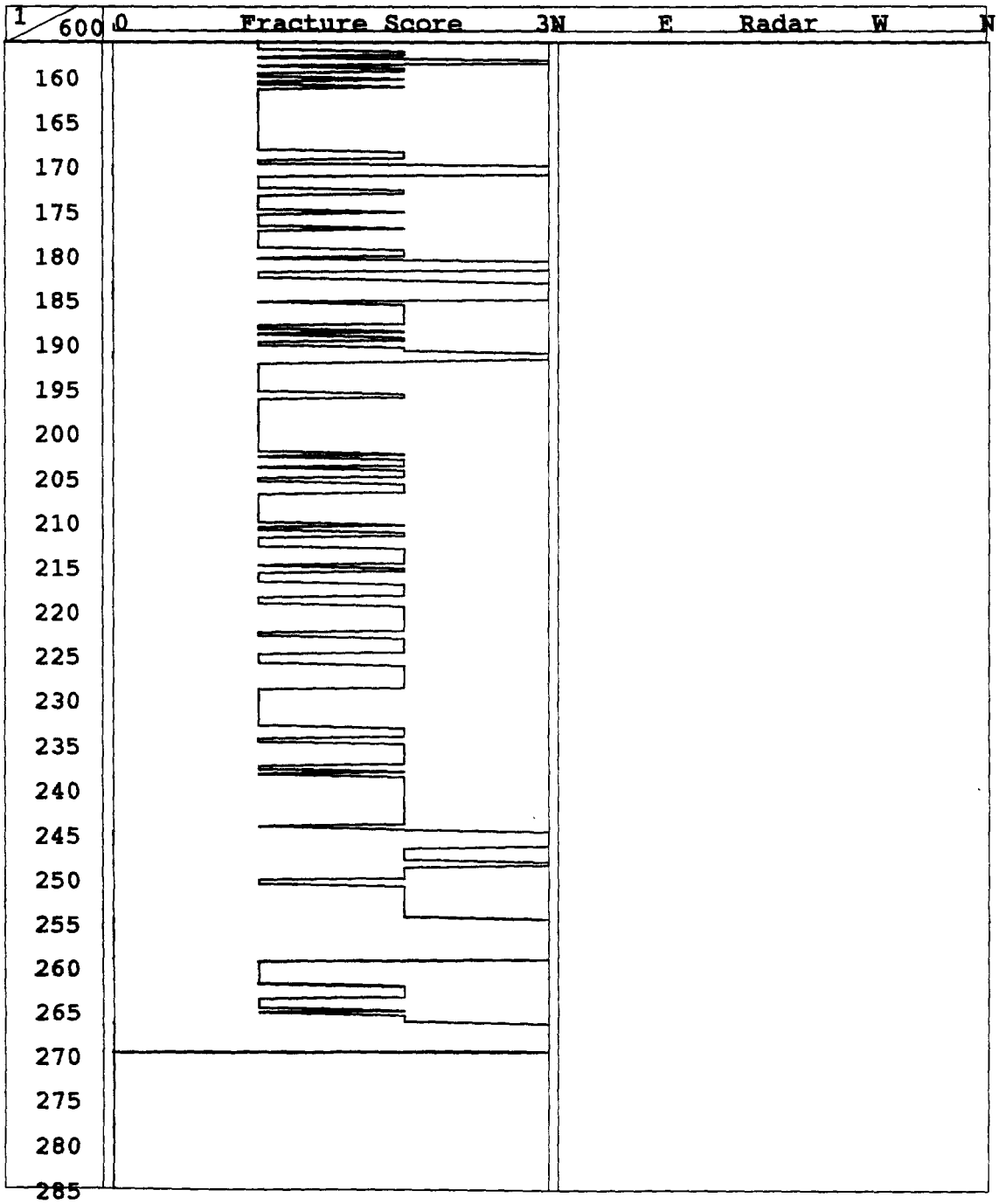

Figure HC-2.4. HC-2 fracture interpretation scores (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) (continued).

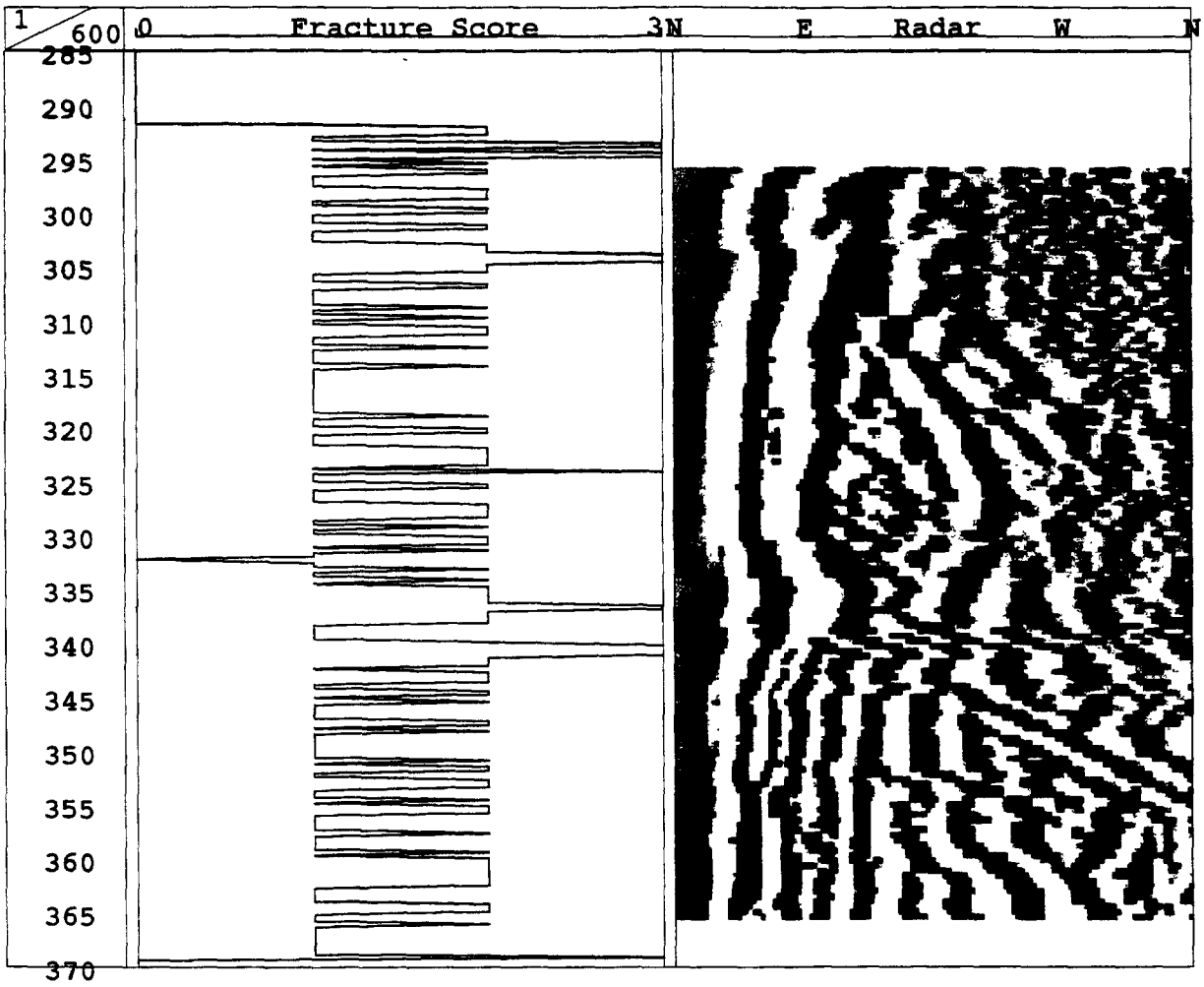

Figure HC-2.4. HC-2 fracture interpretation scores (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) (continued).

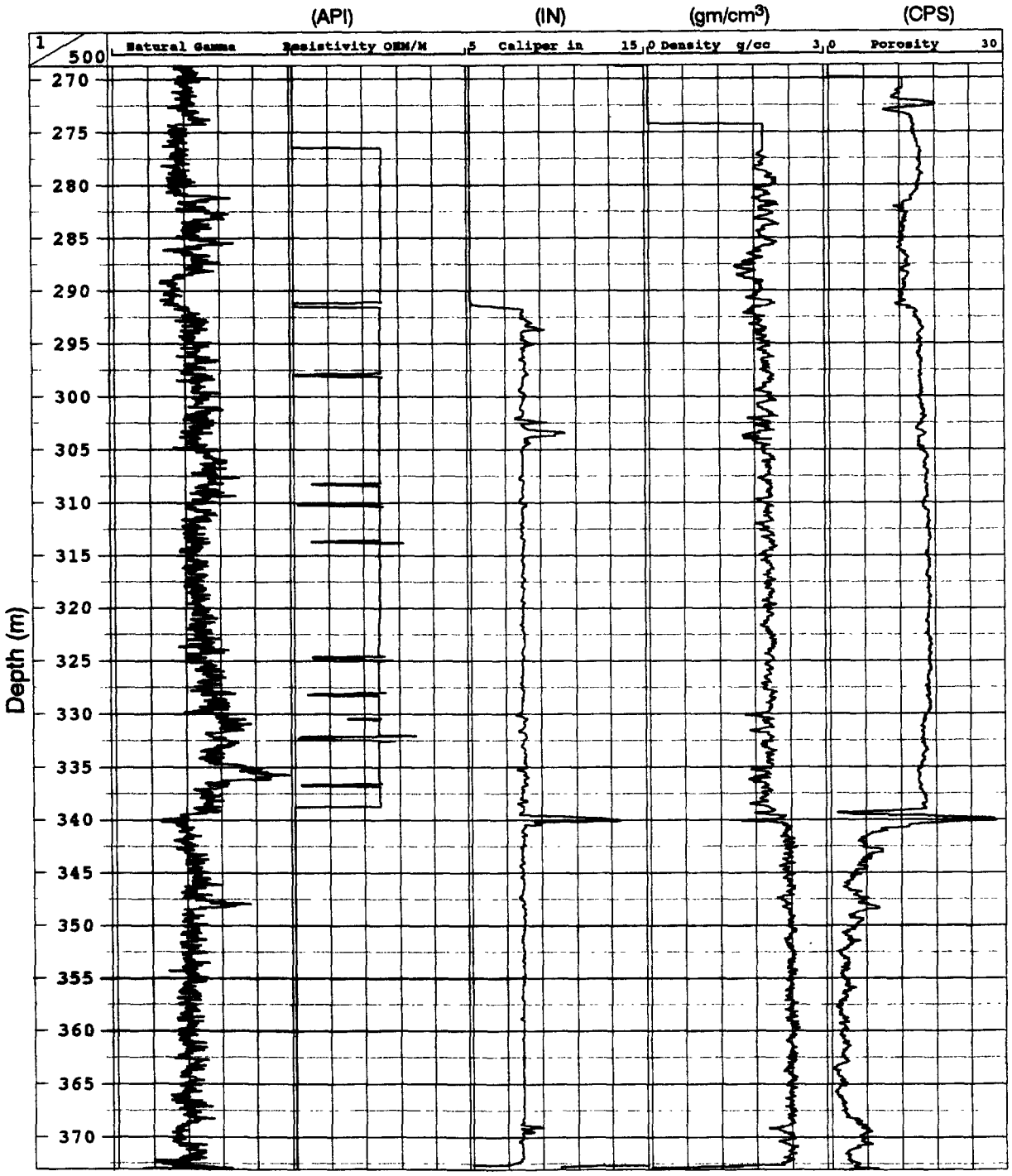

Figure HC-2.5. HC-2 natural gamma, resistivity, caliper, density, and porosity (calculated from neutron log).

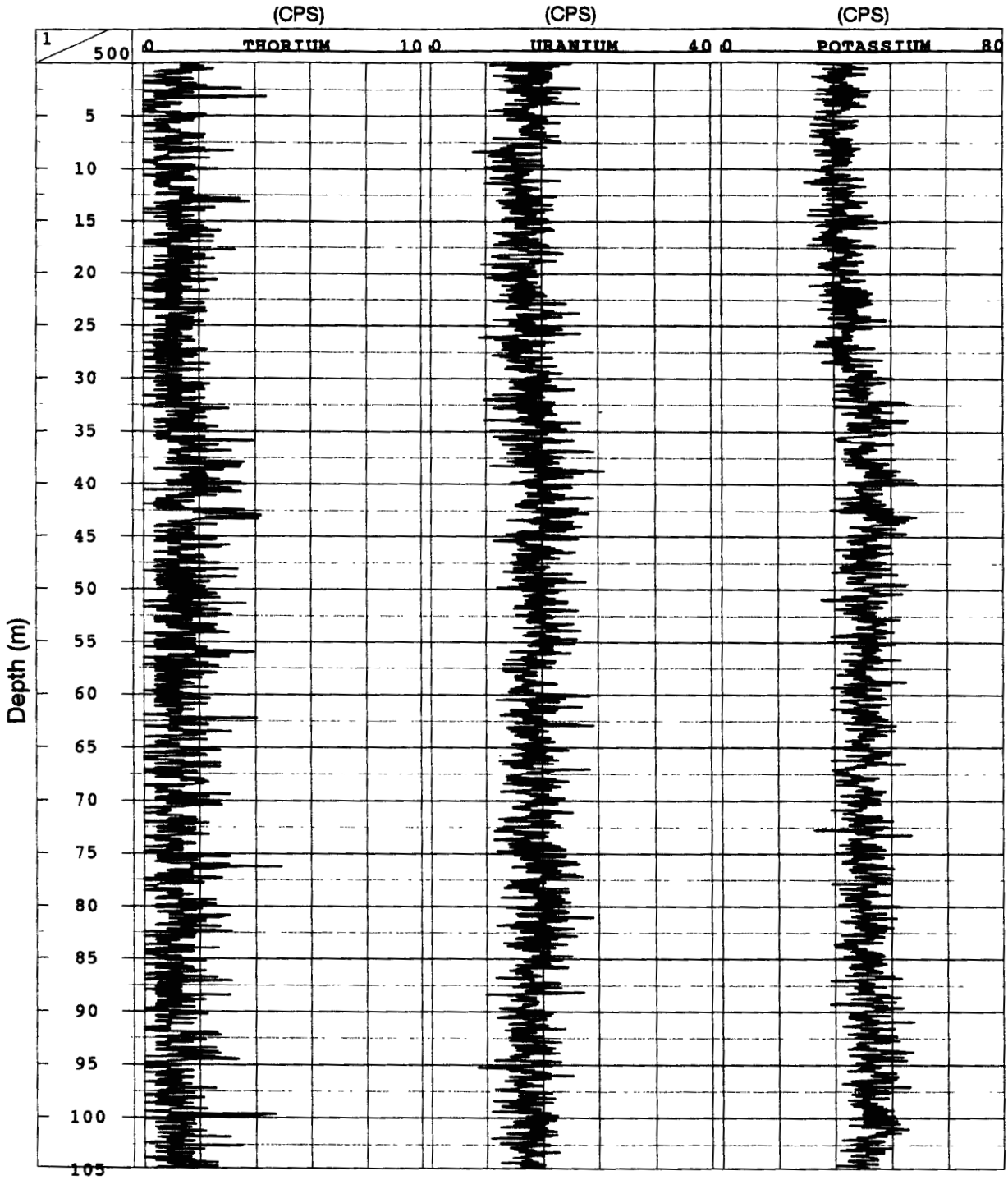

Figure HC-2.6. HC-2 spectral gamma log containing thorium, uranium and potassium.

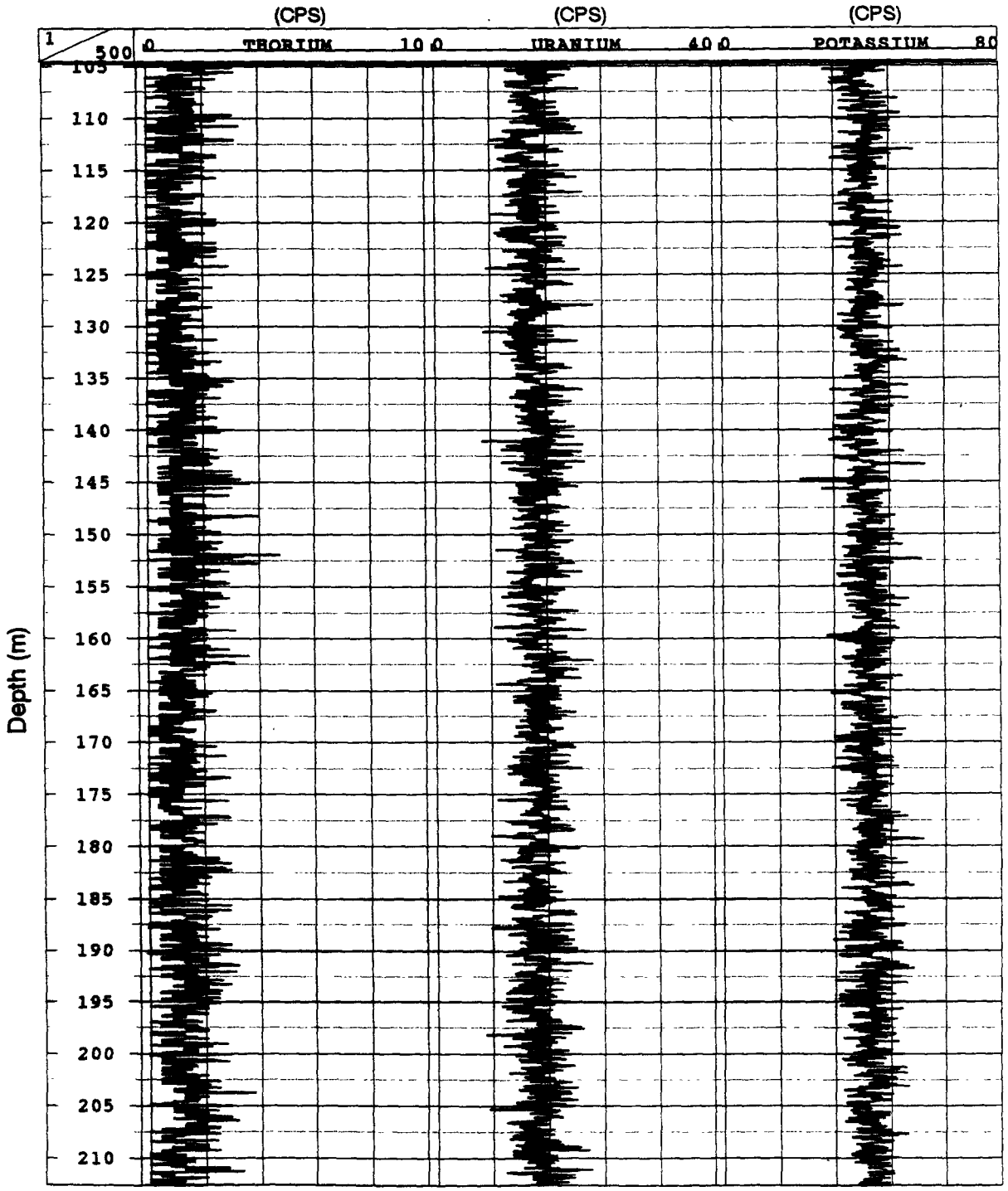

Figure HC-2.6. HC-2 spectral gamma log containing thorium, uranium and potassium (continued).

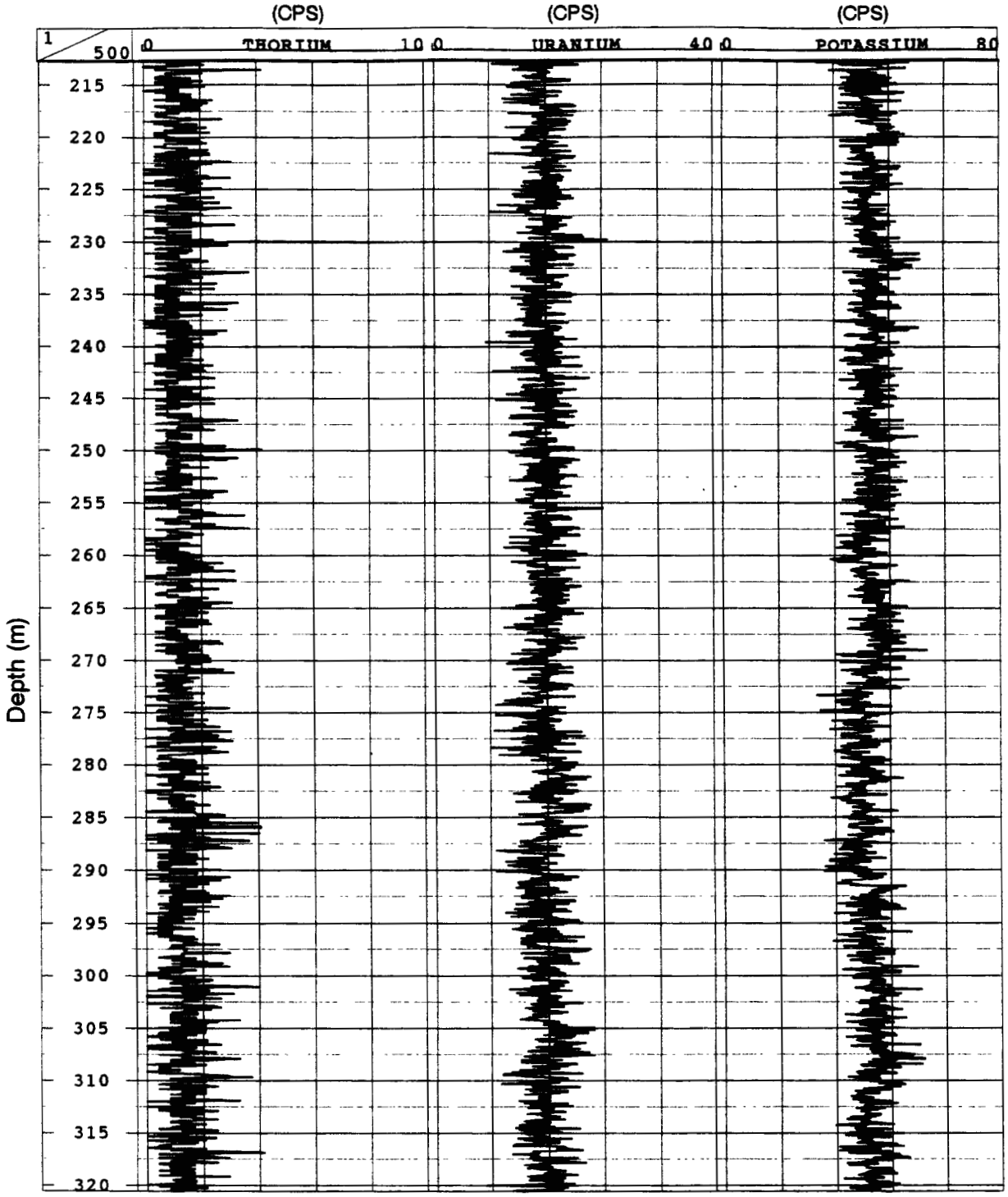

Figure HC-2.6. HC-2 spectral gamma log containing thorium, uranium and potassium (continued).

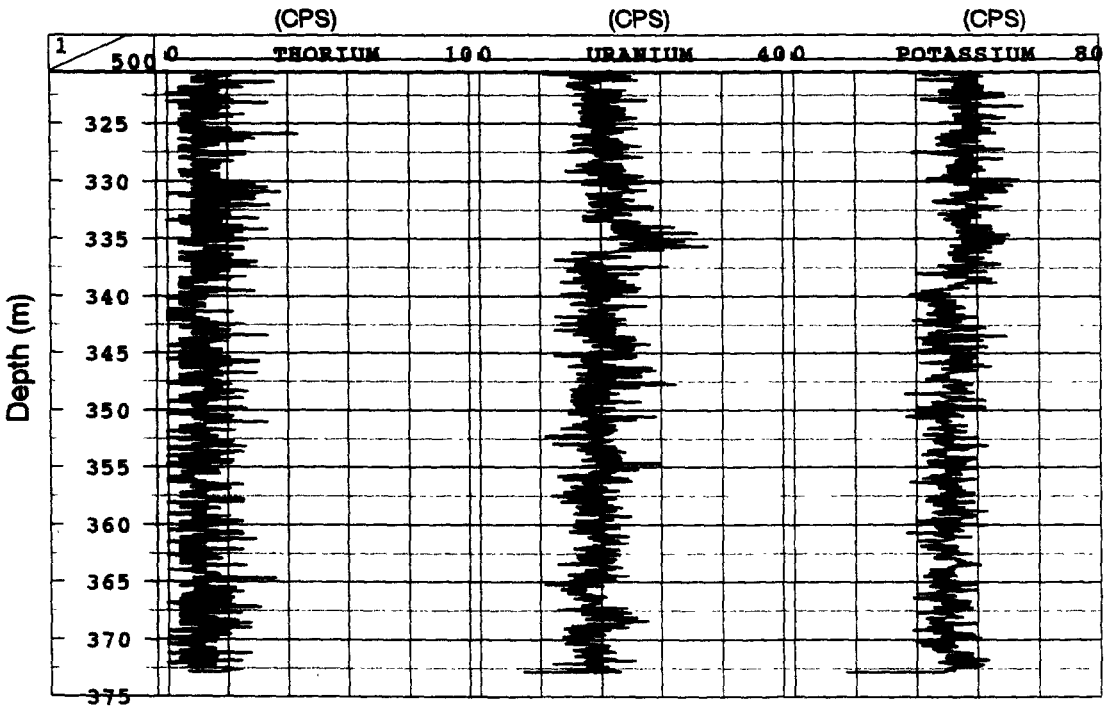

Figure HC-2.6. HC-2 spectral gamma log containing thorium, uranium and potassium (continued).

HC-3

Available Data

- Water Level vs. Time
- Borehole Deviaiton
- Fracture Interpretation Log
- Natural Gamma Log
- Caliper Log
- Density Log
- Neutron Log
- Spectral Gamma Ray Log (thorium, uranium, potassium)

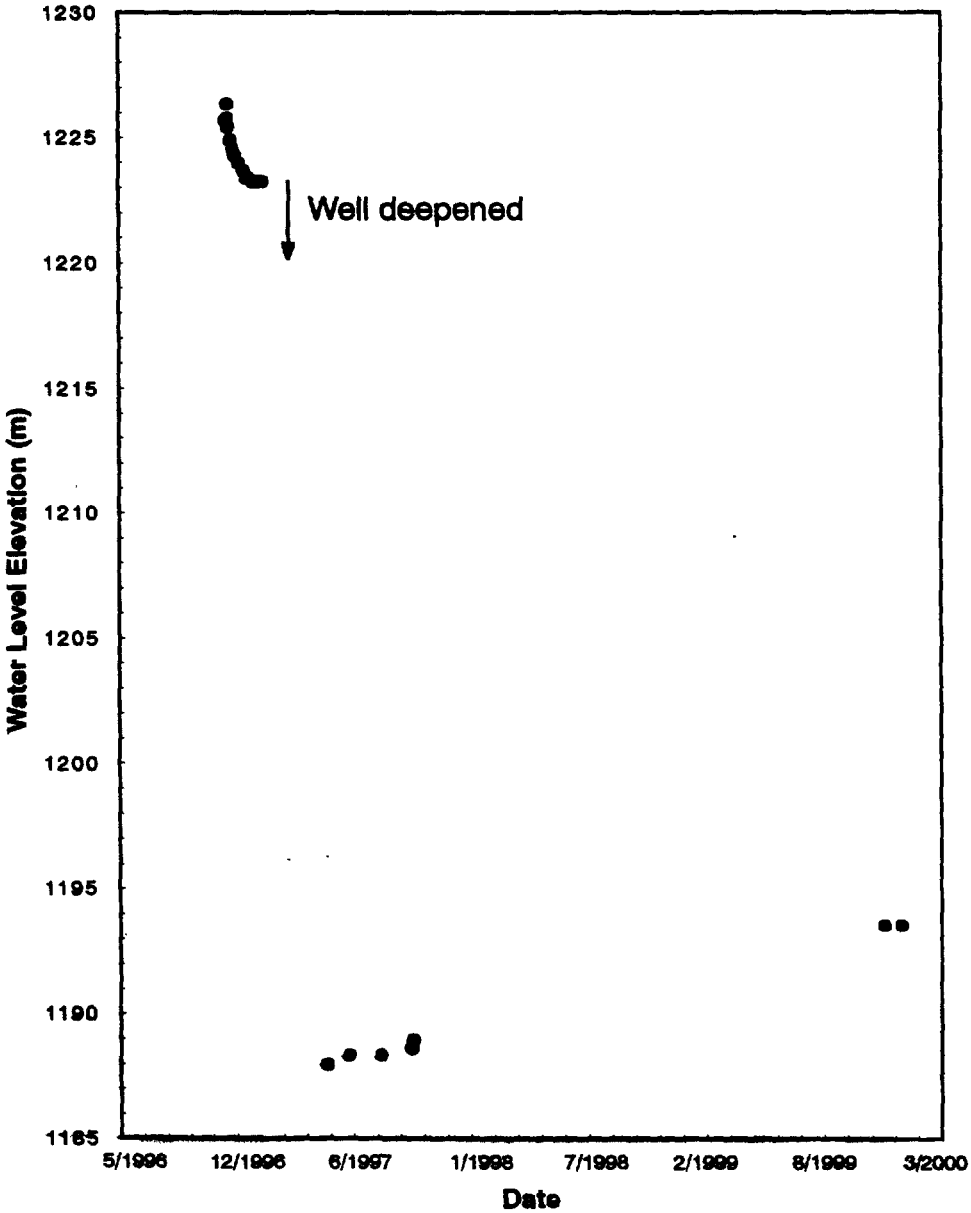

Figure HC-3.1. HC-3 water level vs. time.

Table HC-3.1. HC-3 borehole deviation.

Cable Depth (m)	True Depth (m)	Regression True Depth (m)	Absolute Error (m)
304.80	300.12	300.01	0.1158
312.42	307.42	307.29	0.1281
320.04	314.68	314.53	0.1414
327.66	321.92	321.76	0.1557
335.28	329.17	329.00	0.1711
342.90	336.40	336.21	0.1877
345.22	338.59	338.40	0.1929

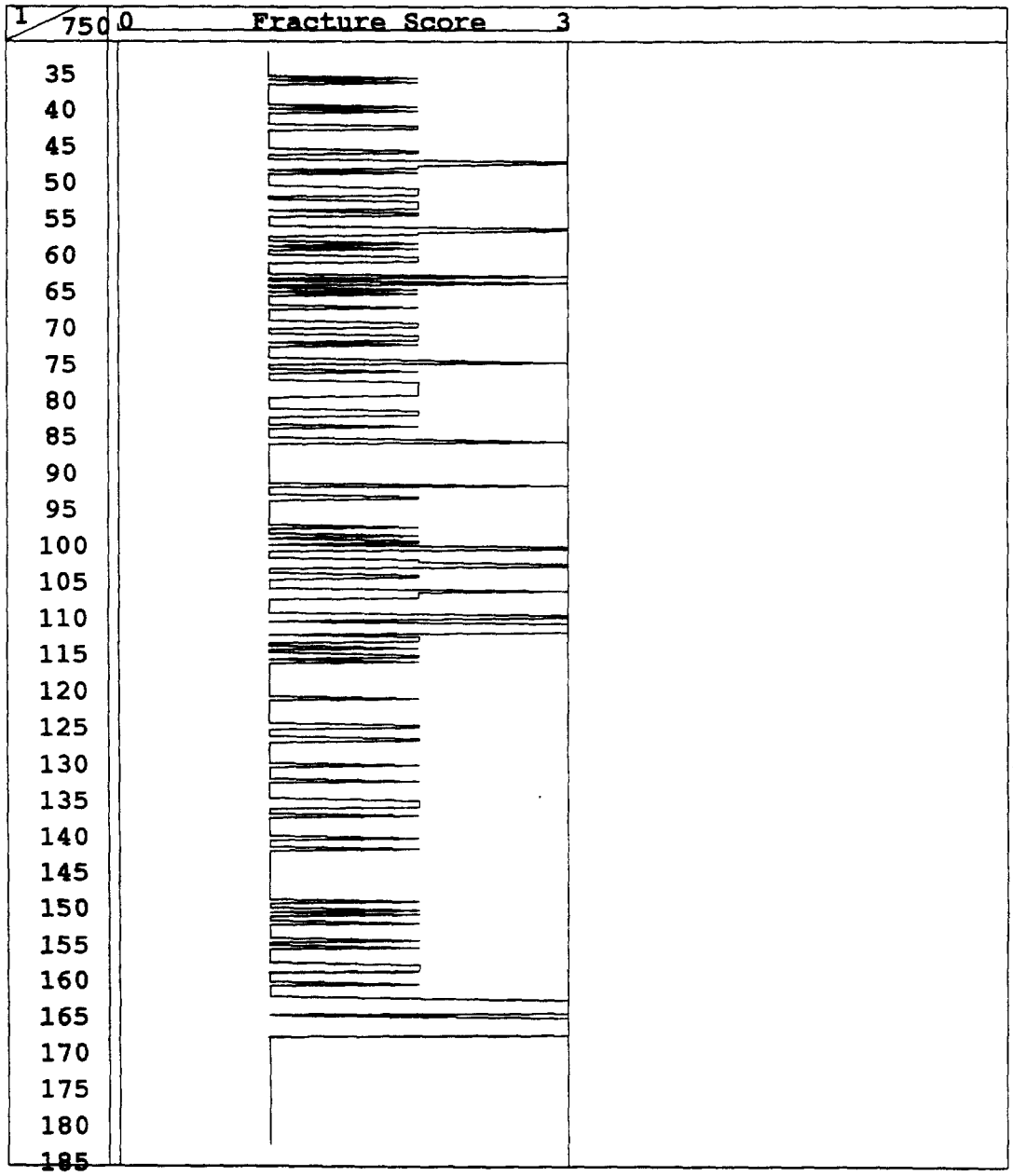

Figure HC-3.2. HC-3 fracture interpretation scores (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault).

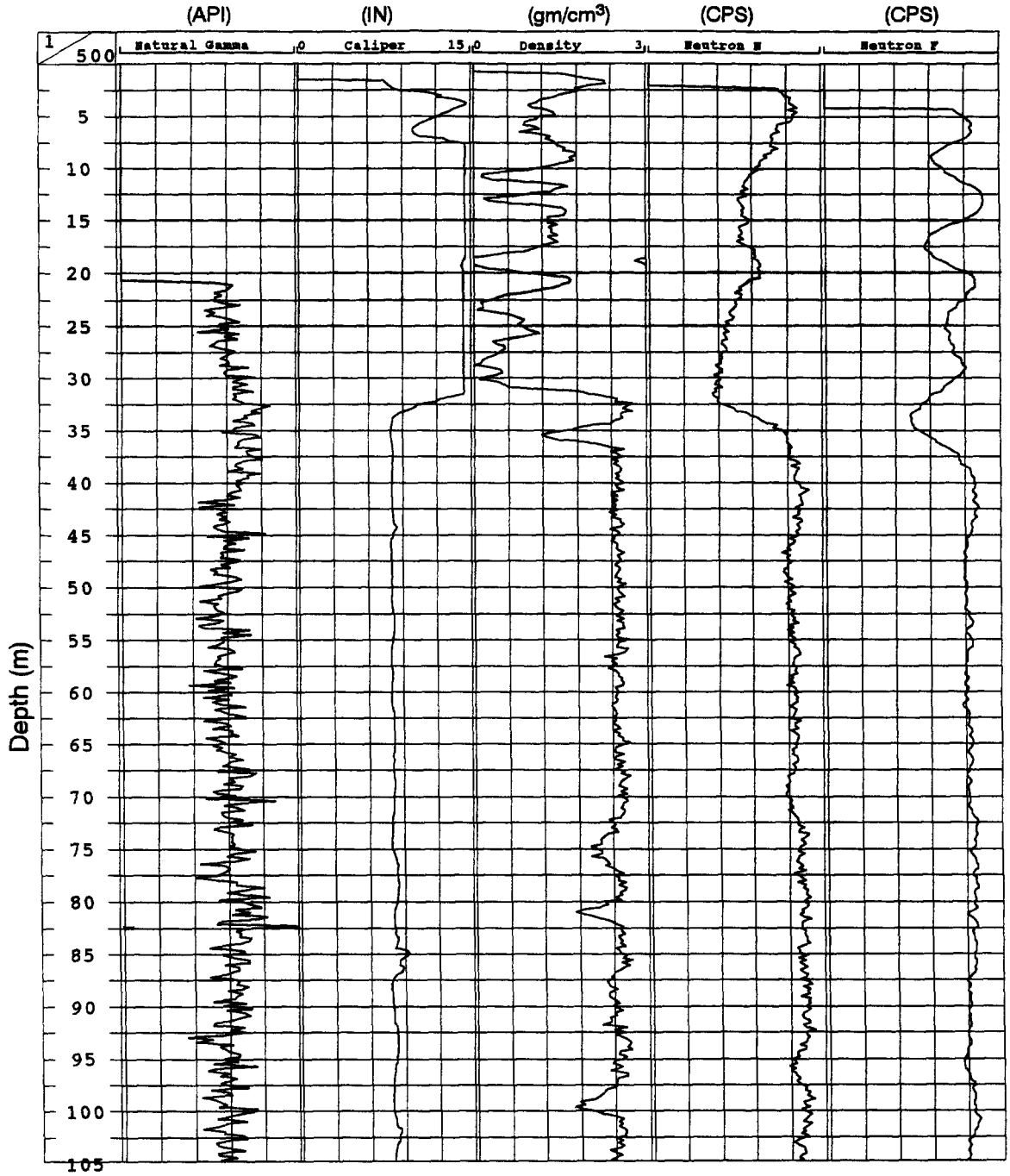

Figure HC-3.3. HC-3 natural gamma, caliper, density, and neutron logs.

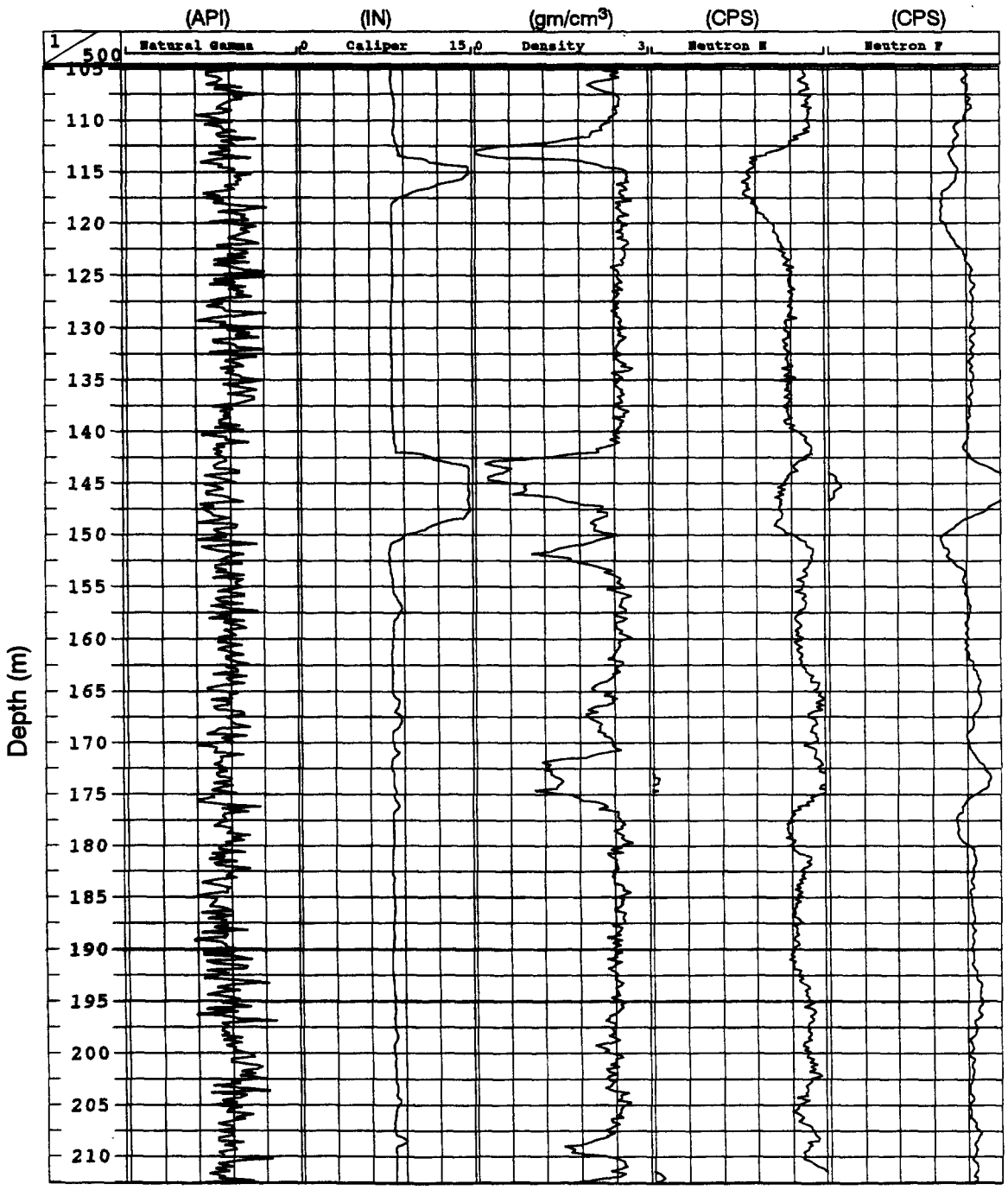

Figure HC-3.3. HC-3 natural gamma, caliper, density, and neutron logs (continued).

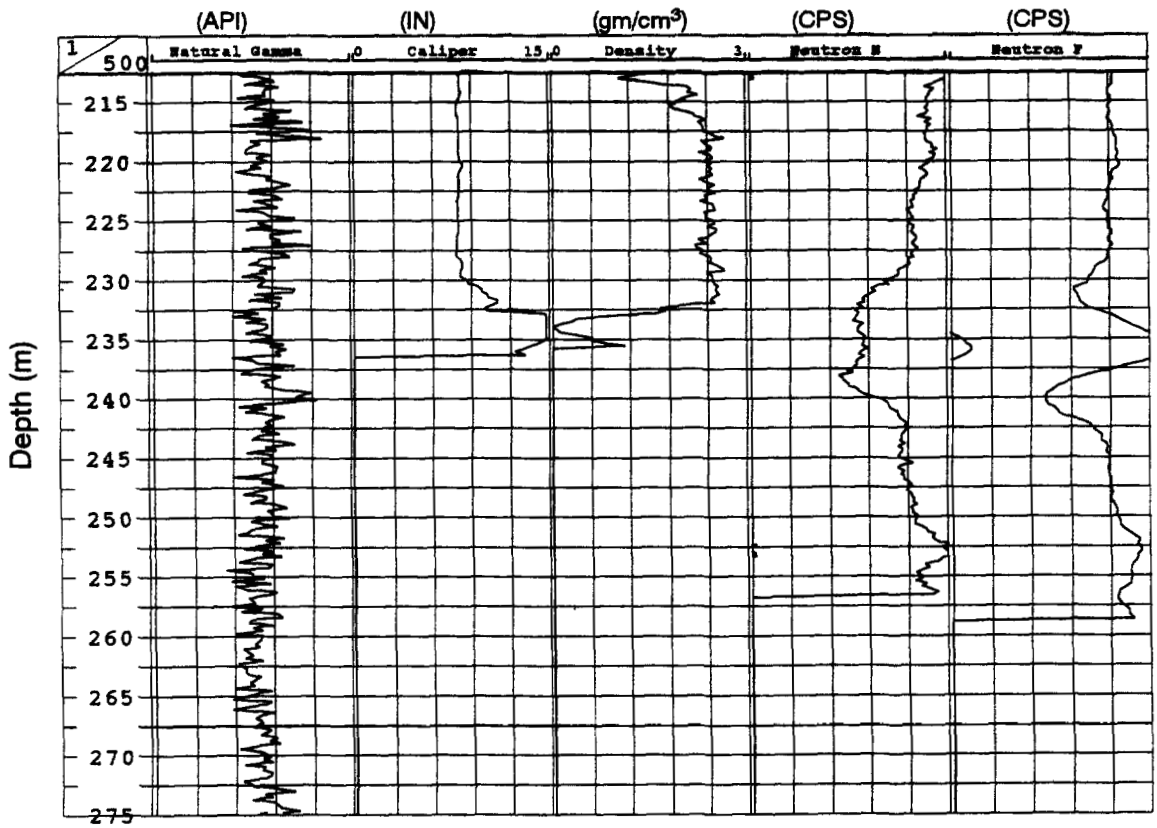

Figure HC-3.3. HC-3 natural gamma, caliper, density, and neutron logs (continued).

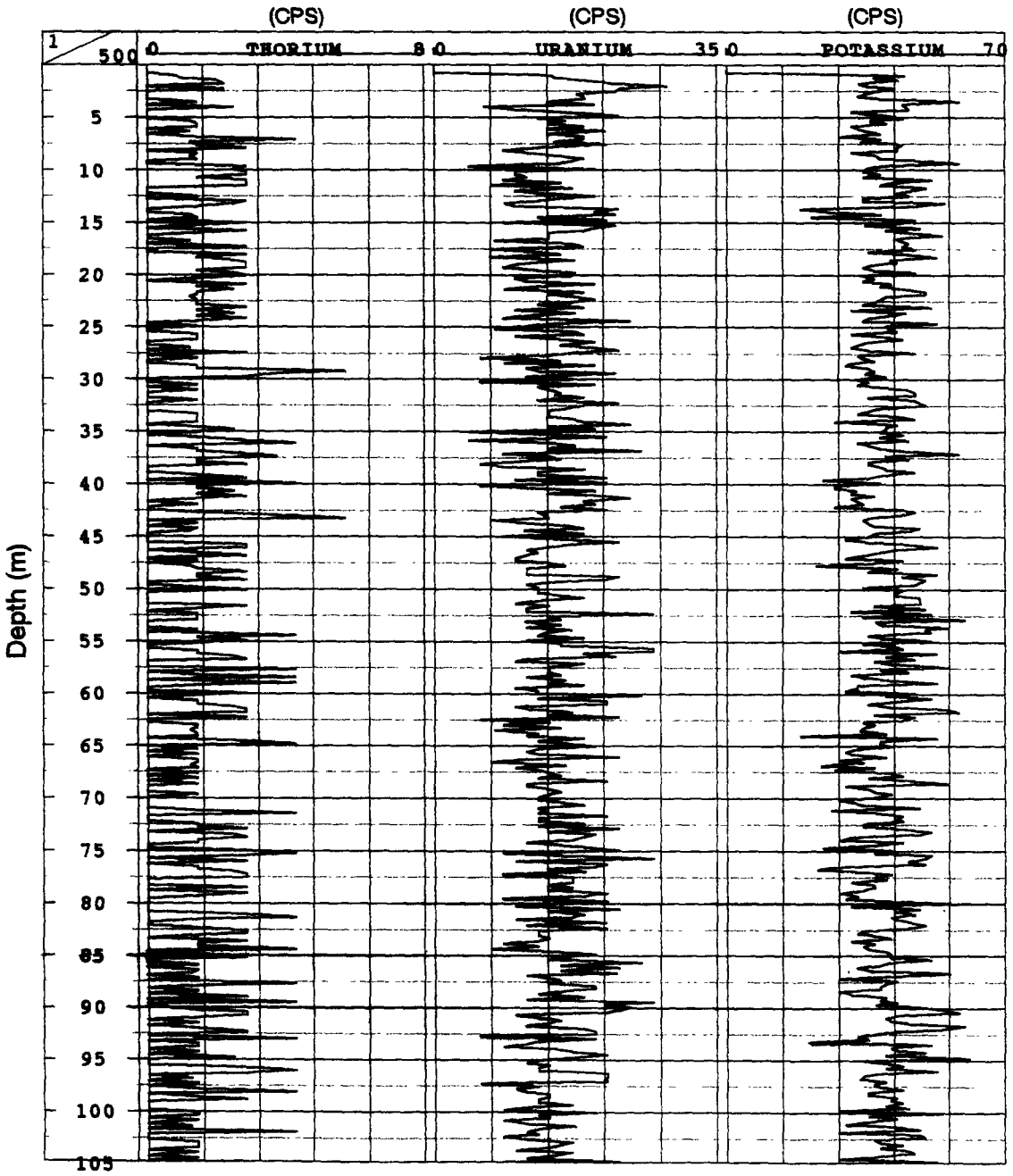

Figure HC-3.4. HC-3 spectral gamma log containing thorium, uranium and postassium.

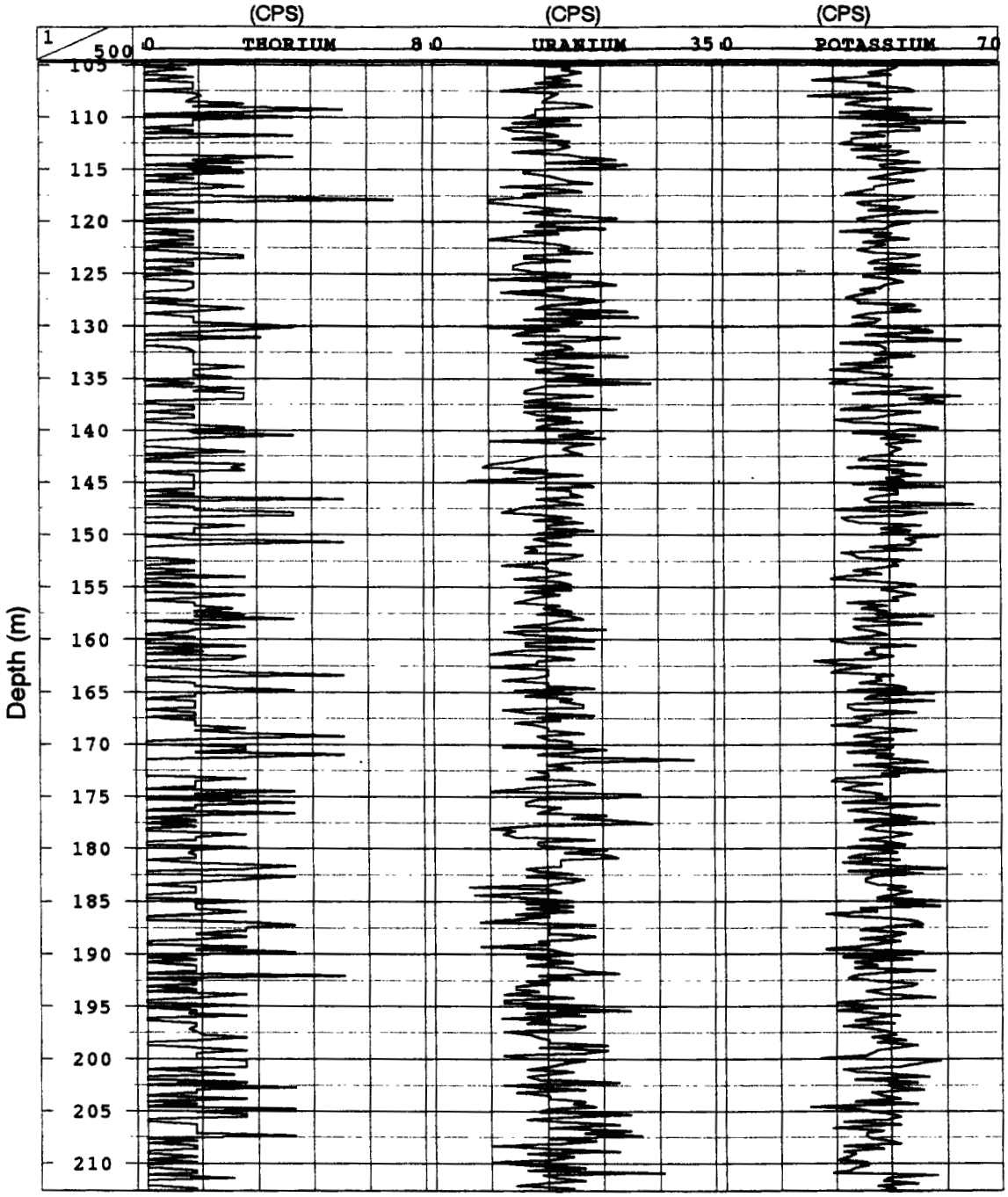

Figure HC-3.4. HC-3 spectral gamma log containing thorium, uranium and postassium (continued).

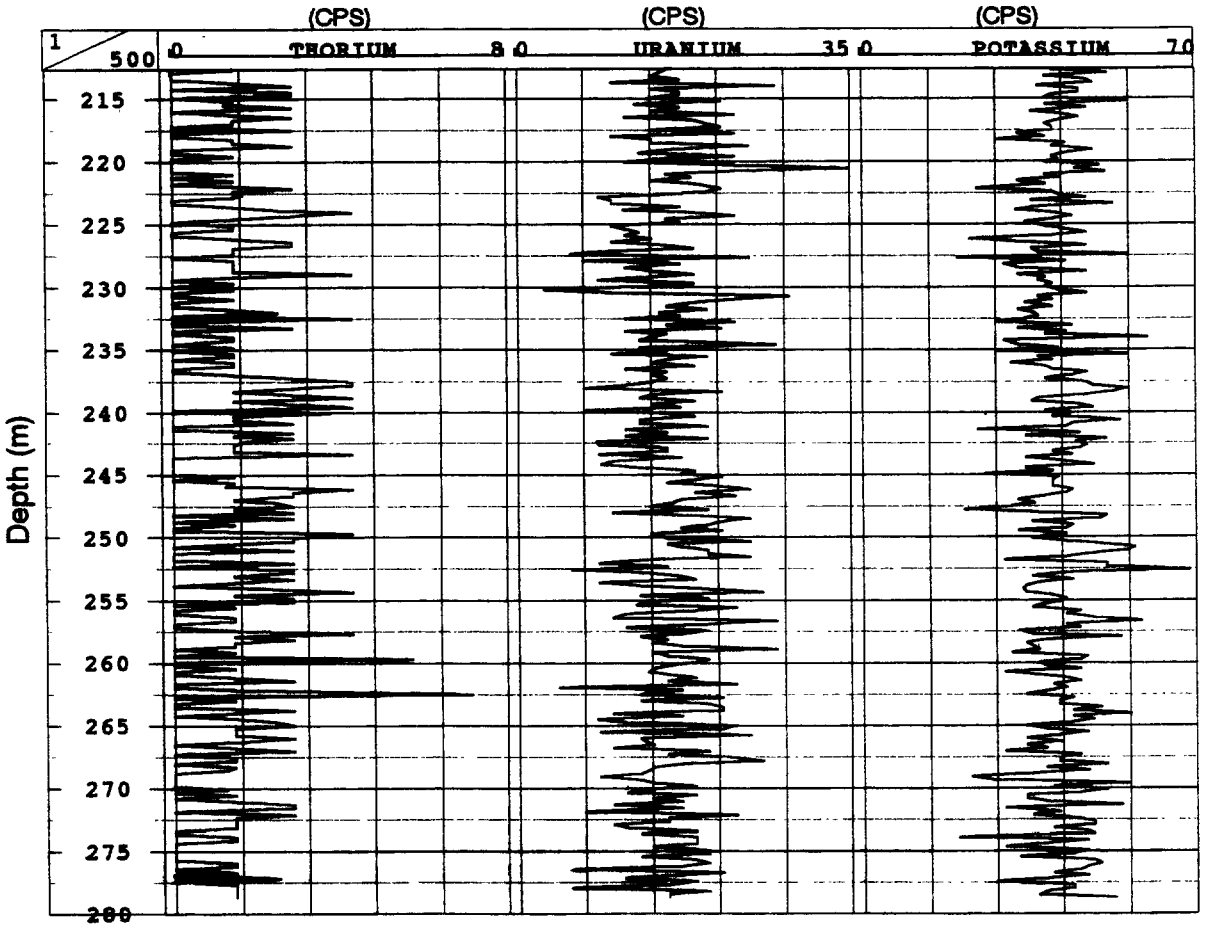

Figure HC-3.4. HC-3 spectral gamma log containing thorium, uranium and postassium (continued).

HC-4

Available Data

- Pumping Test
- Water Level vs. Time
- Stressed Thermal Flow
- Borehole Deviaiton
- Chemtool Log (temperature, EC, pH)
- Fracture Interpretation Log
- Natural Gamma Log
- Resistivity Log
- Caliper Log
- Density Log
- Porosity Log (derived from neutron)
- Neutron Log
- Spectral Gamma Ray Log (thorium, uranium, potassium)

Analysis	
Date:	2/23/1997
ΔS (m):	2.25
Q (m^3/day):	2.53
Screen Thickness (m):	60.4
Transmissivity (m^2/day):	0.21
Hydraulic Conductivity (cm/sec):	4.0E-06

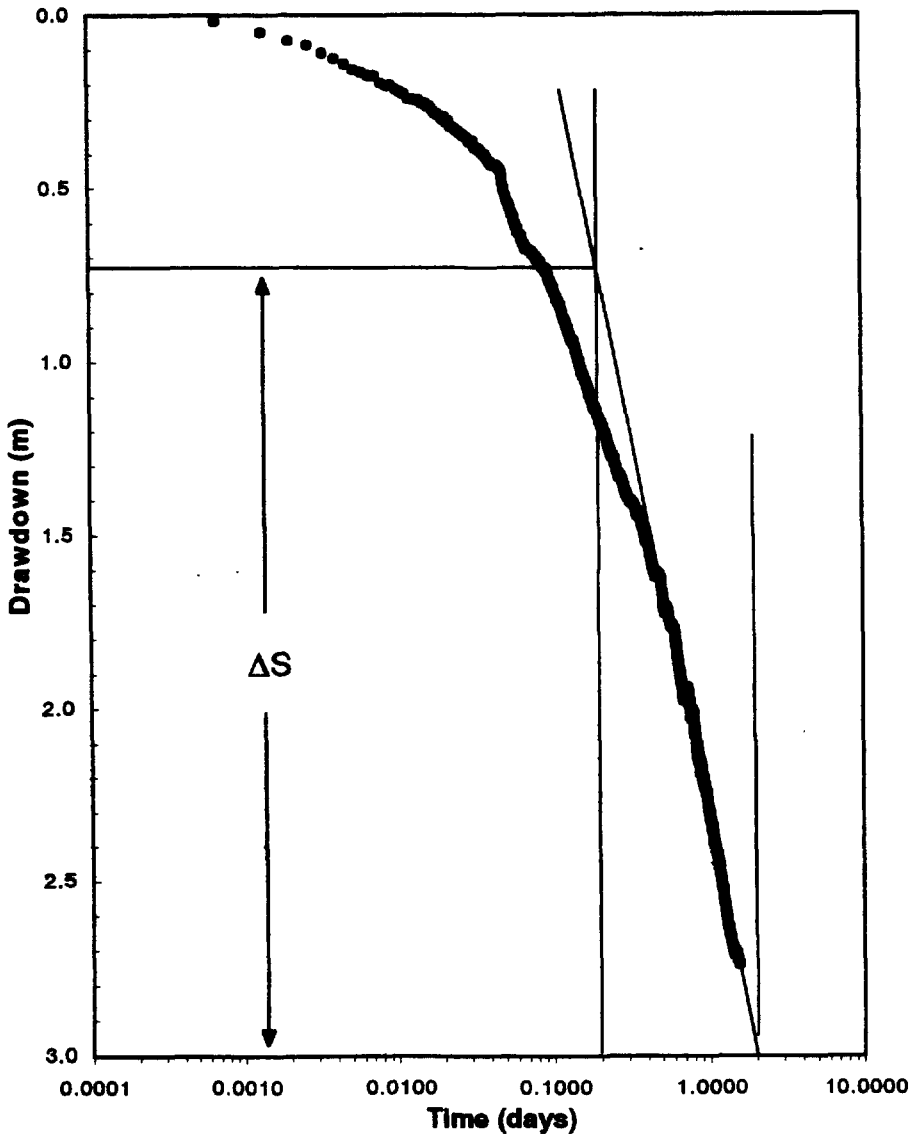

Figure HC-4.1. HC-4 pumping test analysis (1997).

Analysis	
Date:	2/24/1997
ΔS (m):	1.0
Q (m^3/day):	2.56
Screen Thickness (m):	60.4
Transmissivity (m^2/day):	0.47
Hydraulic Conductivity (cm/sec):	9.0E-06

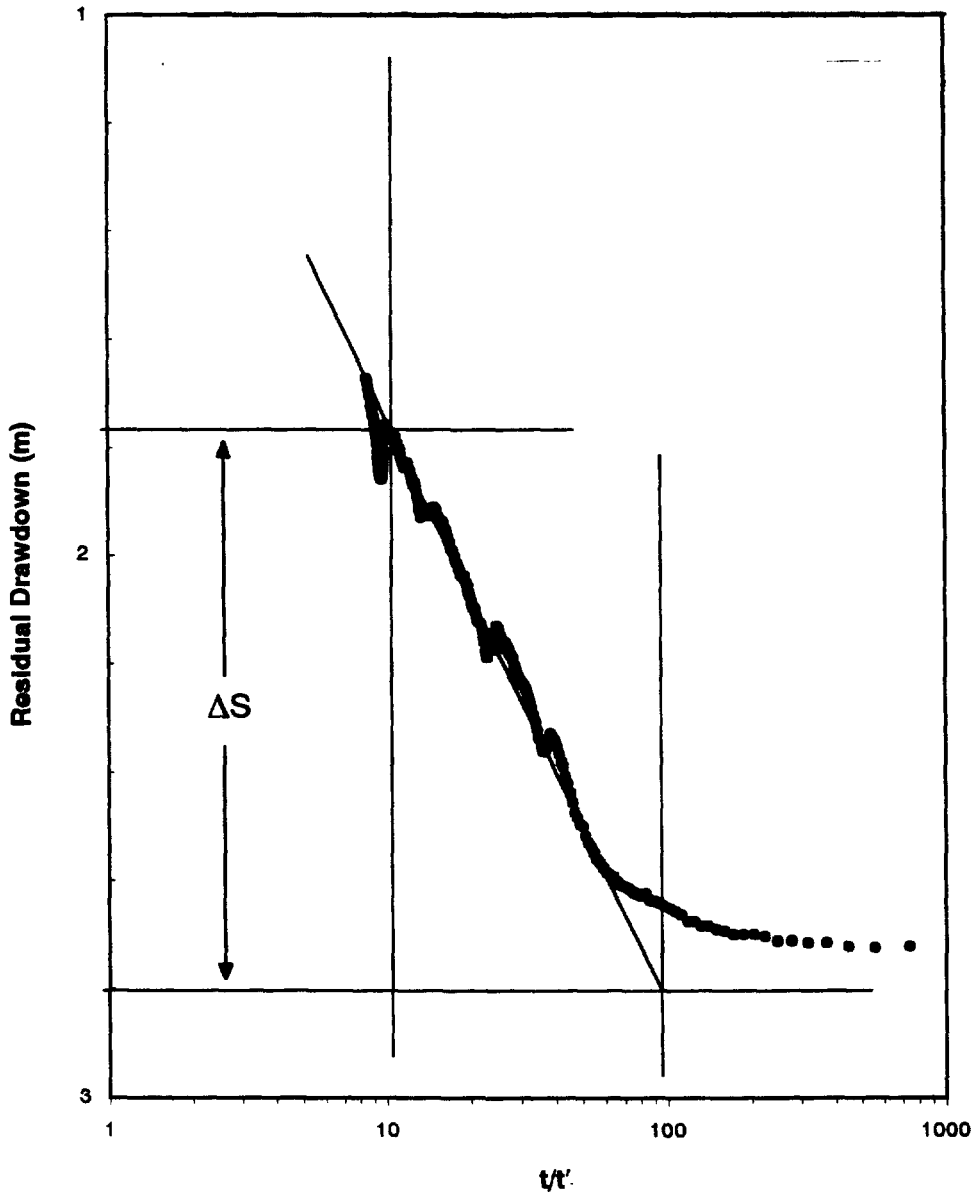

Figure HC-4.2. HC-4 recovery test analysis (1997).

Analysis	
Date:	2/15/2000
ΔS (m):	6.10
Q (m^3/day):	10.14
Screen Thickness (m):	60.4
Transmissivity (m^2/day):	0.30
Hydraulic Conductivity (cm/sec):	6.0E-06

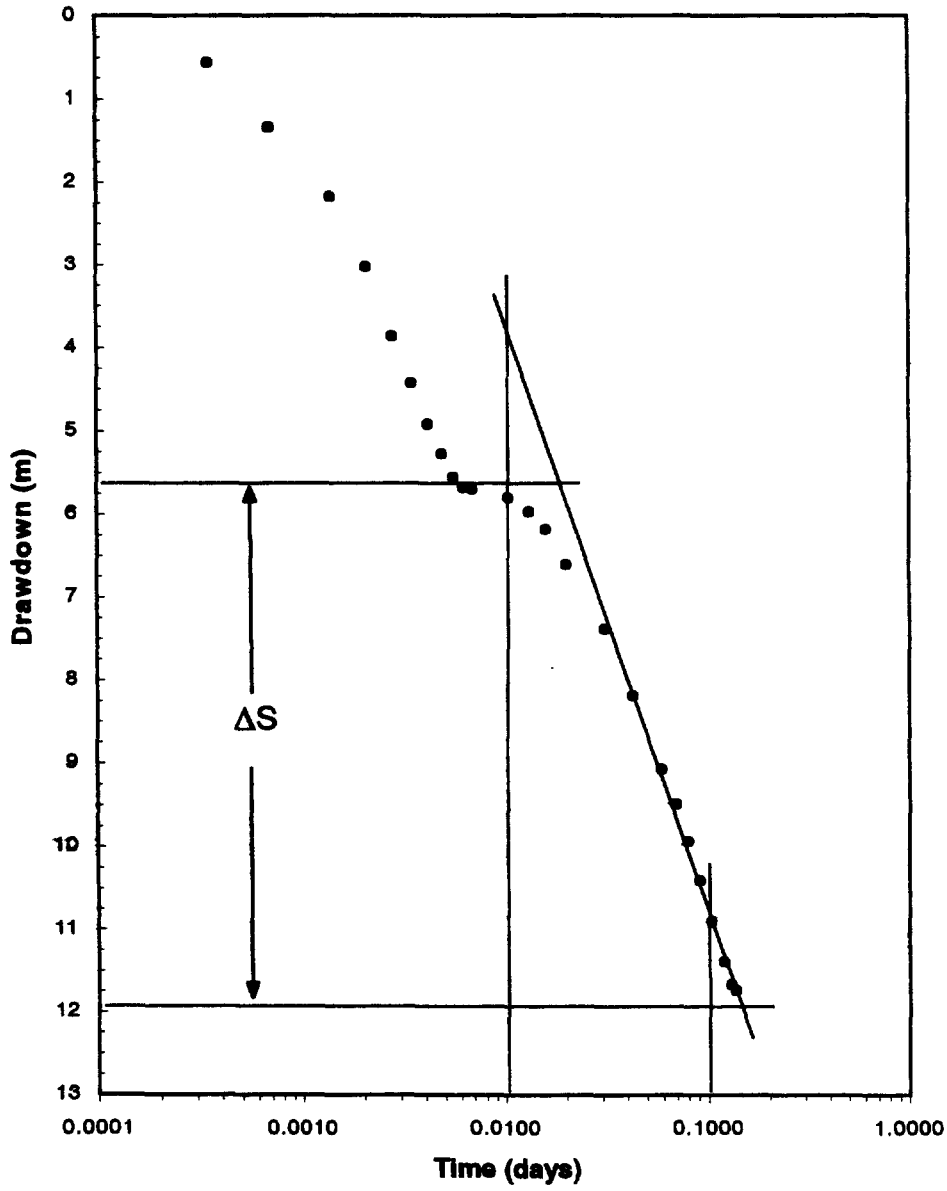

Figure HC-4.3. HC-4 pumping test analysis (2000).

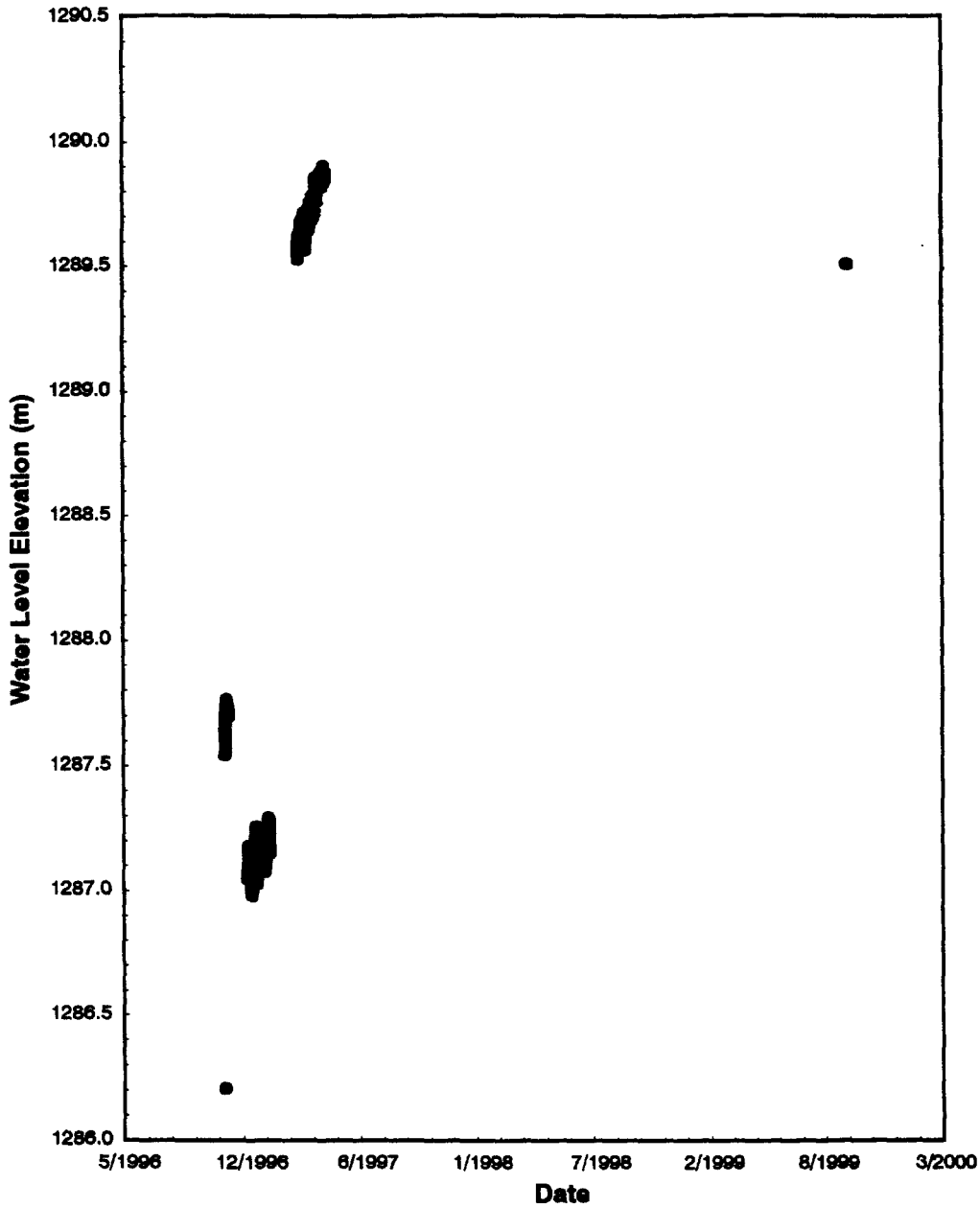

Figure HC-4.4. HC-4 water level vs. time.

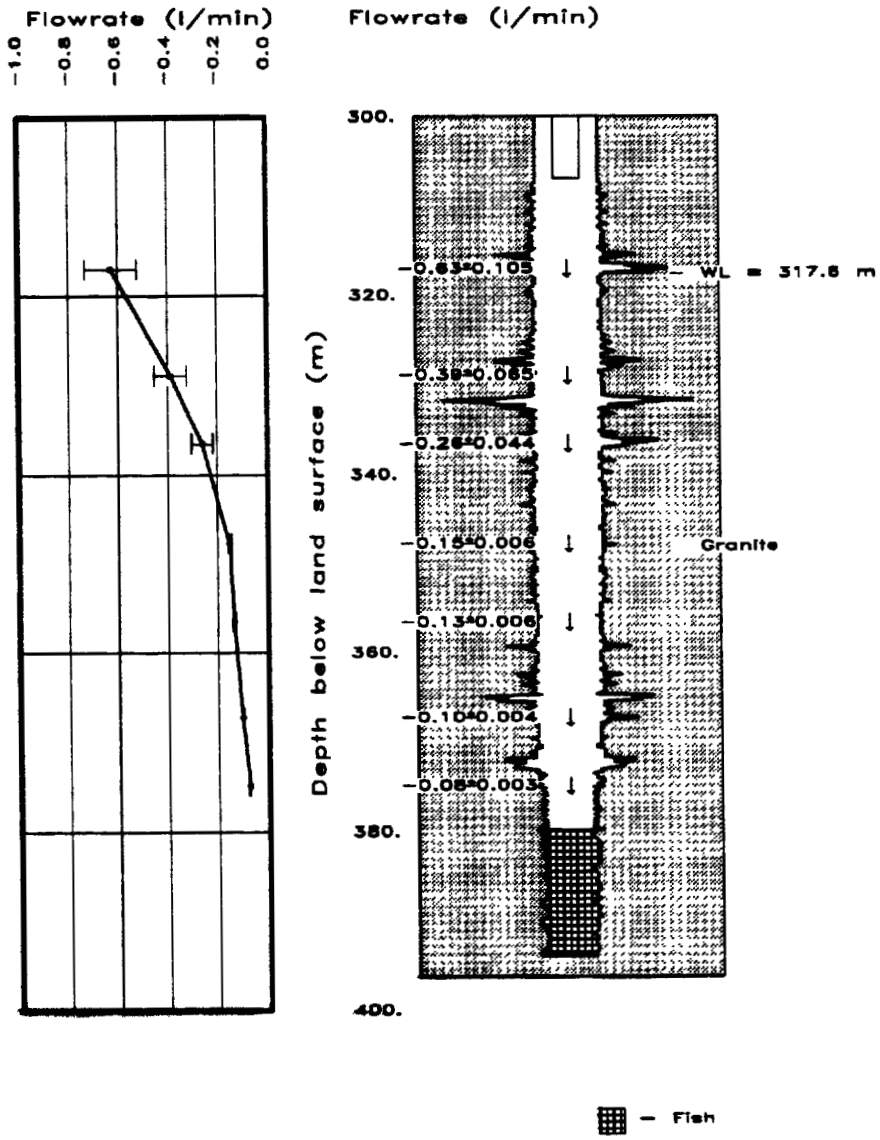

Figure HC-4.5. HC-4 well schematic and stressed thermal flowmeter results.

Table HC-4.1 HC-4 borehole deviaiton.

Cable Depth (m)	True Depth (m)	Regression True Depth (m)	Absolute Error (m)
304.80	303.66	303.66	0.0002
312.42	311.22	311.23	0.0045
320.04	318.79	318.79	0.0025
327.66	326.35	326.35	0.0001
335.28	333.92	333.91	0.0027
342.90	341.48	341.48	0.0002
350.52	349.04	349.04	0.0002
358.14	356.60	356.60	0.0022
365.76	364.16	364.16	0.0044
373.38	371.72	371.72	0.0034
381.00	379.28	379.28	0.0024
388.62	386.85	386.84	0.0016

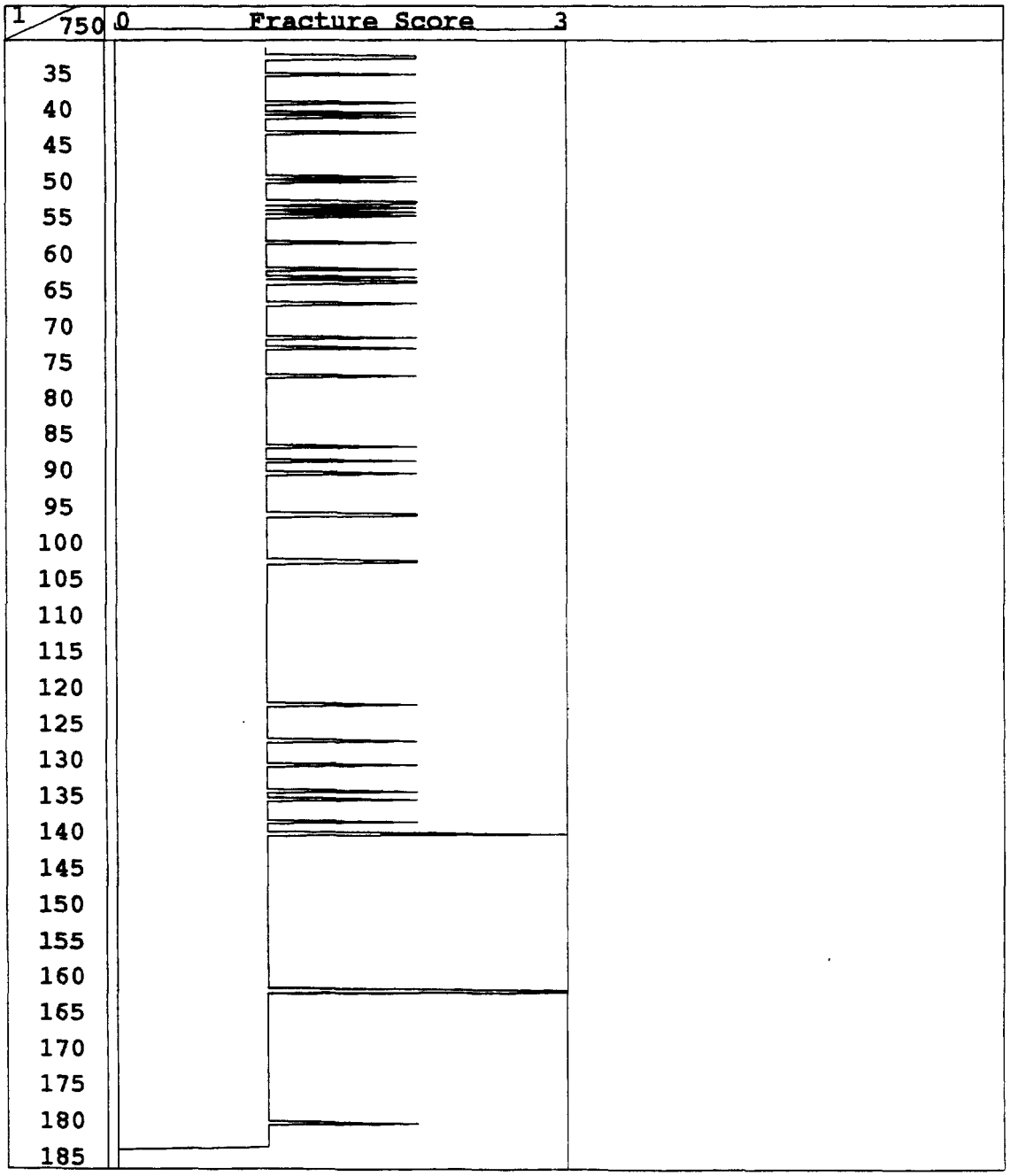

Figure HC-4.6. HC-4 fracture interpretation scores (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault).

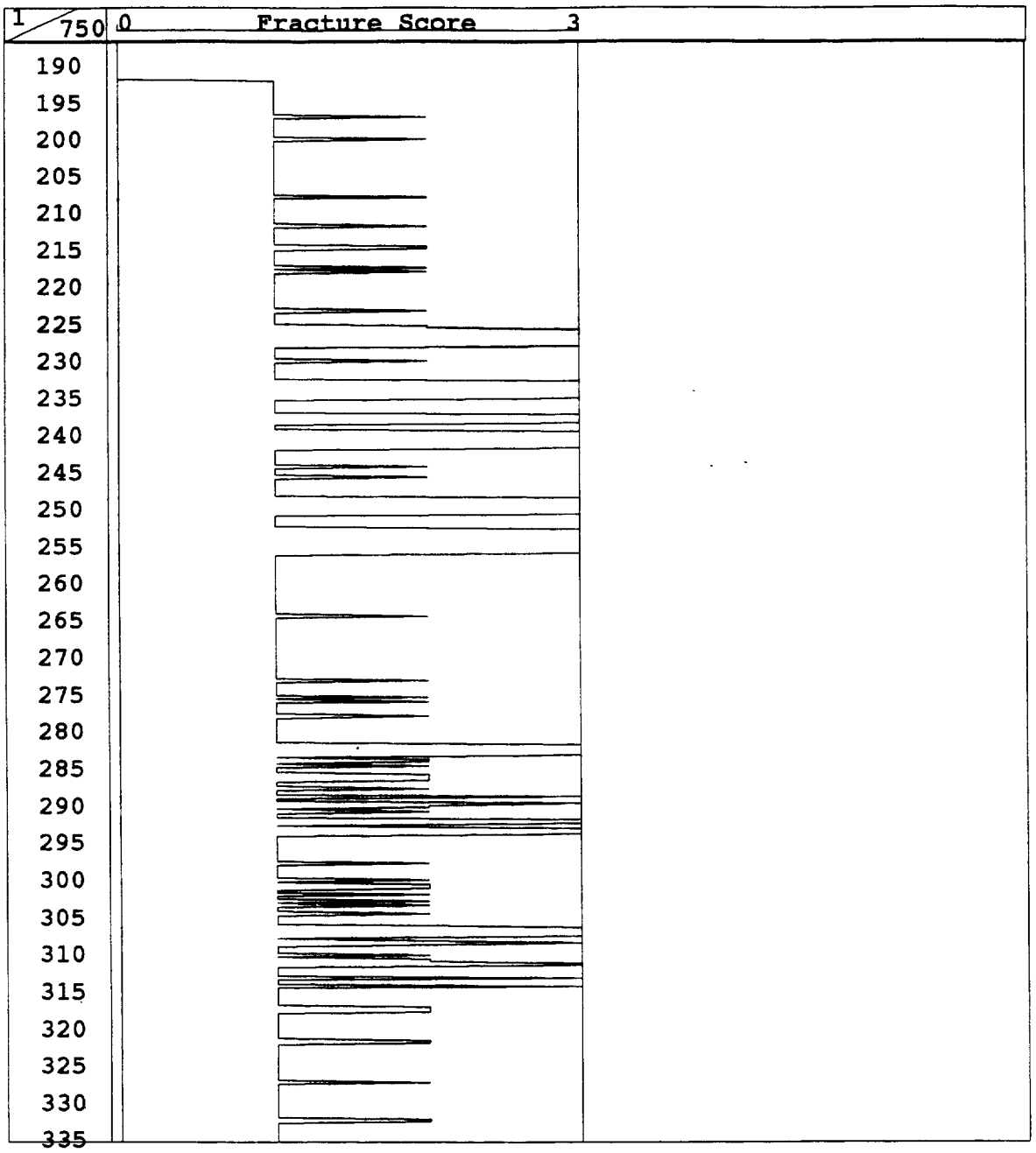

Figure HC-4.6. HC-4 fracture interpretation scores (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) (continued).

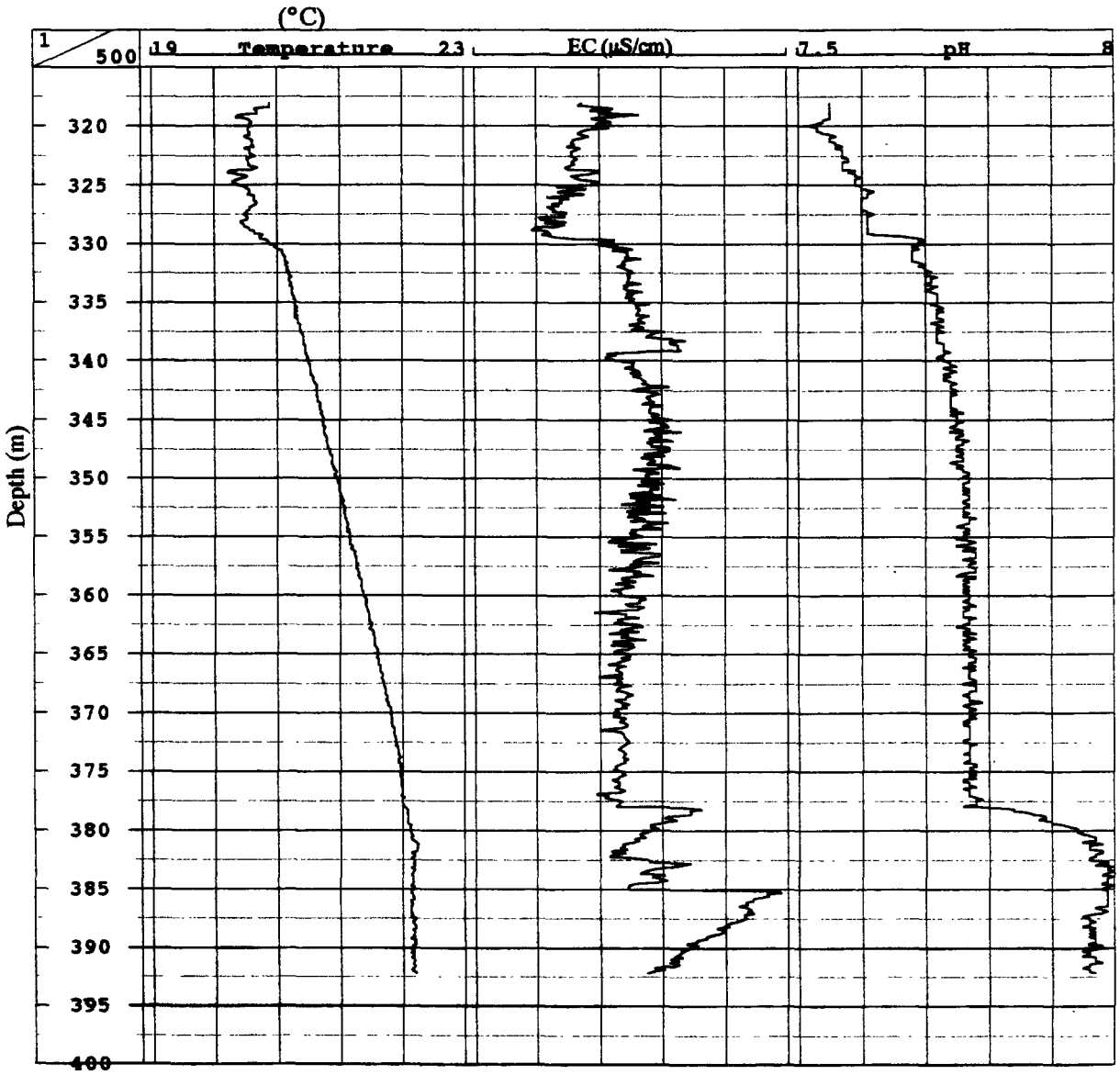

Figure HC-4.7. HC-1 chemlog containing temperature, electrical conductivty and pH.

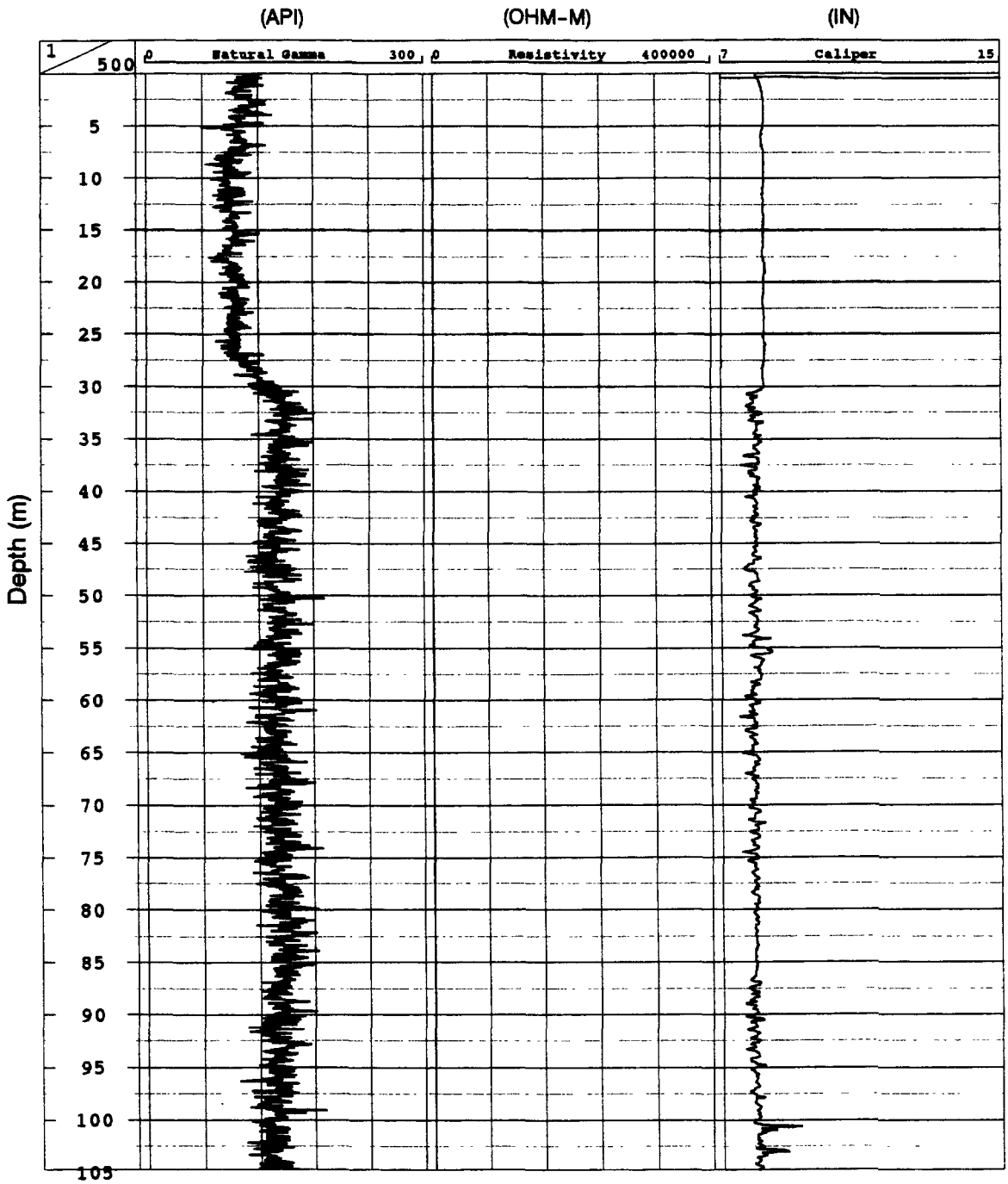

Figure HC-4.8. HC-1 natural gamma, resistivity and caliper logs.

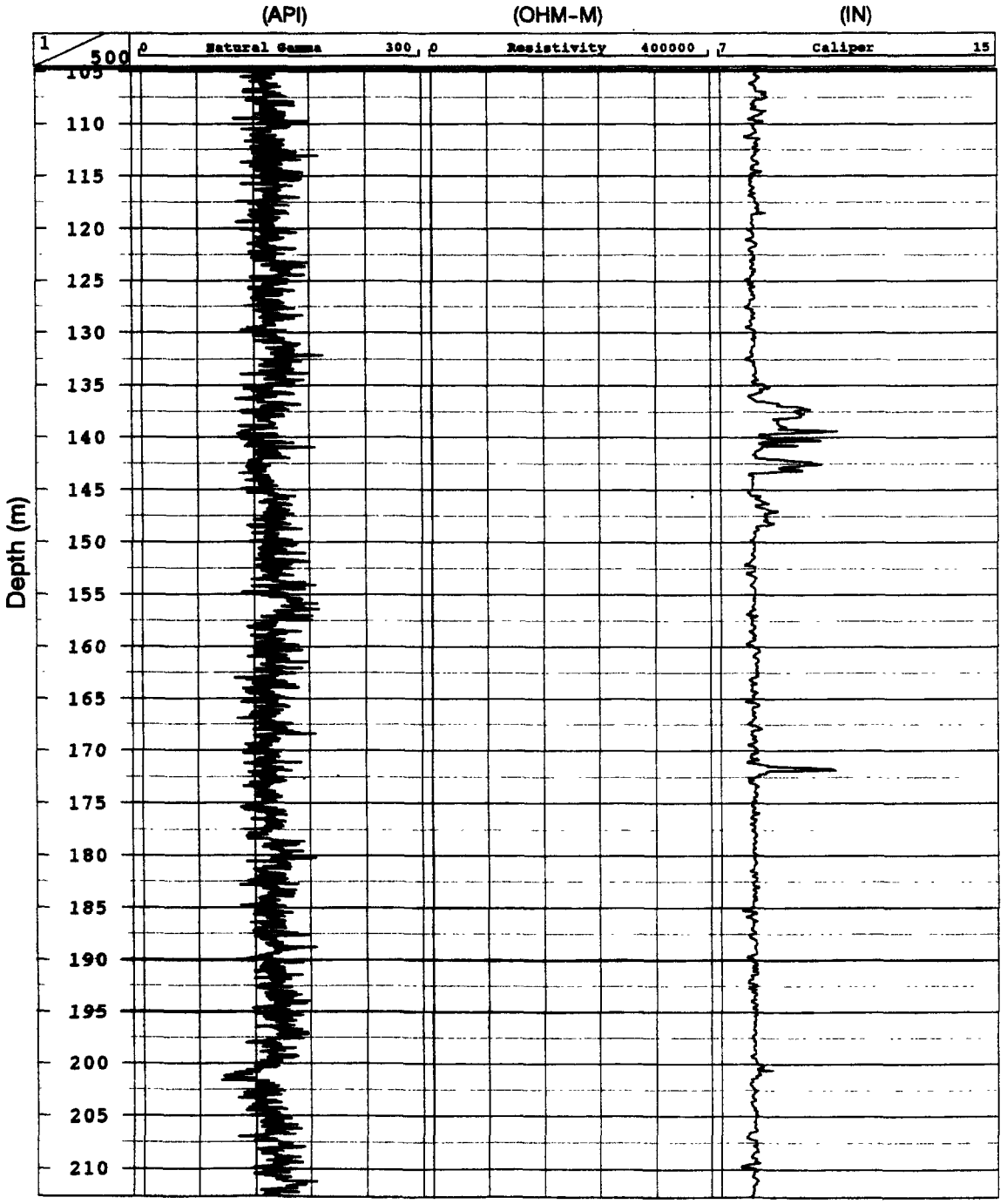

Figure HC-4.8. HC-1 natural gamma, resistivity and caliper logs (continued).

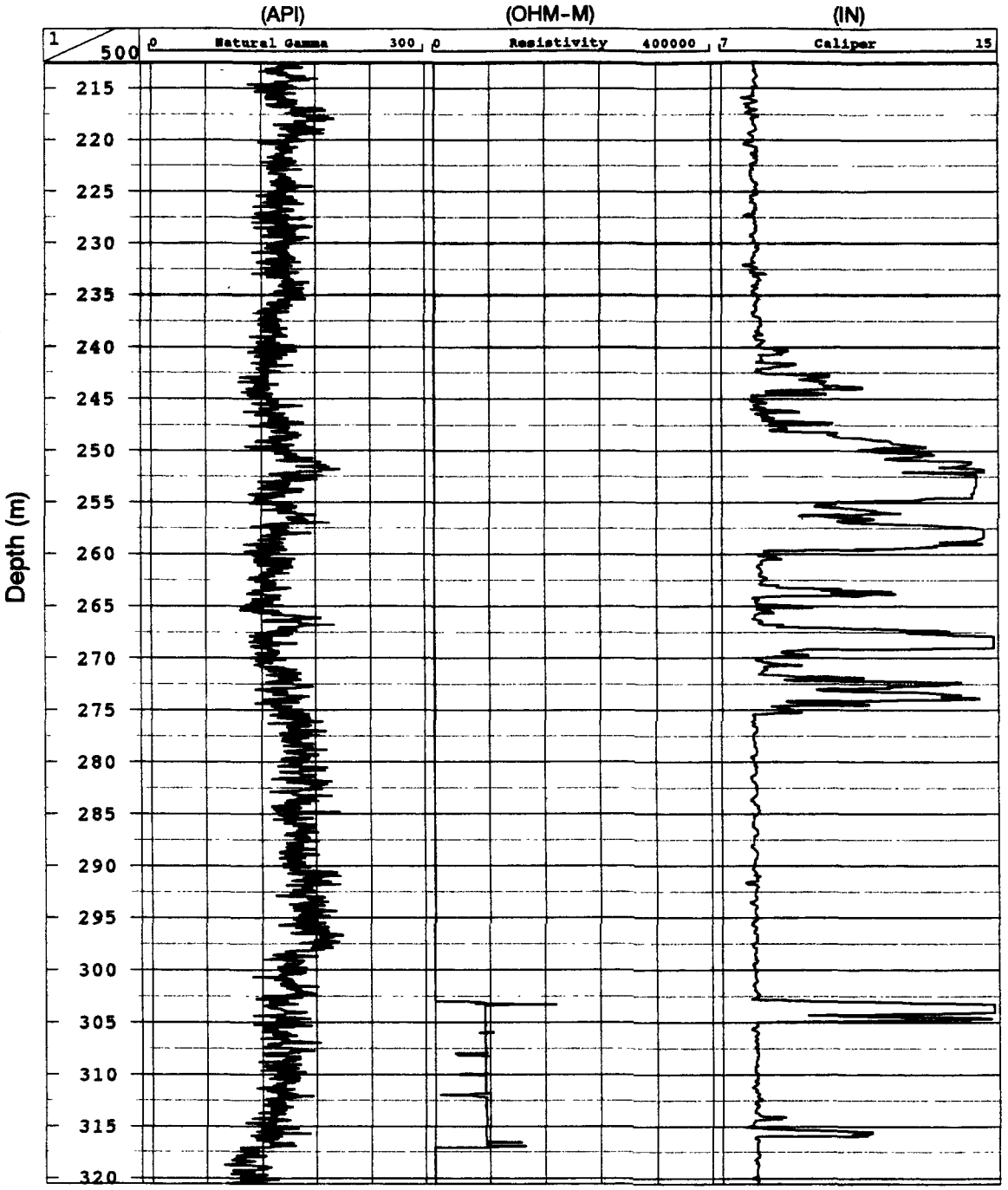

Figure HC-4.8. HC-1 natural gamma, resistivity and caliper logs (continued).

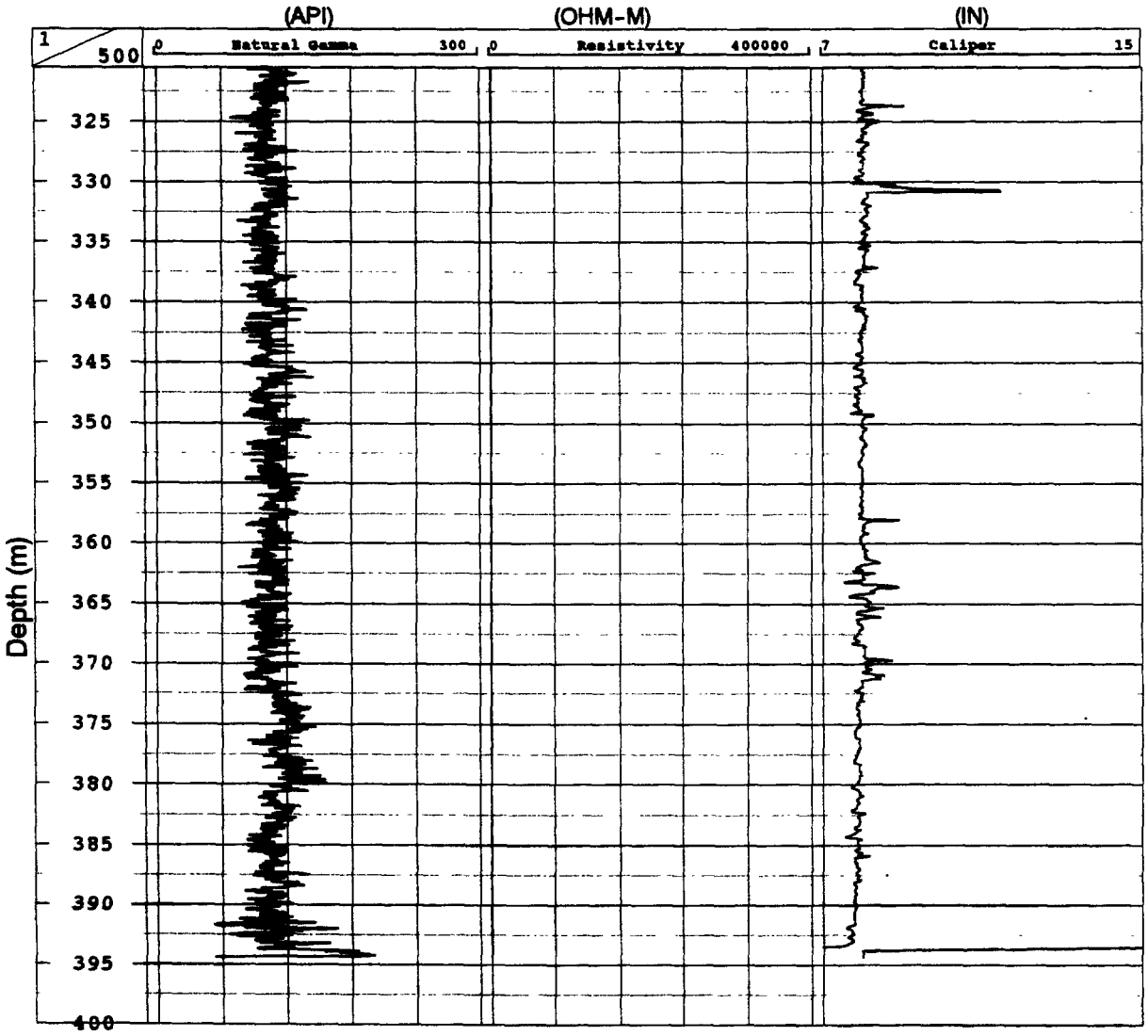

Figure HC-4.8. HC-1 natural gamma, resistivity and caliper logs (continued).

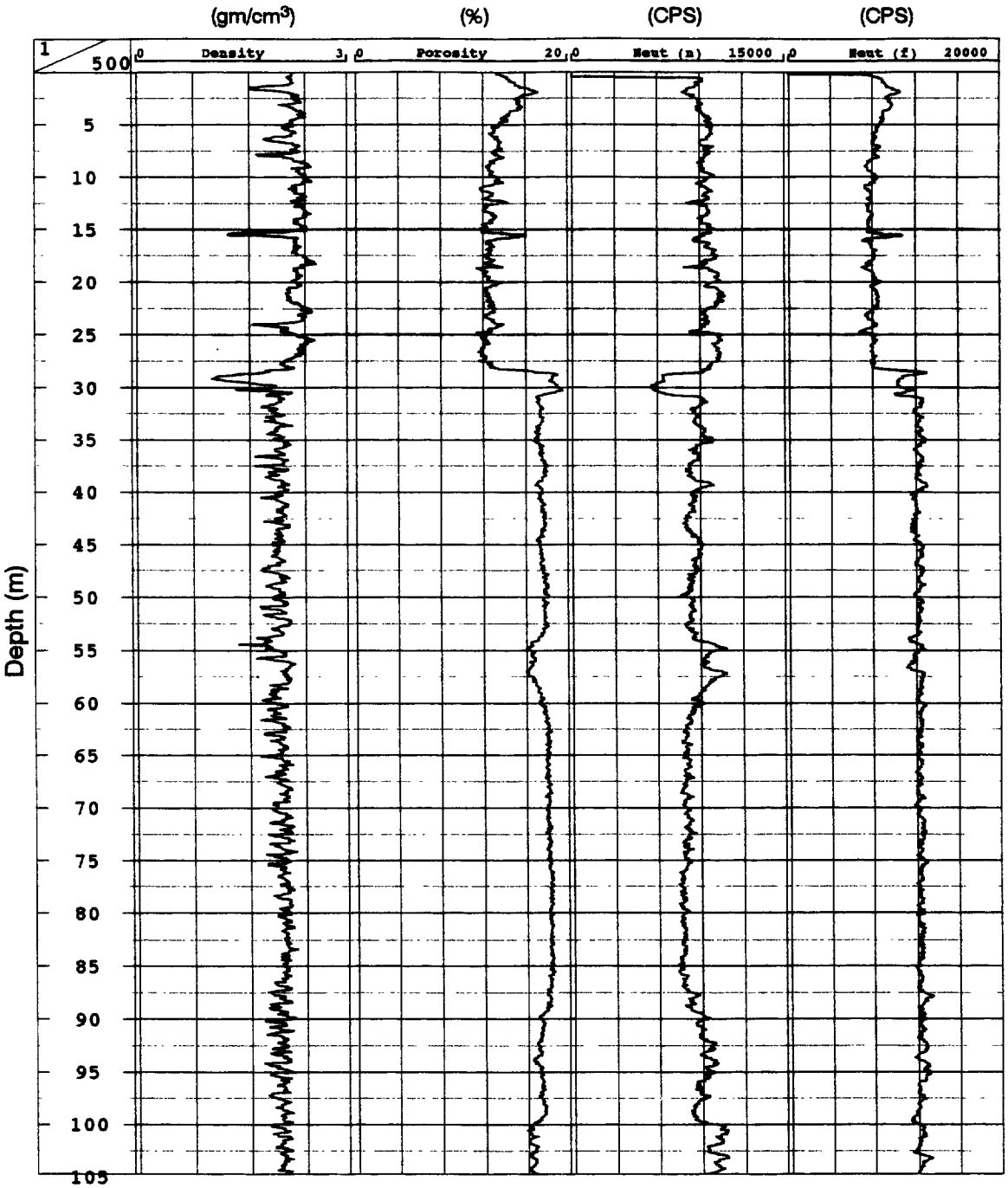

Figure HC-4.9. Density, porosity (derived from neutron) and neutron logs.

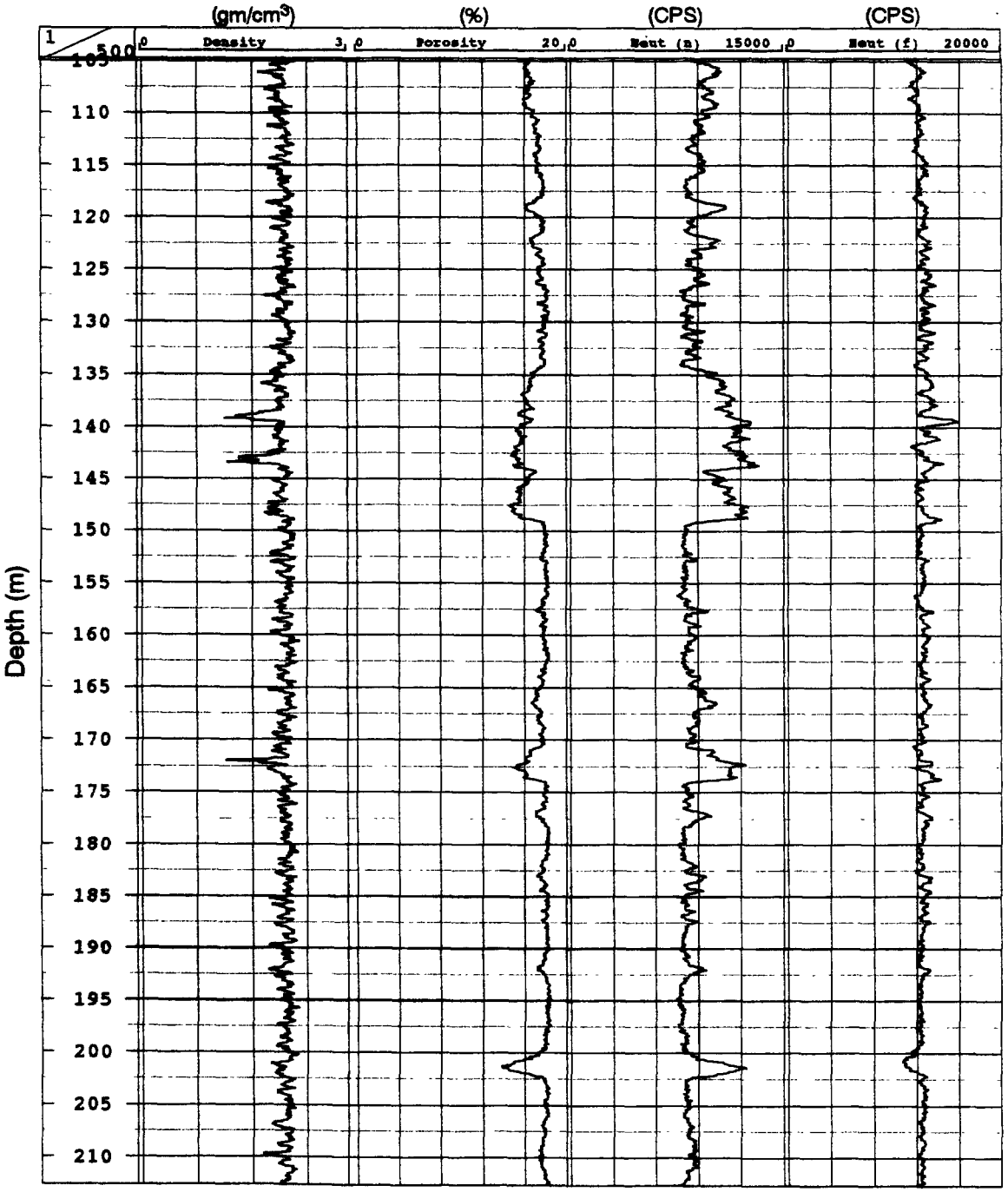

Figure HC-4.9. Density, porosity (derived from neutron) and neutron logs (continued).

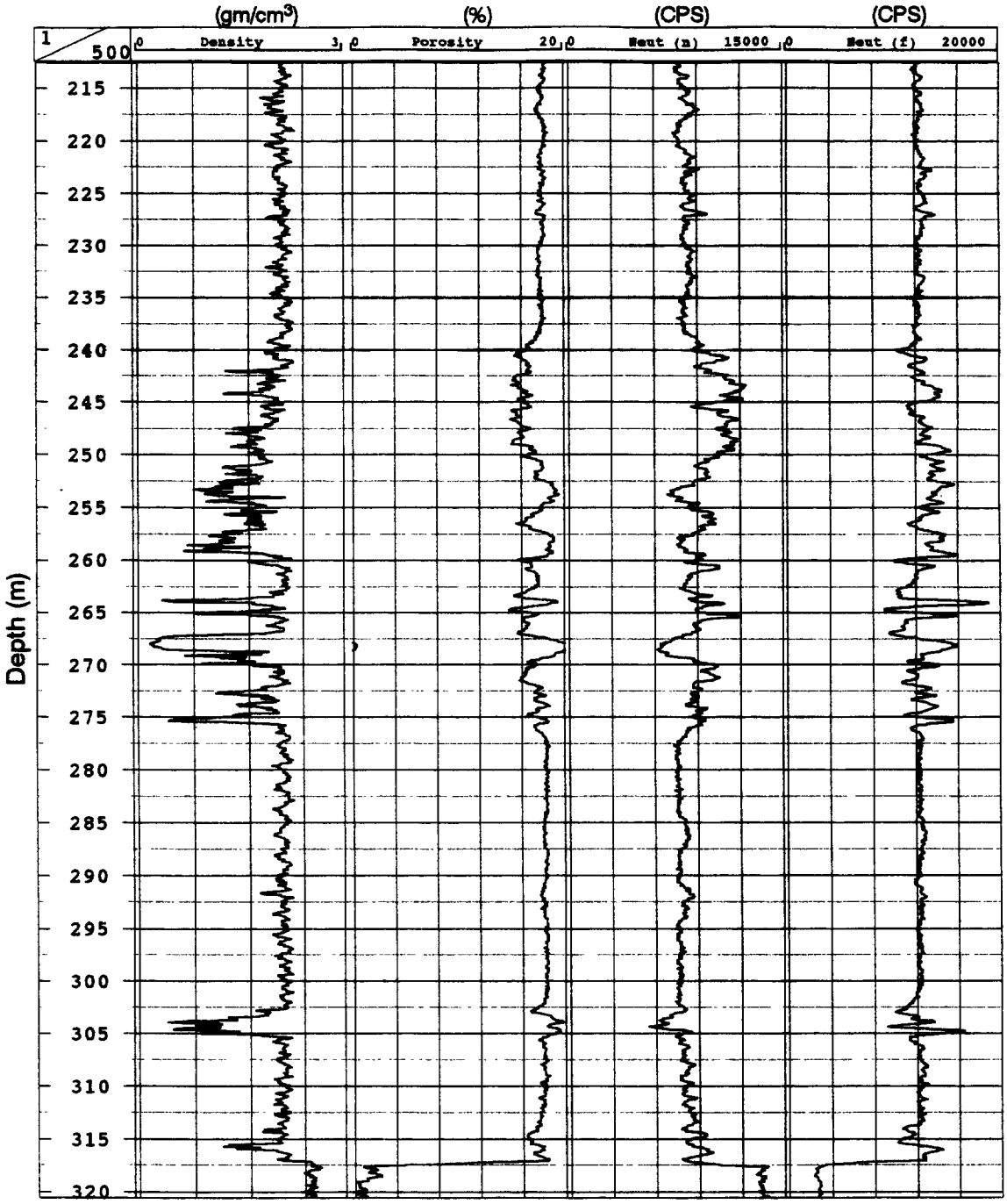

Figure HC-4.9. Density, porosity (derived from neutron) and neutron logs (continued).

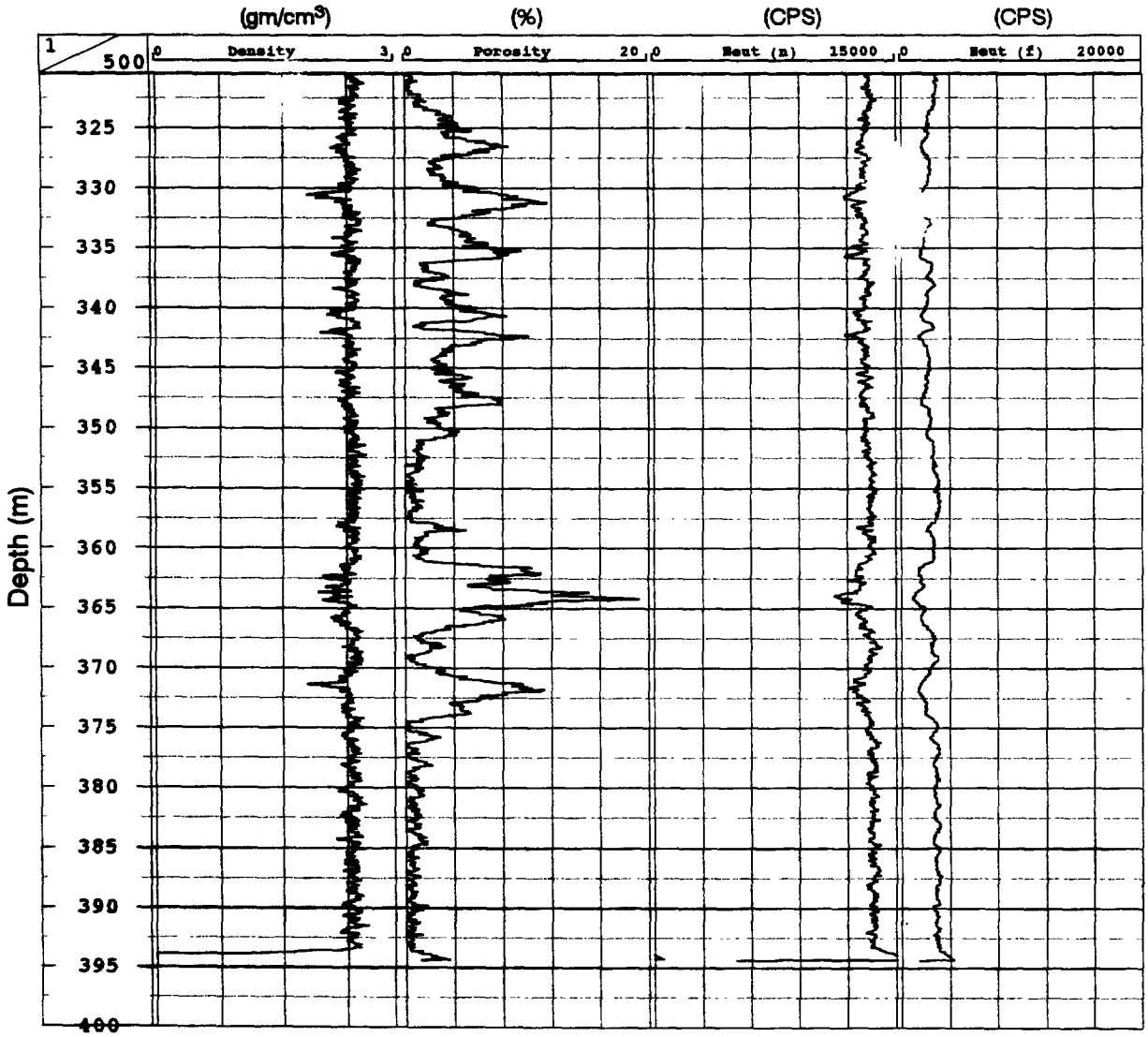

Figure HC-4.9. Density, porosity (derived from neutron) and neutron logs (continued).

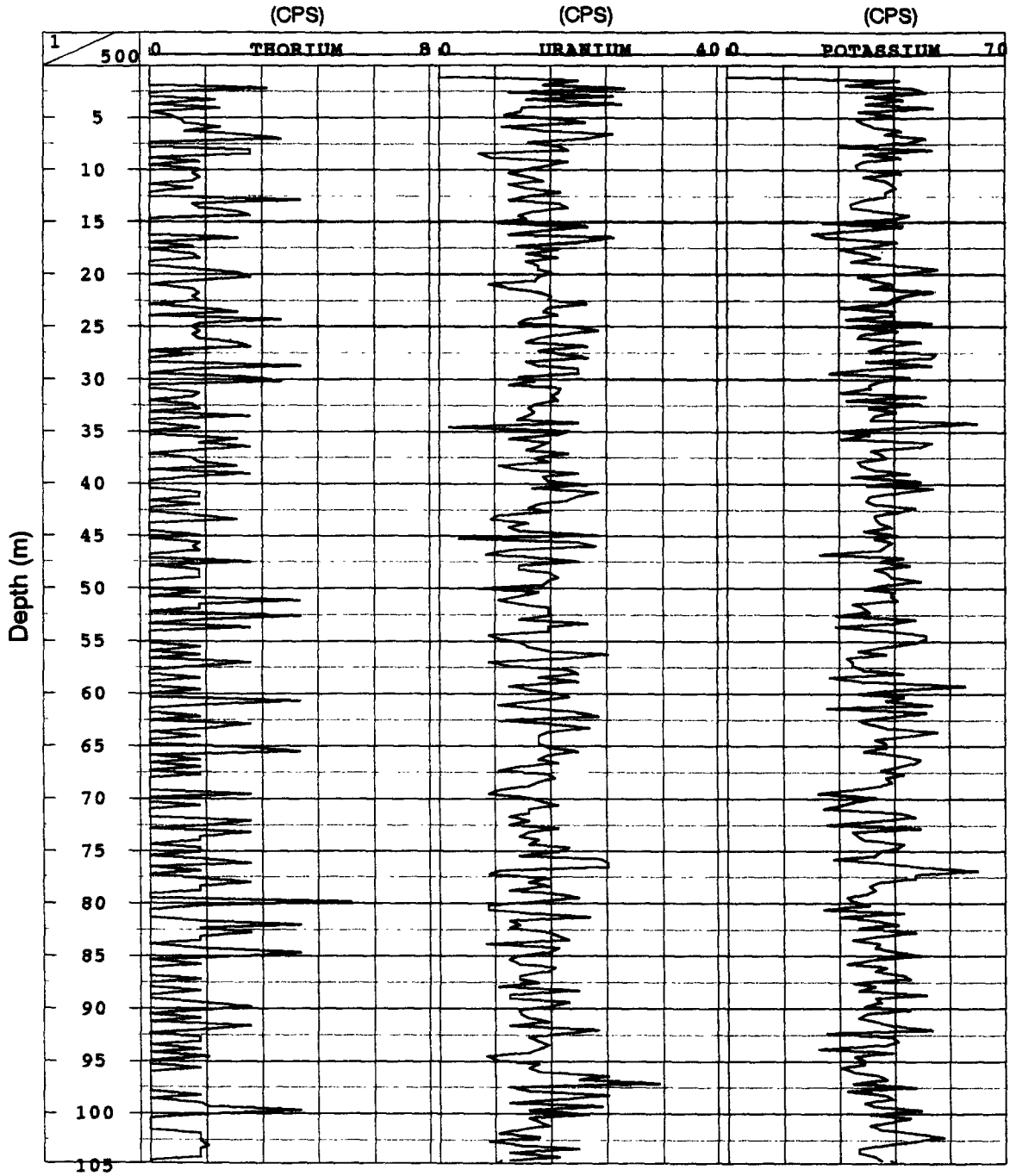

Figure HC-4.10. HC-4 spectral gamma log containing thorium, uranium and potassium.

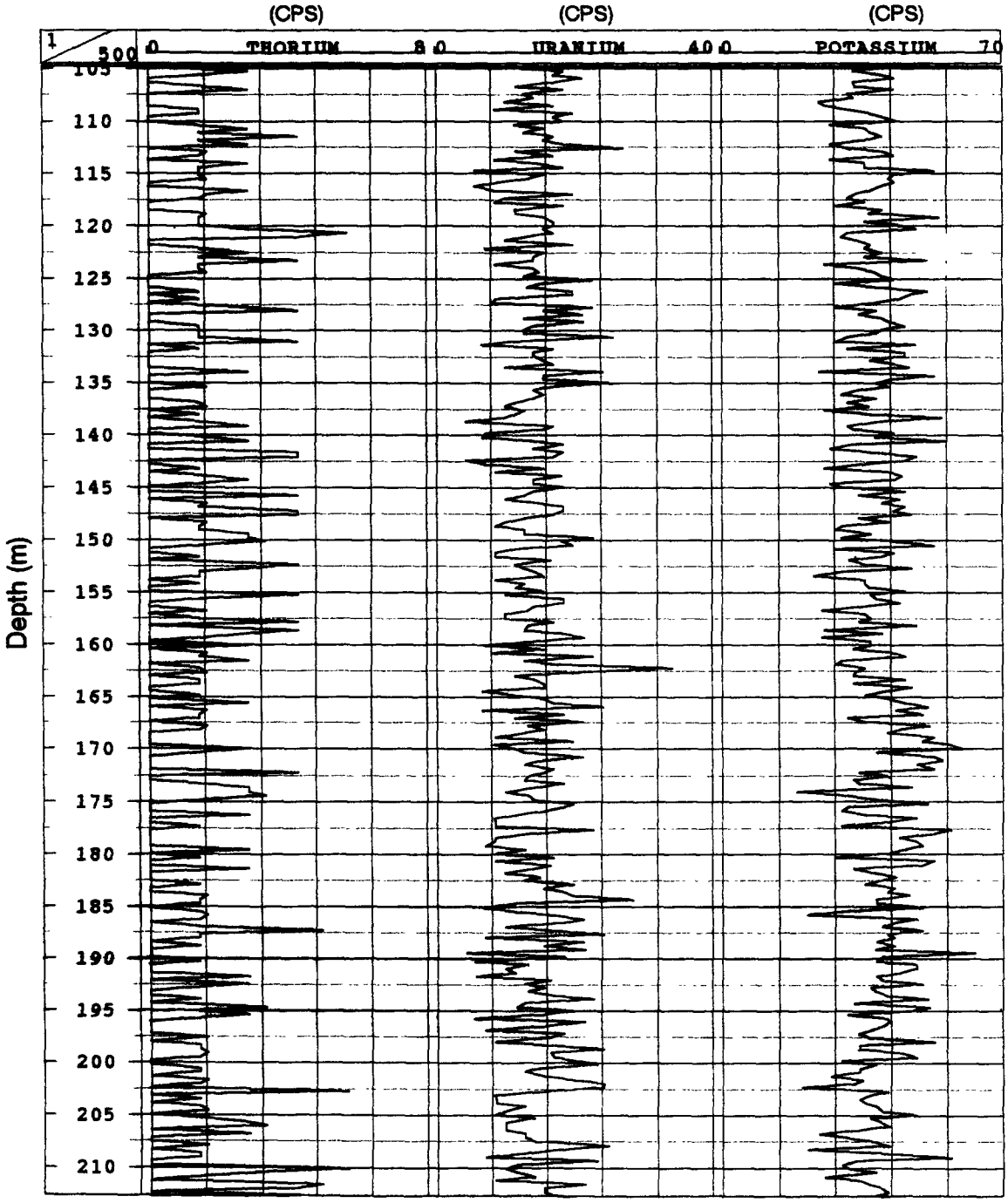

Figure HC-4.10. HC-4 spectral gamma log containing thorium, uranium and potassium (continued).

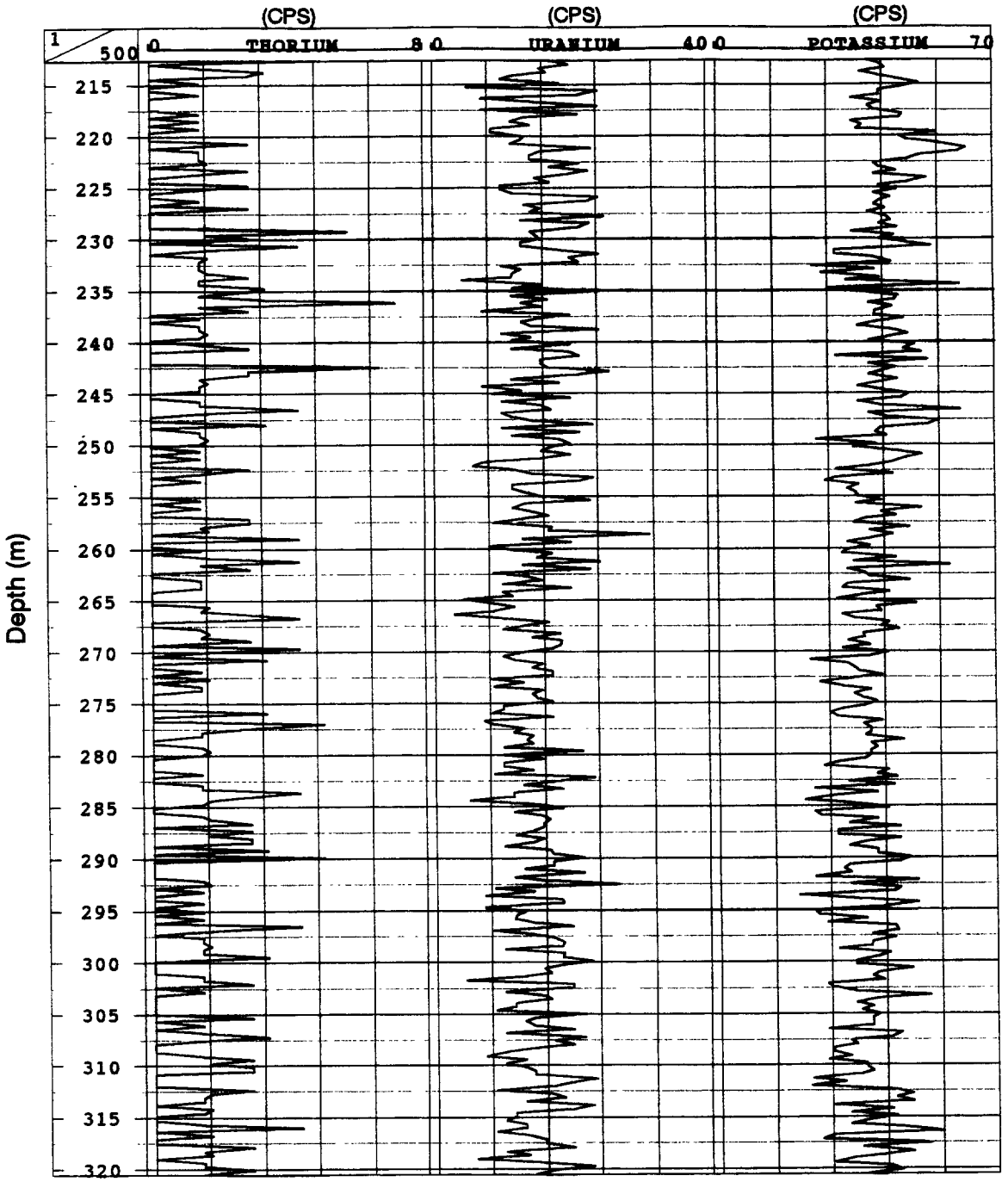

Figure HC-4.10. HC-4 spectral gamma log containing thorium, uranium and potassium (continued).

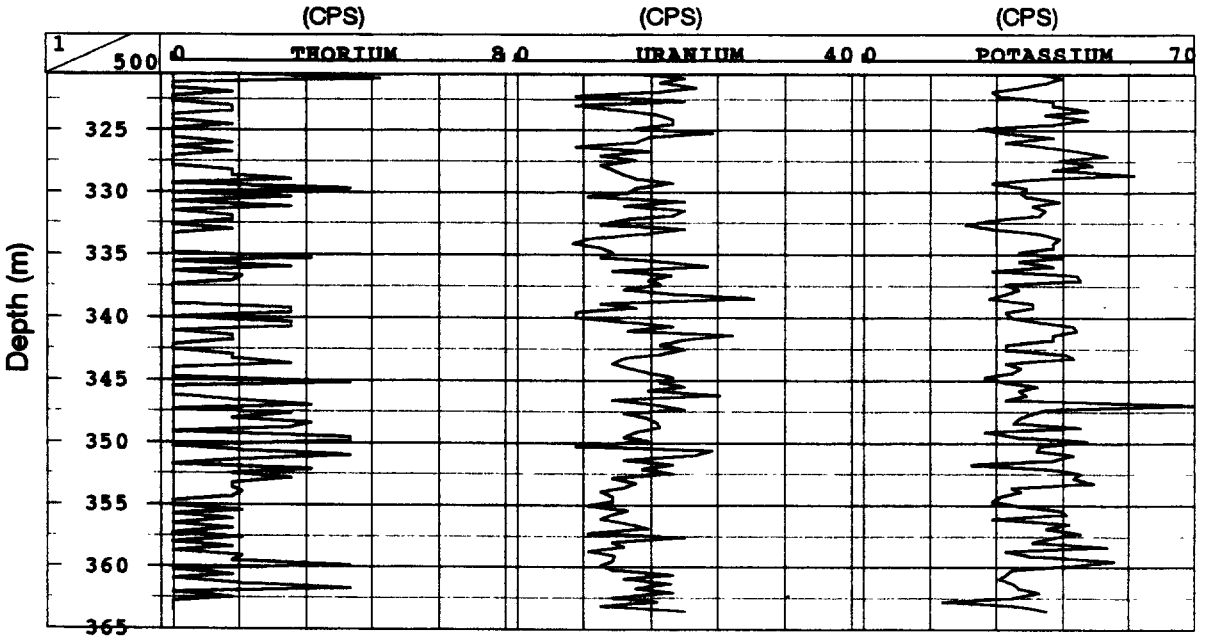

Figure HC-4.10. HC-4 spectral gamma log containing thorium, uranium and potassium (continued).

HC-5

Available Data

- Pumping Test
- Acoustic Televiewer
- Chemtool Log (temperature, EC, pH)
- Borehole Deviation
- Radar Log
- Temperature Log
- Differential Temperature Log
- Caliper Log
- Natural Gamma Log
- Guard Resistivity Log
- Neutron Porosity Log
- Caliper Log
- Compensation Log
- Density Log
- Total Gamma Log
- Spectral Gamma Ray Log (thorium, uranium, potassium)

Analysis	
Date:	10/4/1999
ΔS (m):	1.00
Q (m^3/day):	30.14
Screen Thickness (m):	36.6
Transmissivity (m^2/day):	5.5
Hydraulic Conductivity (cm/sec):	1.7E-04

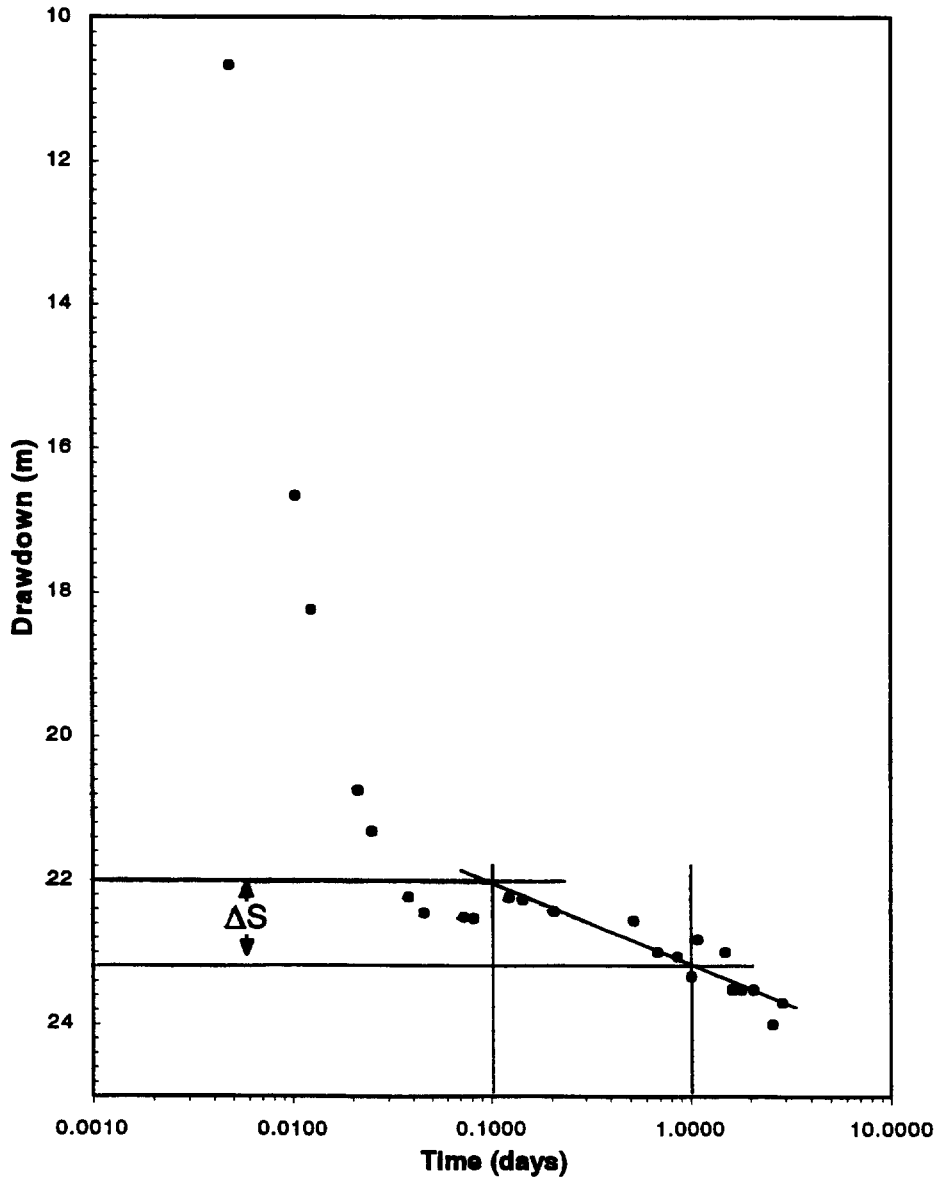

Figure HC-5.1. HC-5 pumping test analysis (1999).

Analysis	
Date:	10/11/1999
ΔS (m):	1.4
Q (m^3/day):	30.14
Screen Thickness (m):	36.6
Transmissivity (m^2/day):	3.9
Hydraulic Conductivity (cm/sec):	1.2E-04

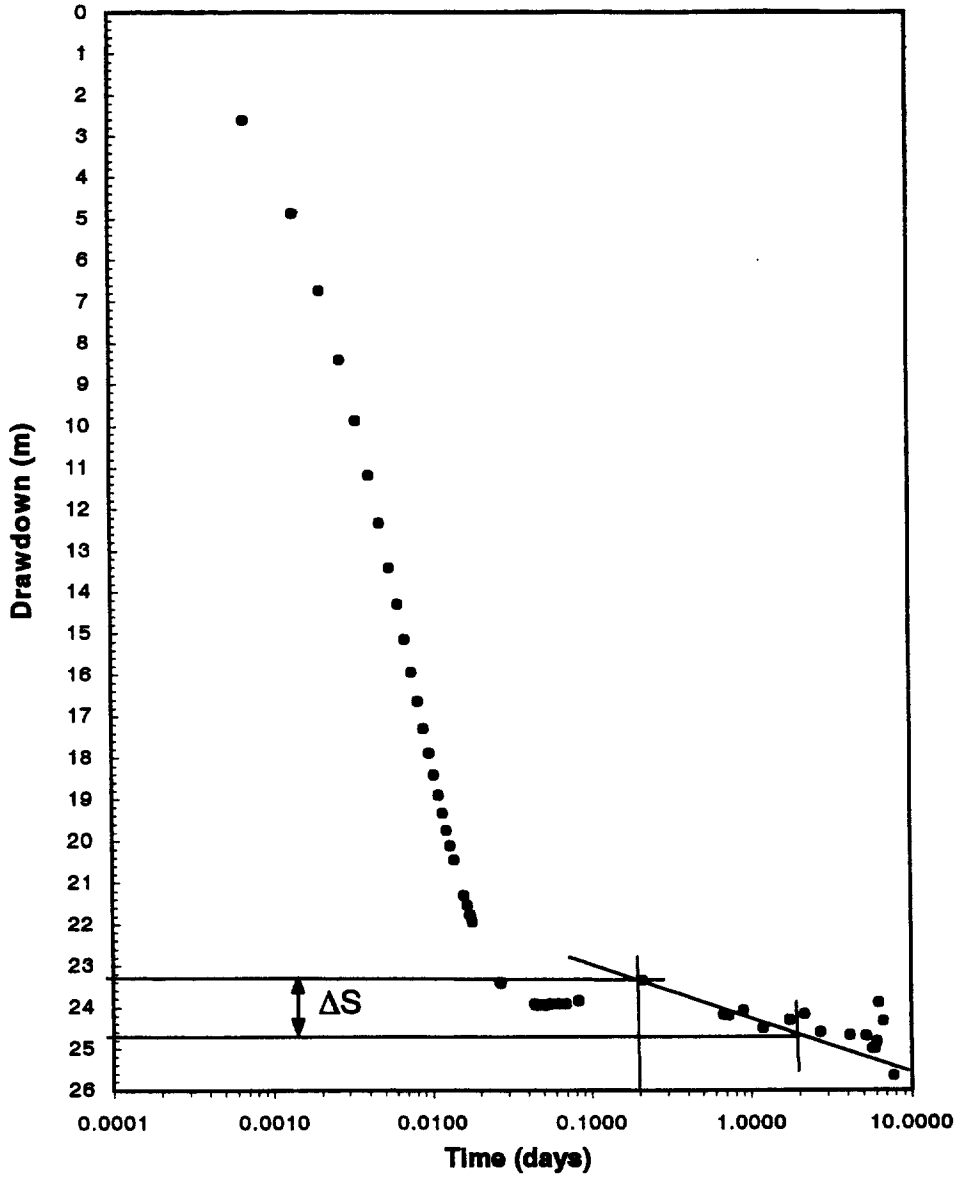

Figure HC-5.2. HC-5 pumping test analysis (1999).

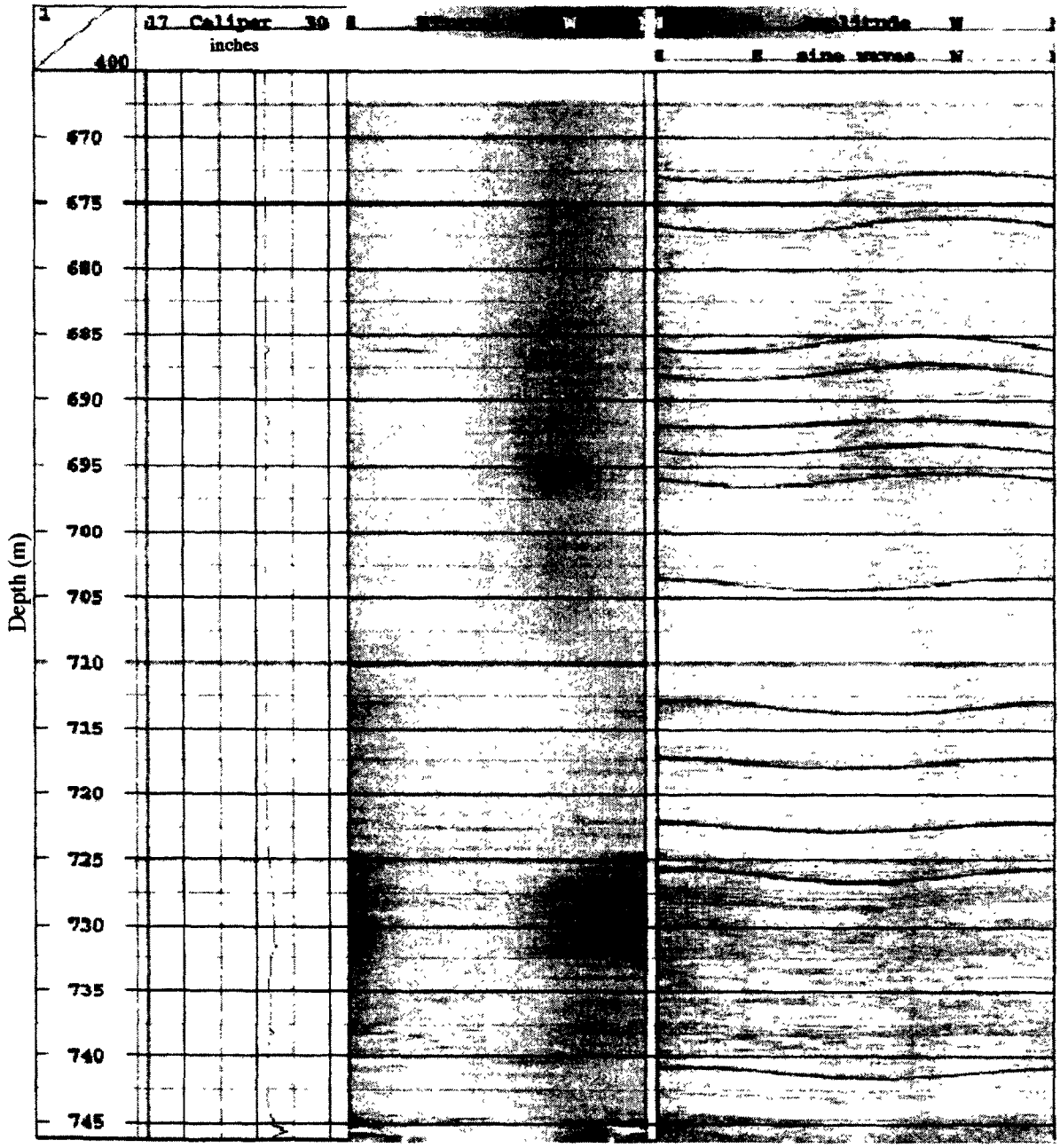

Figure HC-5.3. Acoustic televiewer and caliper log for HC-5.

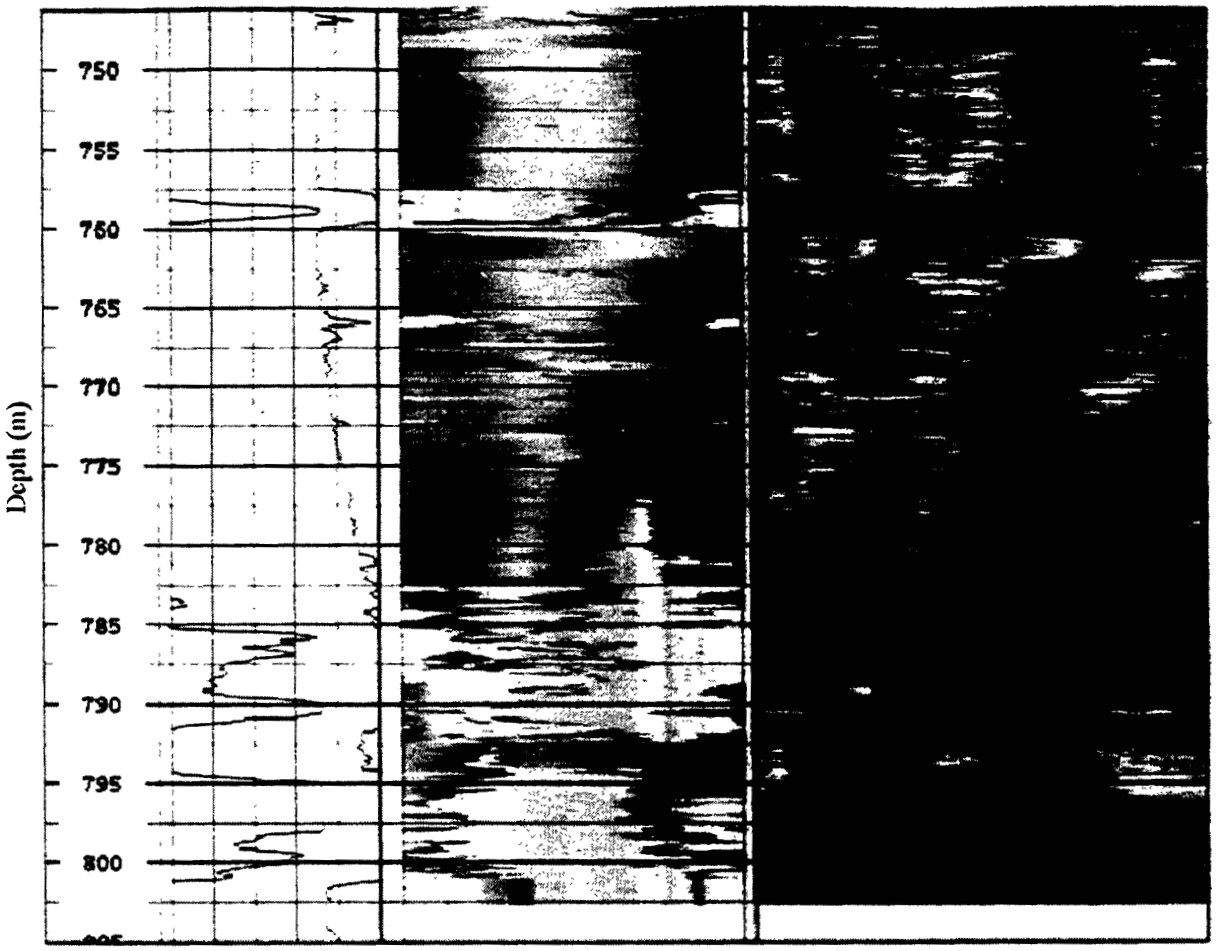

Figure HC-5.3. Acoustic televiewer and caliper log for HC-5 (continued).

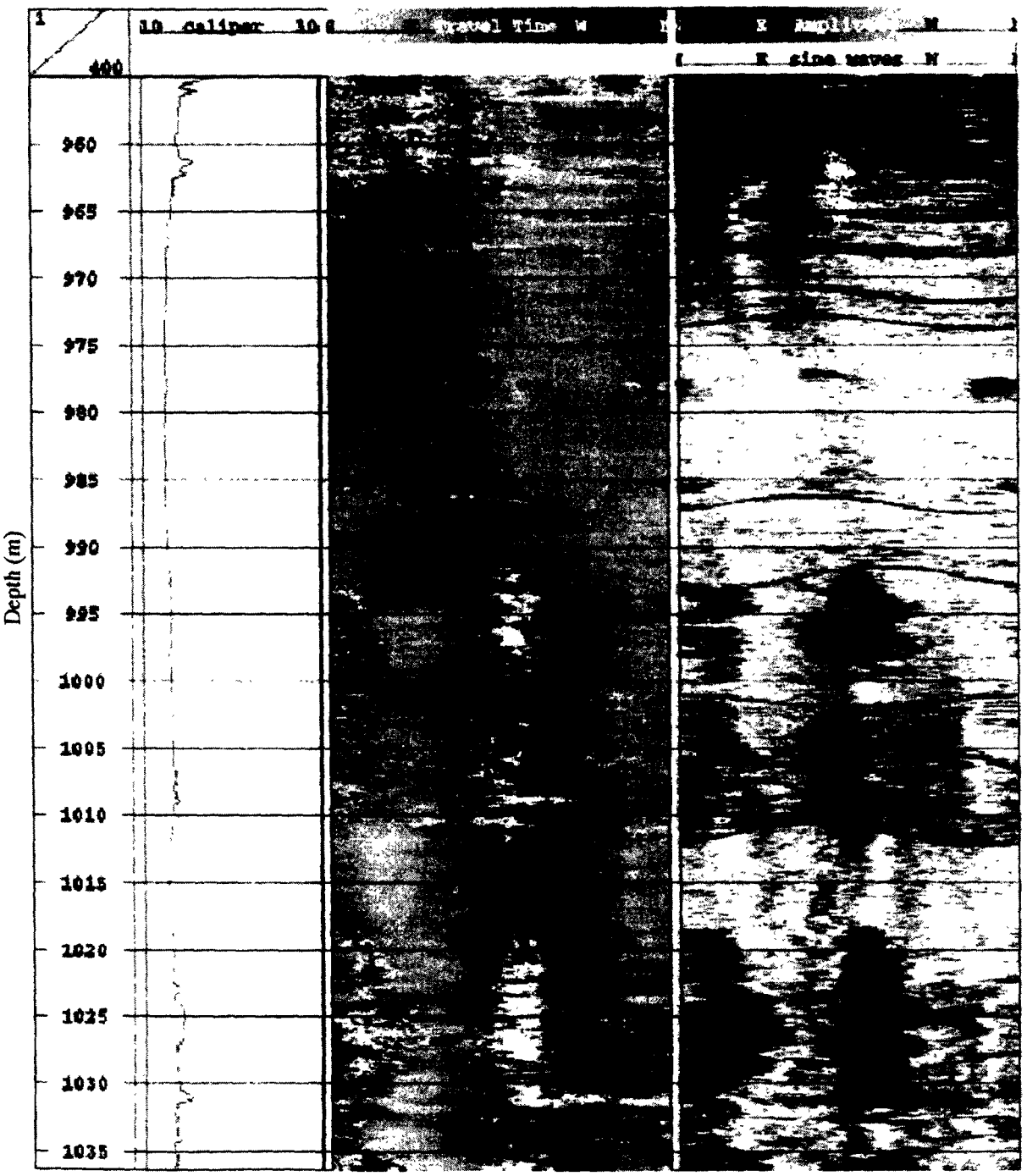

Figure HC-5.3. Acoustic televiewer and caliper log for HC-5 (continued).

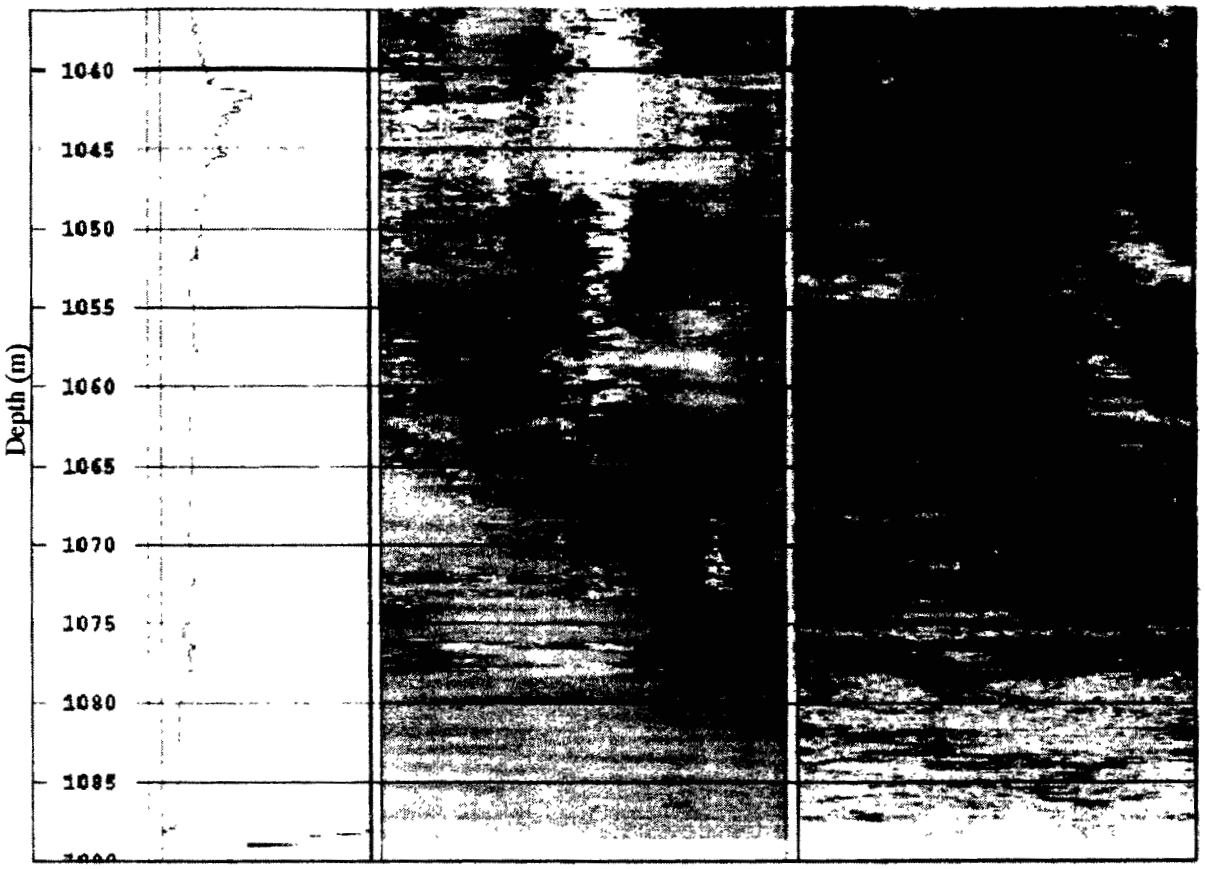

Figure HC-5.3. Acoustic televiewer and caliper log for HC-5 (continued).

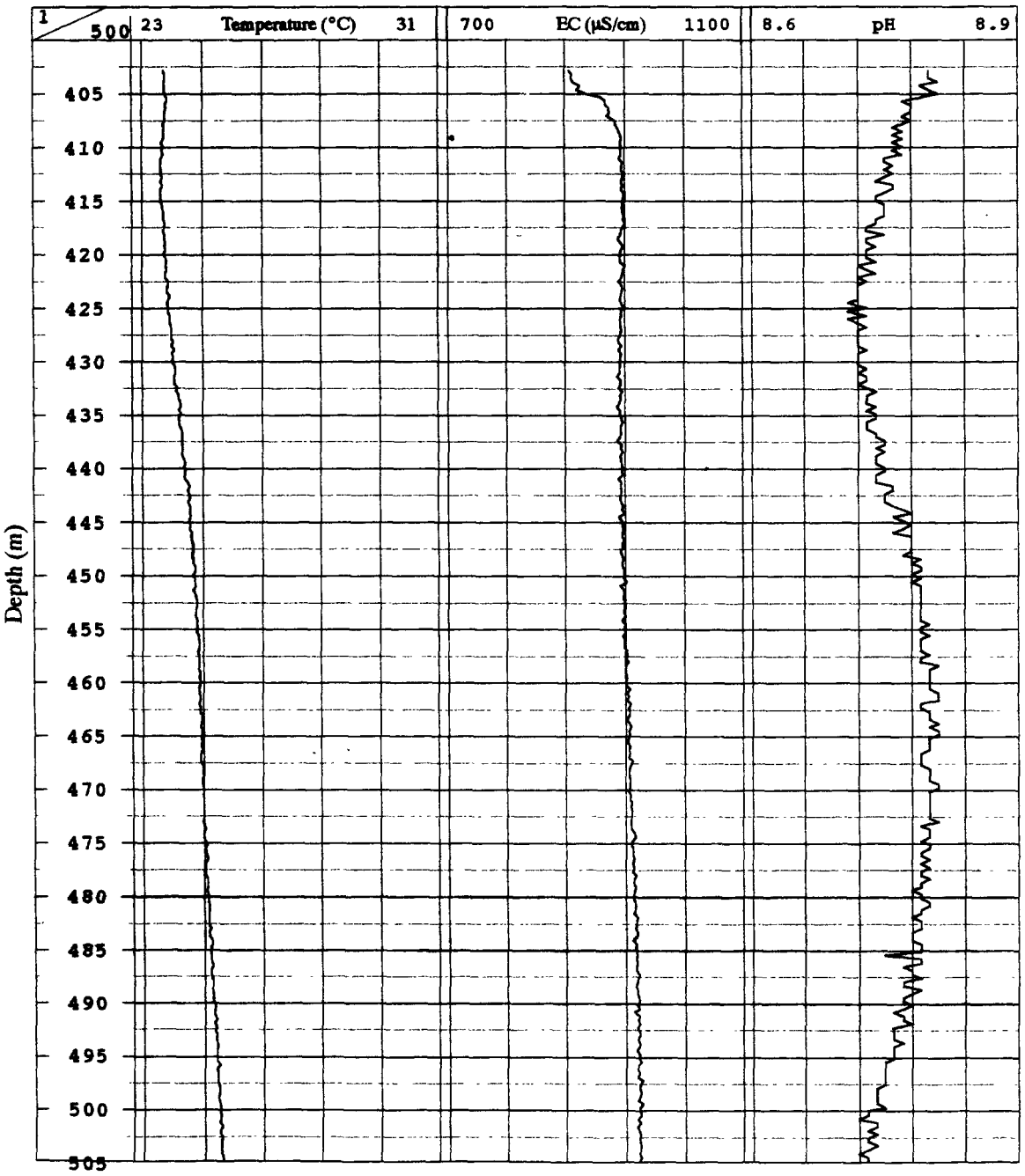

Figure HC-1.5. HC-1 chemlog containing temperature, electrical conductivty and pH.

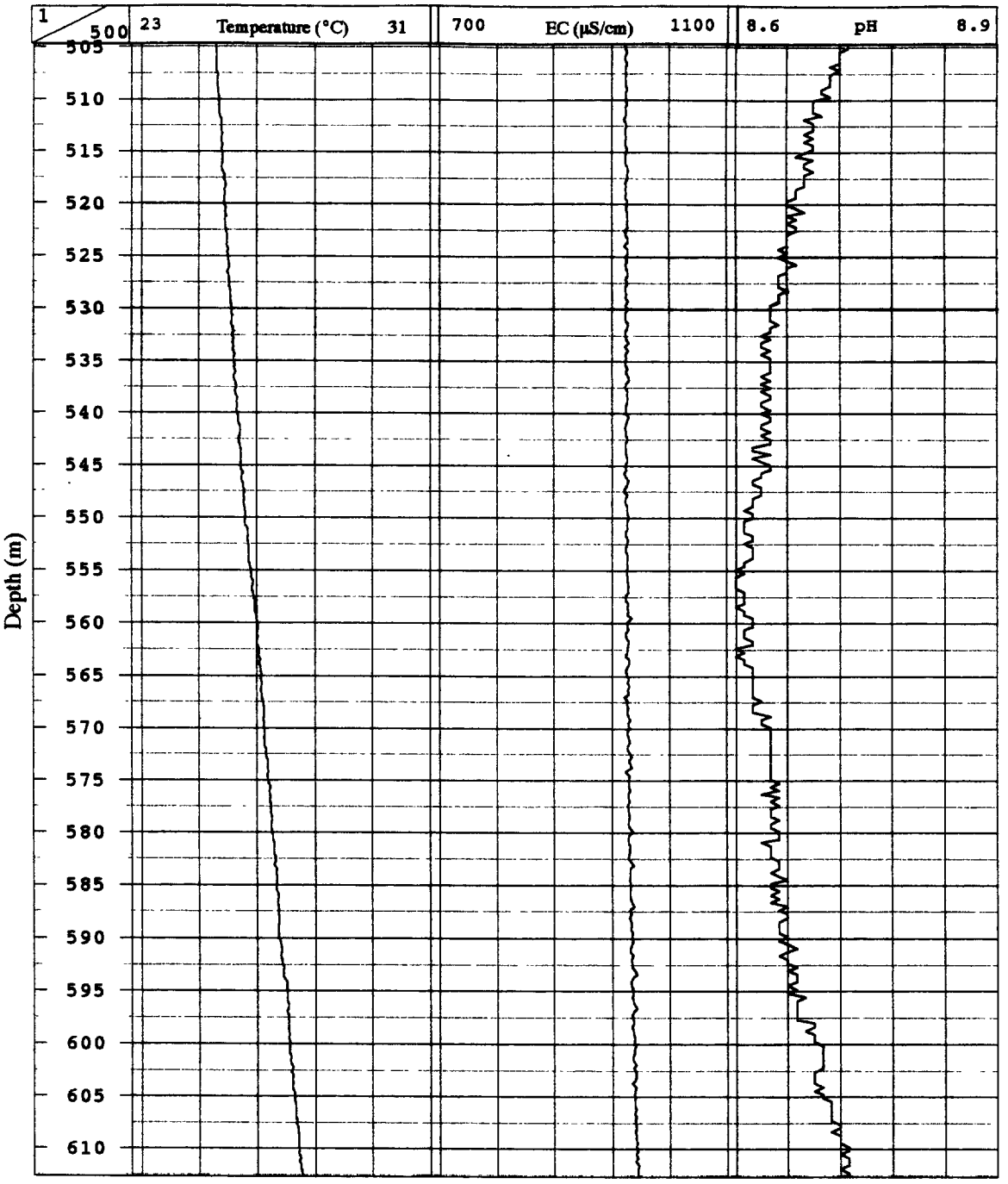

Figure HC-1.5. HC-1 chemlog containing temperature, electrical conductivty and pH (continued).

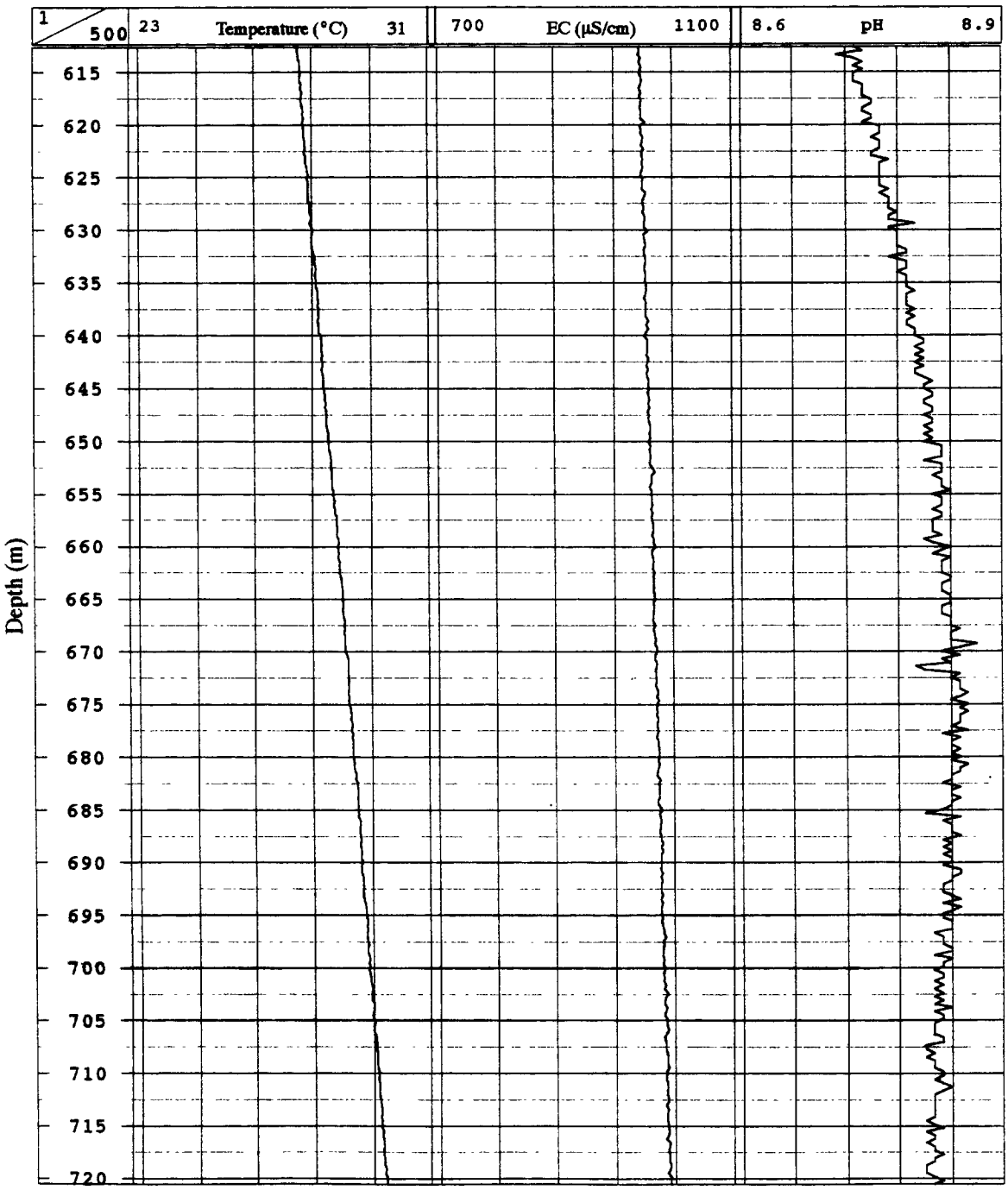

Figure HC-1.5. HC-1 chemlog containing temperature, electrical conductivty and pH (continued).

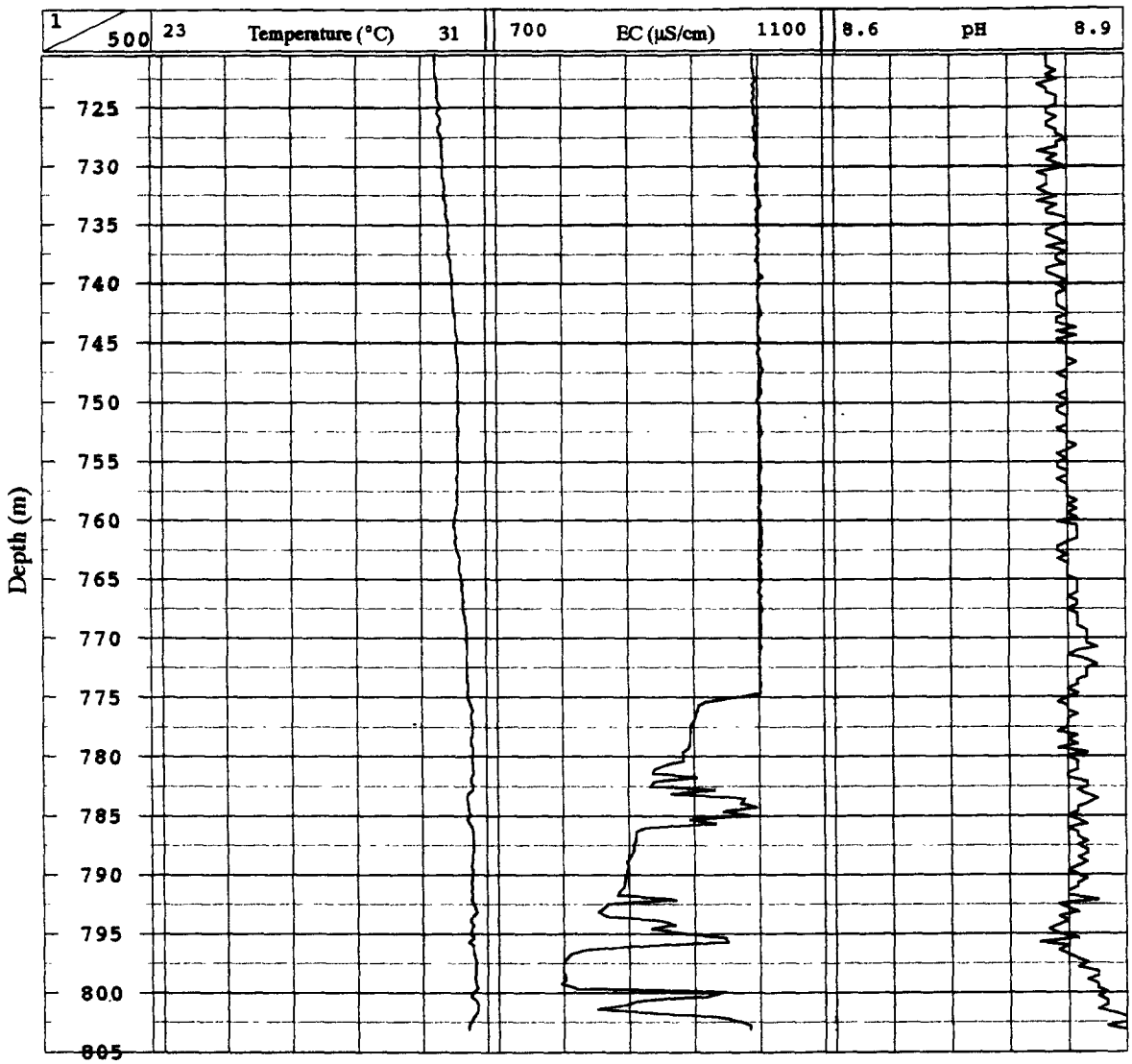

Figure HC-1.5. HC-1 chemlog containing temperature, electrical conductivty and pH (continued).

Table HC-5.1. HC-5 borehole deviation.

Cable Depth (m)	True Depth (m)	Regression True Depth (m)	Absolute Error (m)
76.20	76.20	76.17	0.0256
83.82	83.82	83.80	0.0164
91.44	91.44	91.43	0.0085
99.06	99.06	99.06	0.0017
106.68	106.68	106.68	0.0043
114.30	114.30	114.31	0.0089
121.92	121.92	121.93	0.0122
129.54	129.54	129.55	0.0152
137.16	137.16	137.17	0.0173
144.78	144.77	144.79	0.0188
152.40	152.39	152.41	0.0196
160.02	160.01	160.03	0.0202
167.64	167.63	167.65	0.0199
175.26	175.25	175.27	0.0191
182.88	182.87	182.89	0.0175
190.50	190.49	190.51	0.0157
198.12	198.11	198.12	0.0138
205.74	205.73	205.74	0.0114
213.36	213.35	213.36	0.0090
220.98	220.97	220.97	0.0080
228.60	228.58	228.59	0.0075
236.22	236.20	236.21	0.0076
243.84	243.81	243.82	0.0075
251.46	251.43	251.44	0.0064
259.08	259.05	259.05	0.0060
266.70	266.66	266.67	0.0055
274.32	274.28	274.28	0.0040
281.94	281.89	281.90	0.0039
289.56	289.51	289.51	0.0051
297.18	297.12	297.13	0.0043
304.80	304.74	304.74	0.0039
312.42	312.36	312.36	0.0030
320.04	319.97	319.97	0.0041
327.66	327.58	327.59	0.0051
335.28	335.20	335.20	0.0051
342.90	342.81	342.82	0.0062
350.52	350.43	350.43	0.0058
358.14	358.04	358.05	0.0046
365.76	365.66	365.66	0.0037
373.38	373.27	373.28	0.0034
381.00	380.89	380.89	0.0023
388.62	388.51	388.51	0.0020
396.24	396.12	396.12	0.0013
403.86	403.74	403.74	0.0011
411.48	411.35	411.35	0.0014
419.10	418.97	418.97	0.0027
426.72	426.58	426.58	0.0036
434.34	434.9	434.20	0.0049
441.96	441.81	441.81	0.0063
449.58	449.42	449.43	0.0071
457.20	457.04	457.05	0.0085
464.82	464.65	464.66	0.0088
472.44	472.27	472.28	0.0101
480.06	479.88	479.89	0.0119

Table HC-5.1. HC-5 borehole deviation.

Cable Depth (m)	True Depth (m)	Regression True Depth (m)	Absolute Error (m)
487.68	487.49	487.51	0.0142
495.30	495.10	495.12	0.0159
502.92	502.72	502.74	0.0170
510.54	510.33	510.35	0.0191
518.16	517.94	517.97	0.0205
525.78	525.56	525.58	0.0230
533.40	533.17	533.19	0.0247
541.02	540.78	540.81	0.0257
548.64	548.40	548.42	0.0272
556.26	556.01	556.04	0.0291
563.88	563.62	563.65	0.0308
571.50	571.23	571.26	0.0323
579.12	578.84	578.88	0.0342
586.74	586.46	586.49	0.0352
594.36	594.07	594.10	0.0355
601.98	601.68	601.72	0.0354
609.60	609.29	609.33	0.0346
617.22	616.91	616.94	0.0340
624.84	624.52	624.55	0.0337
632.46	632.13	632.16	0.0337
640.08	639.74	639.78	0.0340
647.70	647.35	647.39	0.0334
655.32	654.97	655.00	0.0317
662.94	662.58	662.61	0.0303
670.56	670.19	670.22	0.0279
678.18	677.80	677.83	0.0246
685.80	685.41	685.44	0.0233
693.42	693.02	693.04	0.0216
701.04	700.64	700.65	0.0170
708.66	708.25	708.26	0.0144
716.28	715.86	715.87	0.0121
723.90	723.46	723.47	0.0115
731.52	731.07	731.08	0.0097
739.14	738.68	738.69	0.0060
746.76	746.29	746.29	0.0040
754.38	753.89	753.90	0.0023
762.00	761.50	761.50	0.0008
769.62	769.10	769.10	0.0015
777.24	776.70	776.71	0.0053
784.86	784.30	784.31	0.0087
792.48	791.88	791.91	0.0287
800.10	799.49	799.52	0.0240
807.72	807.09	807.12	0.0221
815.34	814.70	814.72	0.0215
822.96	822.30	822.32	0.0223
830.58	829.89	829.92	0.0267
838.20	837.49	837.52	0.0276
845.82	845.09	845.12	0.0260
853.44	852.69	852.71	0.0268
861.06	860.29	860.31	0.0252
868.68	867.89	867.91	0.0242
876.30	875.48	875.51	0.0217
883.92	883.08	883.10	0.0207
891.54	890.67	890.70	0.0259

Table HC-5.1. HC-5 borehole deviation.

Cable Depth (m)	True Depth (m)	Regression True Depth (m)	Absolute Error (m)
899.16	898.27	898.30	0.0285
906.78	905.86	905.89	0.0274
914.40	913.46	913.49	0.0249
922.02	921.06	921.08	0.0242
929.64	928.65	928.67	0.0264
937.26	936.24	936.27	0.0240
944.88	943.84	943.86	0.0235
952.50	951.43	951.46	0.0216
960.12	959.03	959.05	0.0229
967.74	966.61	966.64	0.0287
975.36	974.20	974.24	0.0320
982.98	981.80	981.83	0.0328
990.60	989.38	989.42	0.0371
998.22	996.97	997.02	0.0426
1005.84	1004.56	1004.61	0.0482
1013.46	1012.15	1012.20	0.0502
1021.08	1019.74	1019.79	0.0571
1028.70	1027.33	1027.39	0.0605
1036.32	1034.92	1034.98	0.0586
1043.94	1042.52	1042.57	0.0509
1051.56	1050.12	1050.17	0.0454
1059.18	1057.73	1057.76	0.0358
1066.80	1065.34	1065.36	0.0205
1074.42	1072.94	1072.95	0.0101
1082.04	1080.55	1080.55	0.0037
1088.44	1086.93	1086.93	0.0004

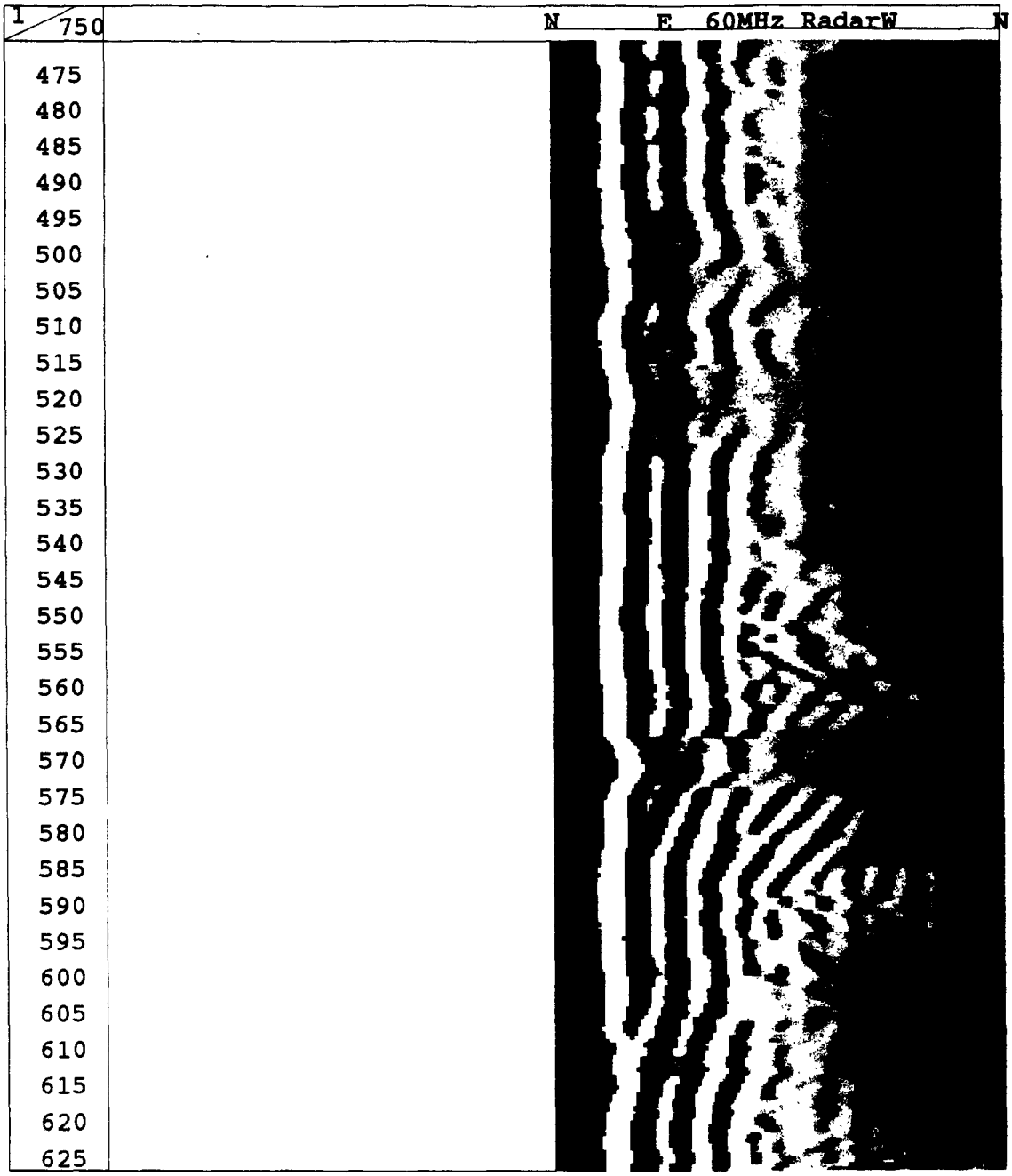

Figure HC-5.5. Ominidirectinal radar log for HC-5 from 470 to 725 m.

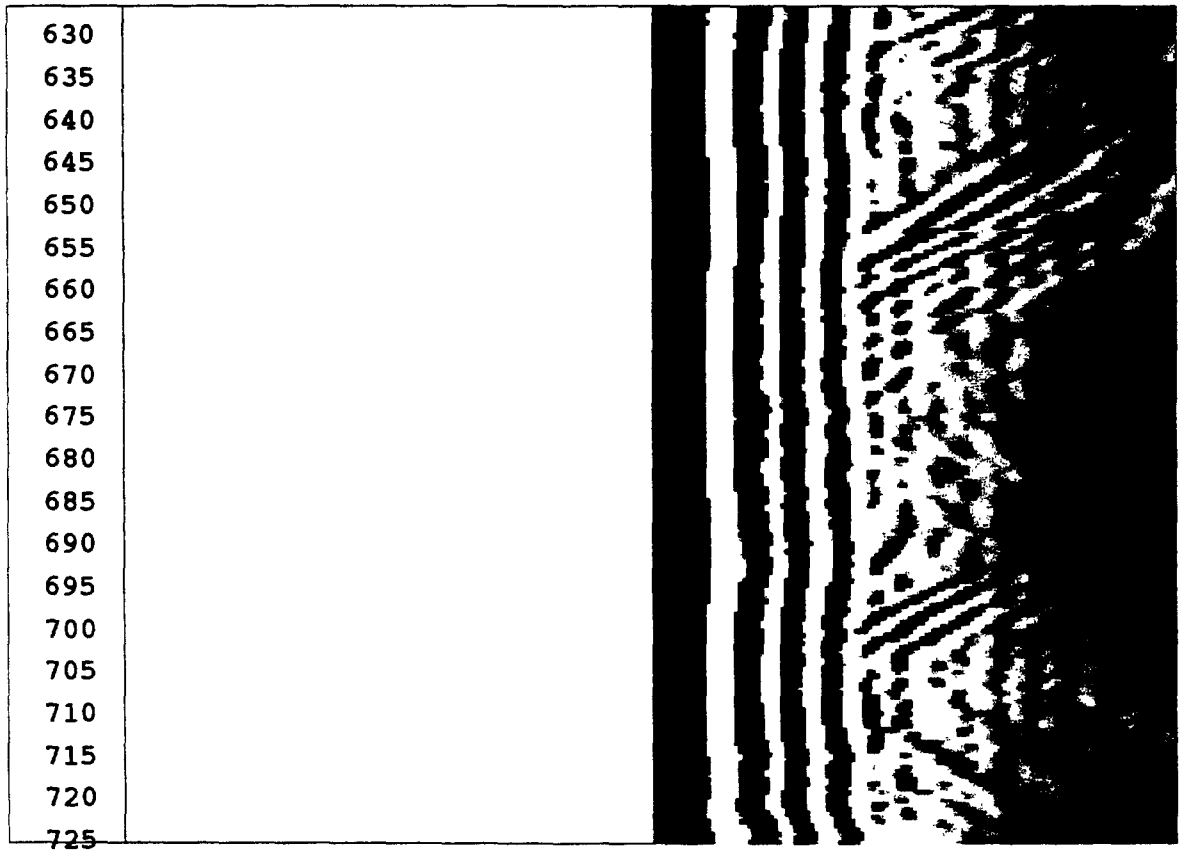

Figure HC-5.5. Ominidirectinal radar log for HC-5 from 470 to 725 m (continued).

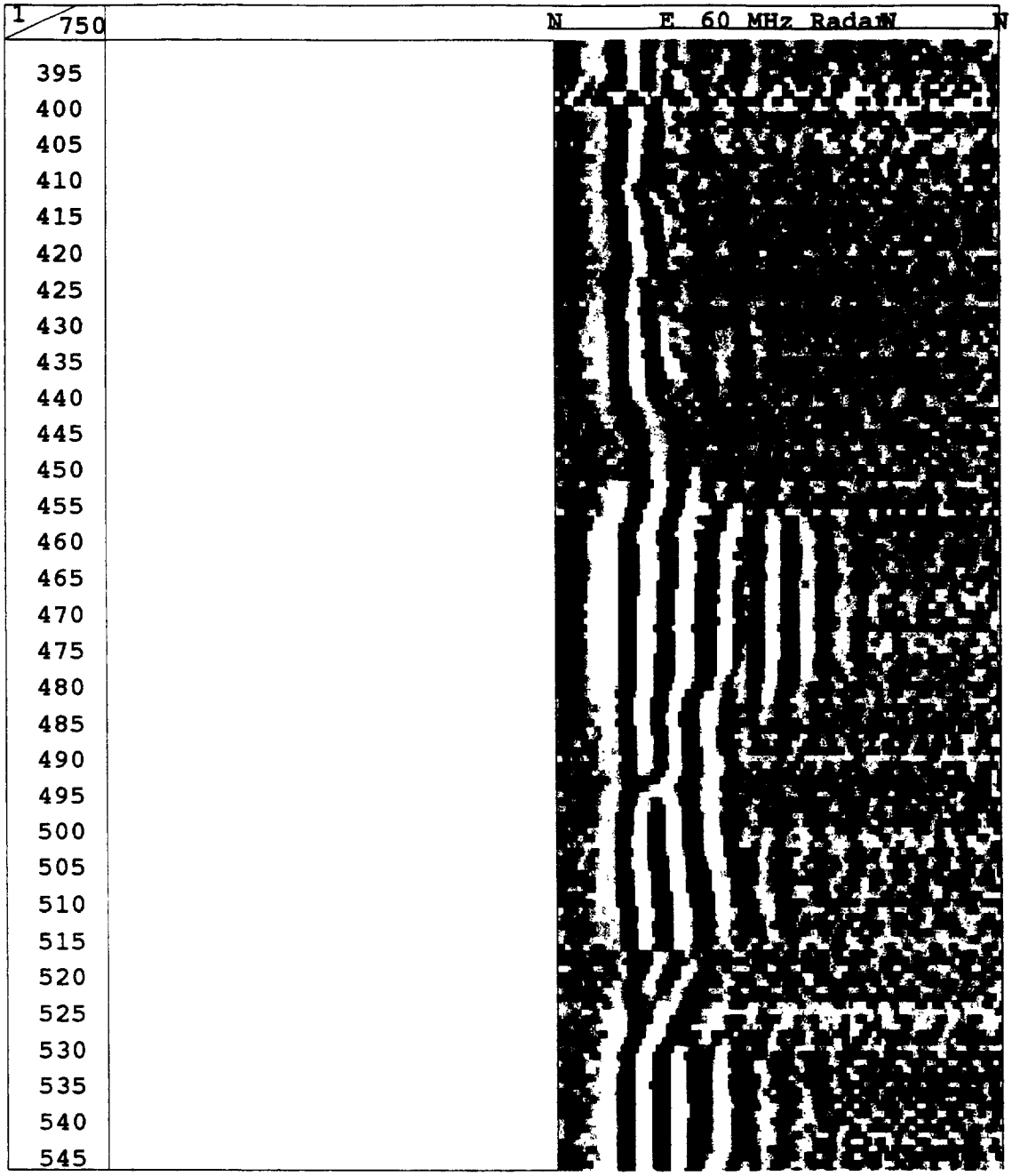

Figure HC-5.6. Dipole component of directional radar for HC-5 from 390 to 600 m.

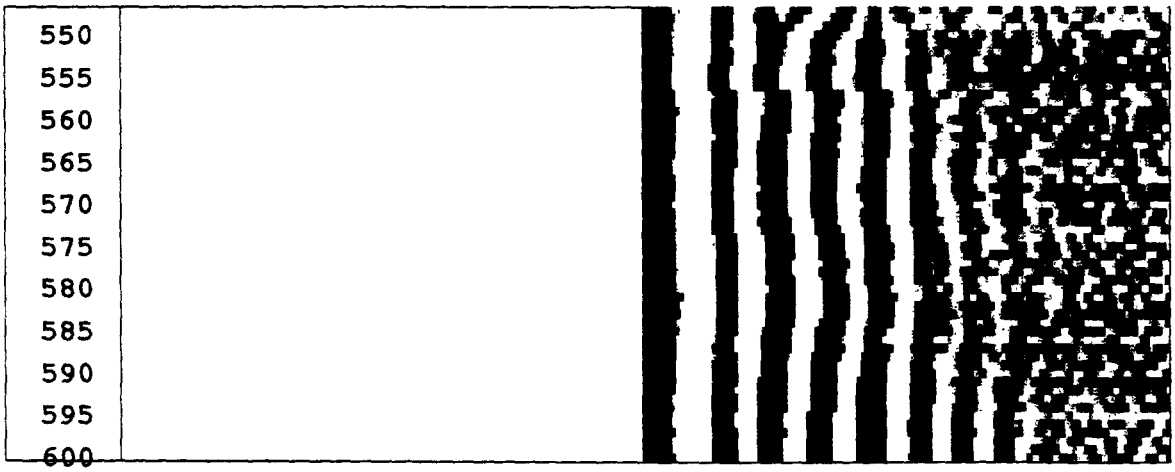

Figure HC-5.6. Dipole component of directional radar for HC-5 from 390 to 600 m (continued).

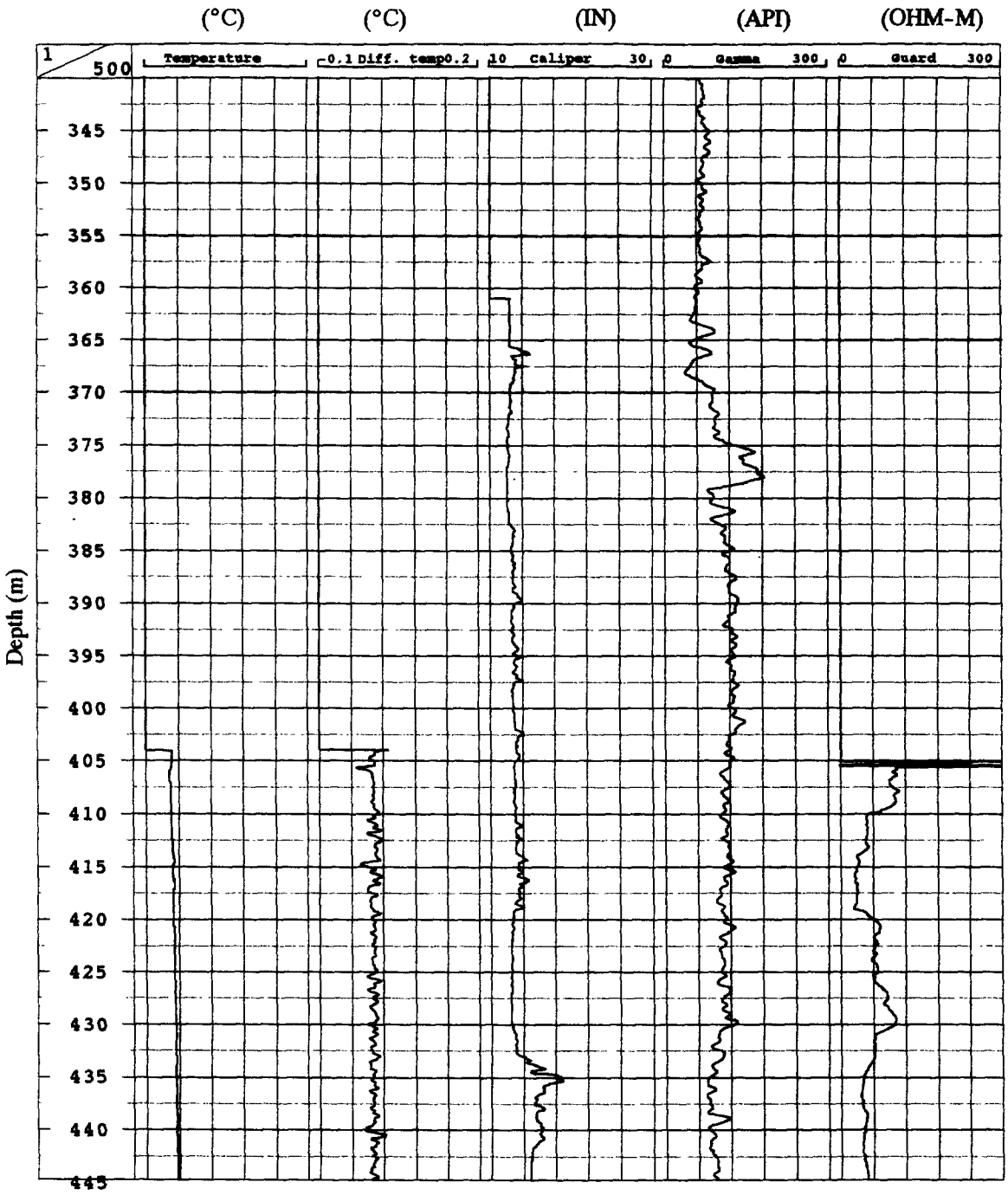

Figure HC-5.7. HC-5 temperature, differential temperature, caliper, natural gamma and guard resistivity log.

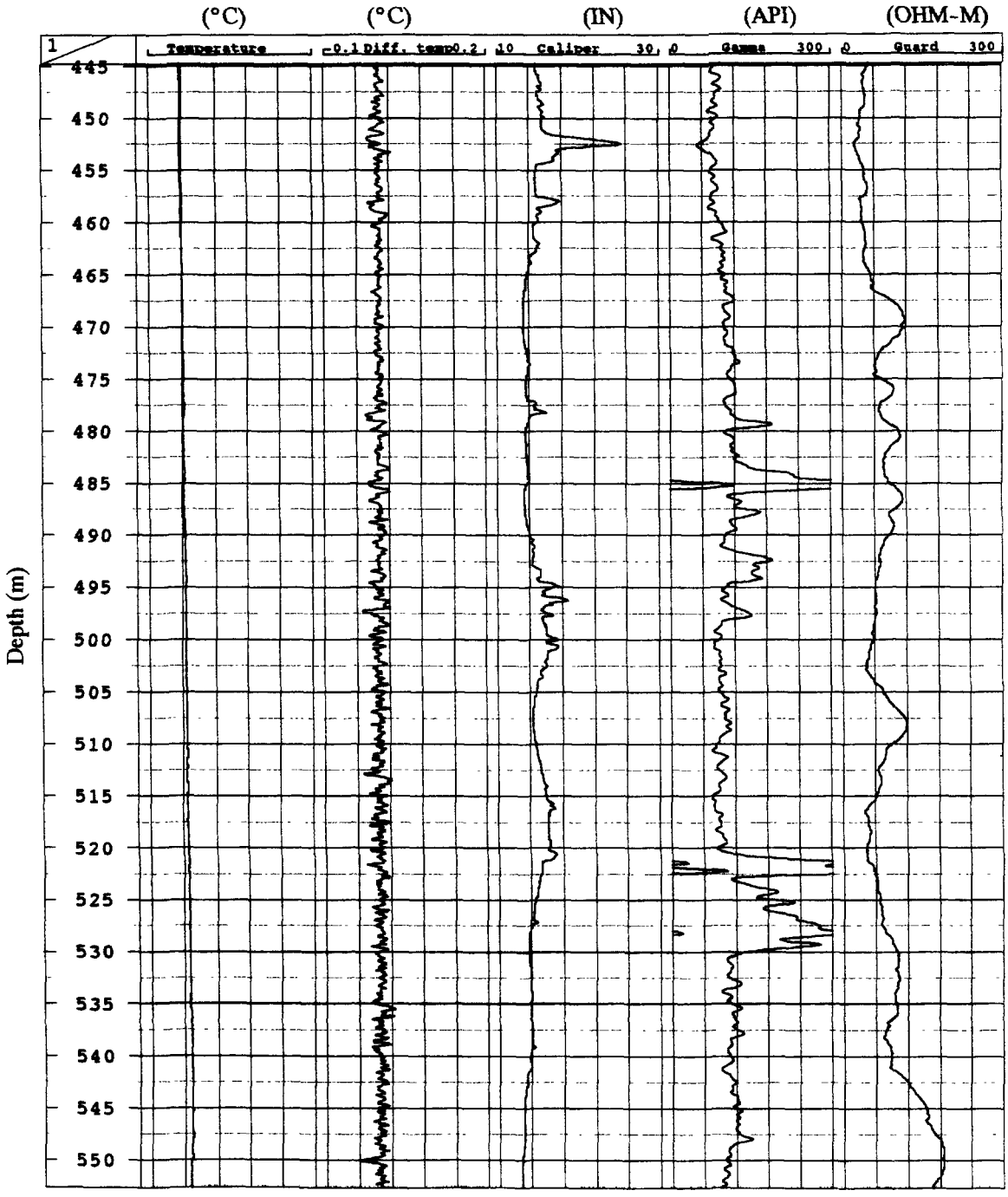

Figure HC-5.7. HC-5 temperature, differential temperature, caliper, natural gamma and guard resistivity log (continued).

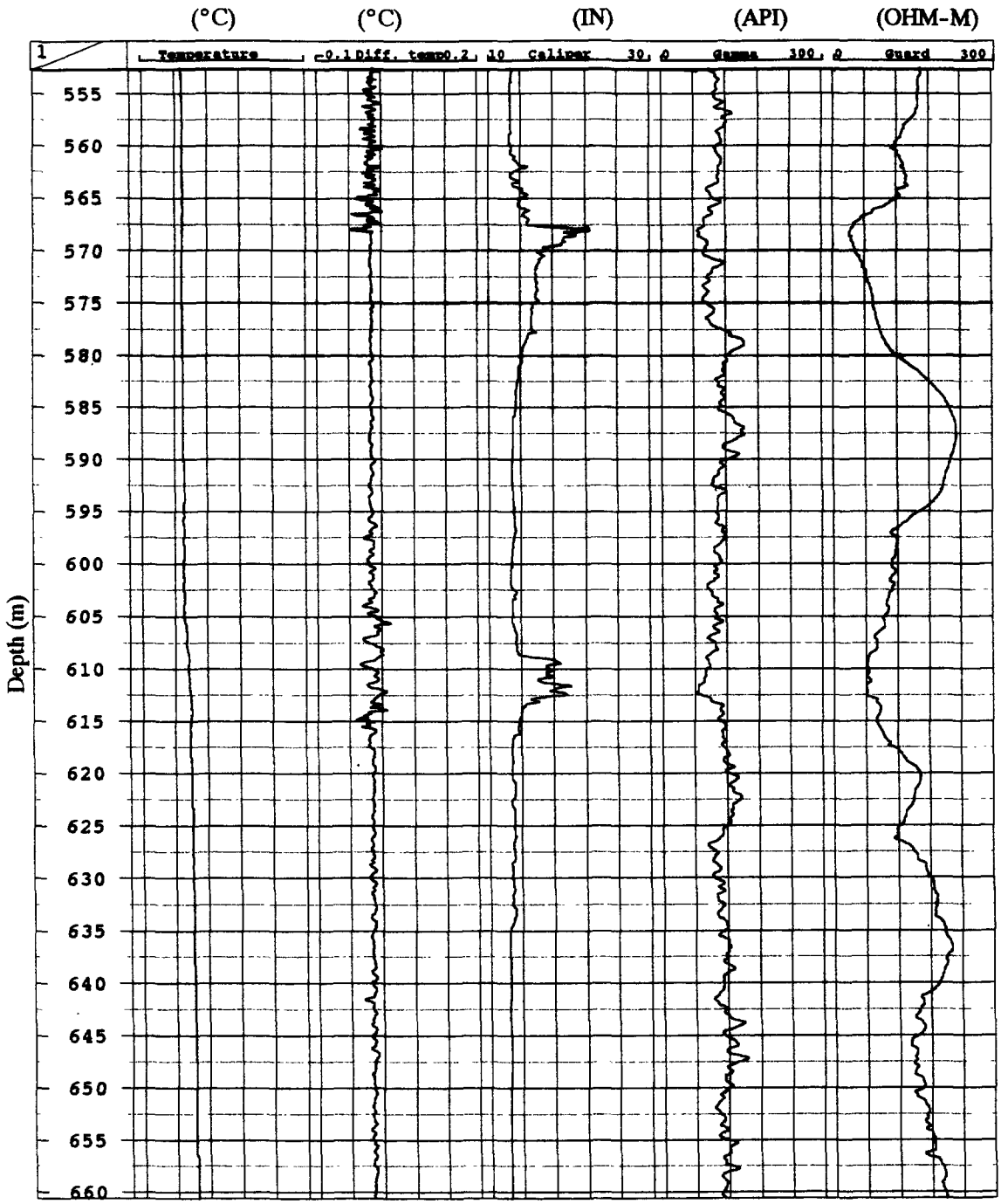

Figure HC-5.7. HC-5 temperature, differential temperature, caliper, natural gamma and guard resistivity log (continued).

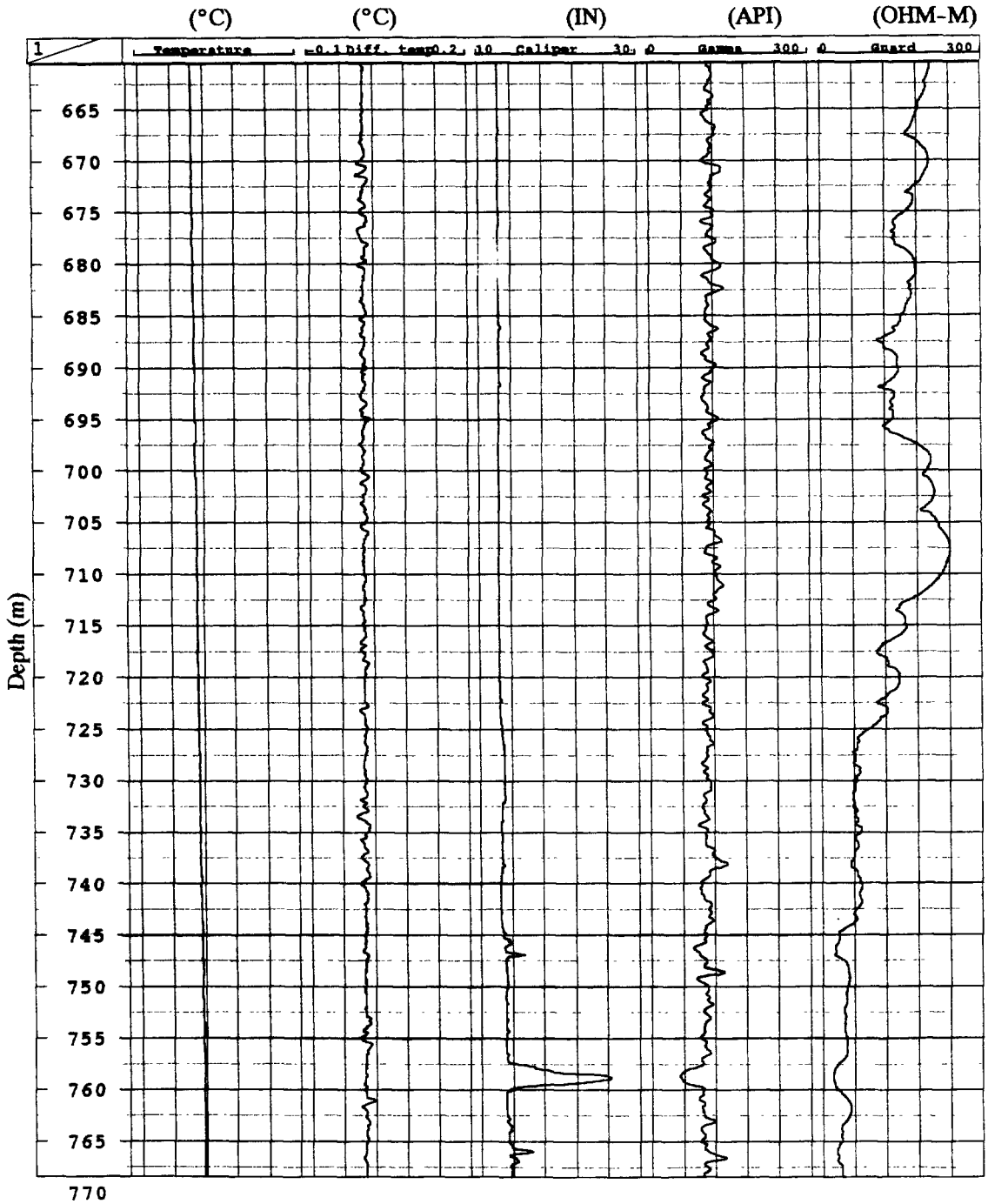

Figure HC-5.7. HC-5 temperature, differential temperature, caliper, natural gamma and guard resistivity log (continued).

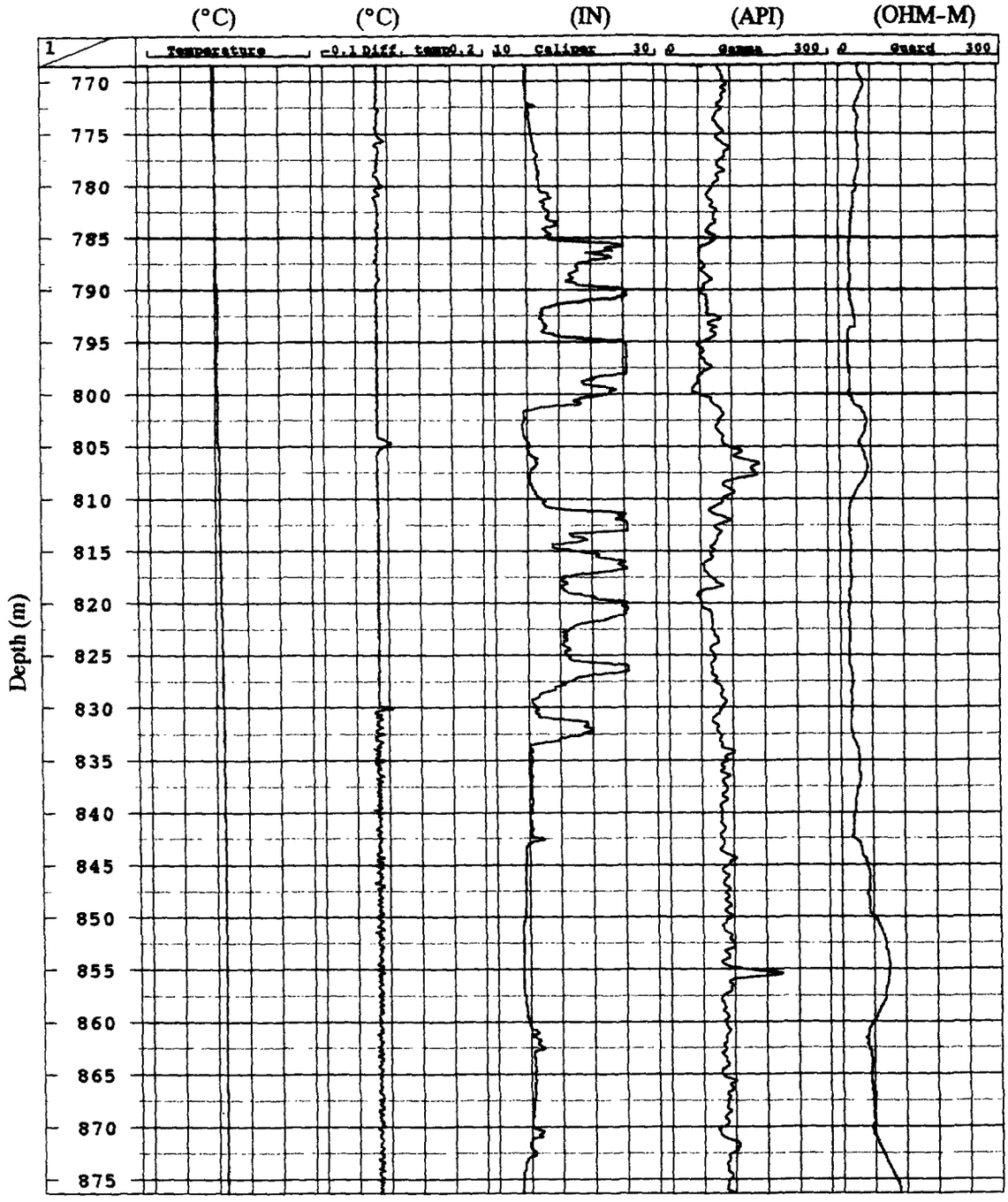

Figure HC-5.7. HC-5 temperature, differential temperature, caliper, natural gamma and guard resistivity log (continued).

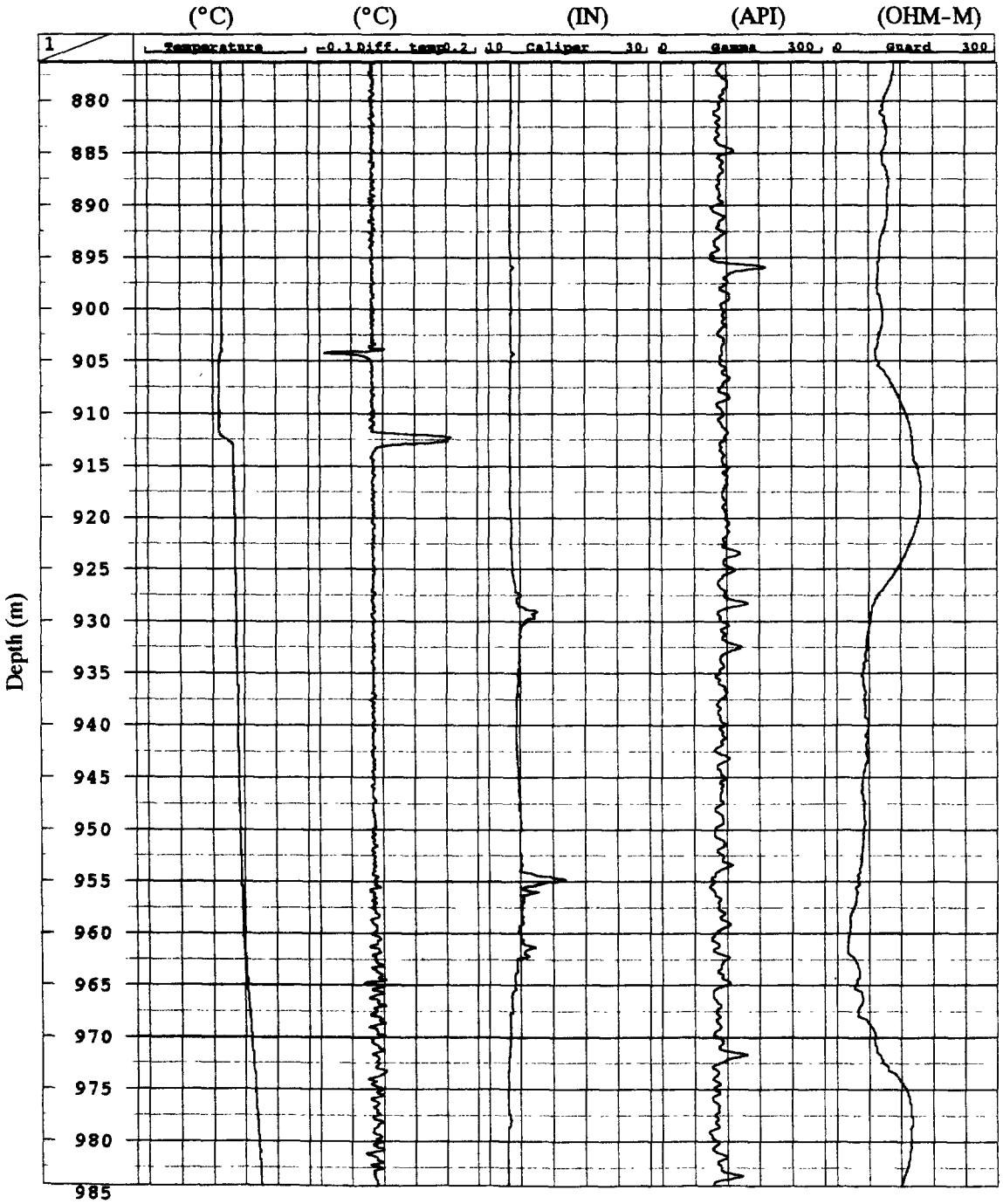

Figure HC-5.7. HC-5 temperature, differential temperature, caliper, natural gamma and guard resistivity log (continued).

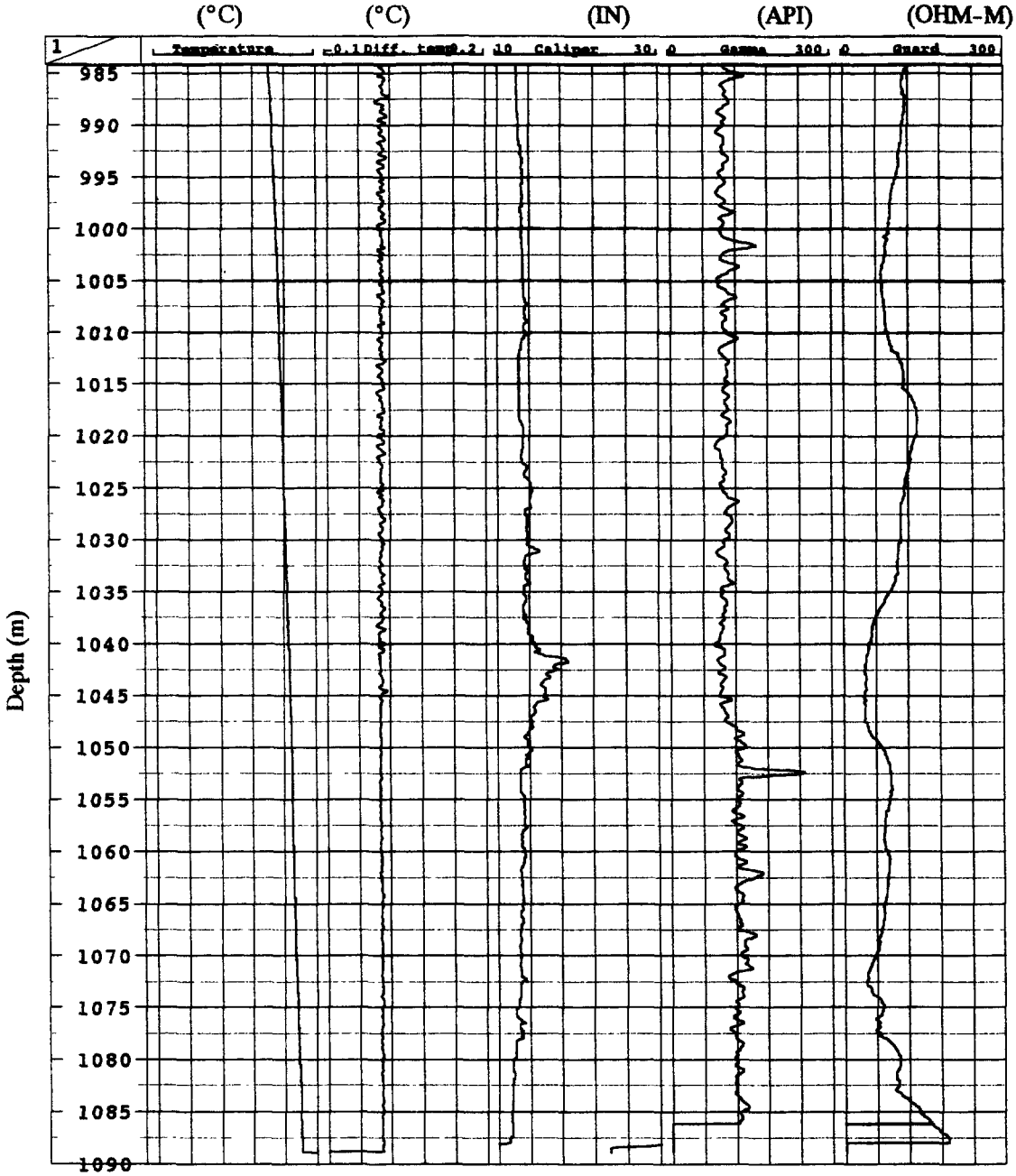

Figure HC-5.7. HC-5 temperature, differential temperature, caliper, natural gamma and guard resistivity log (continued).

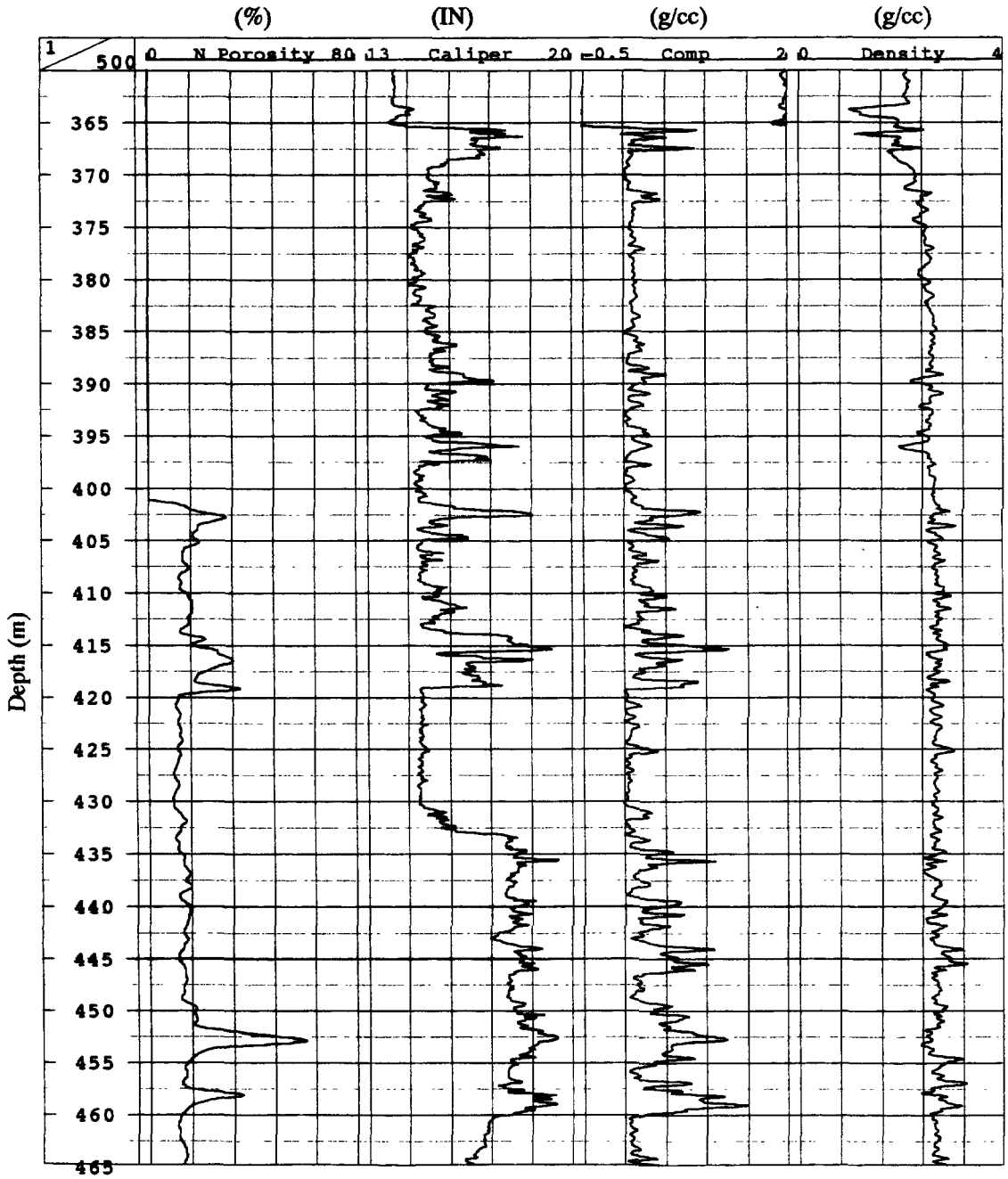

Figure HC-5.8. HC-5 neutron porosity, caliper, compensation and density logs.

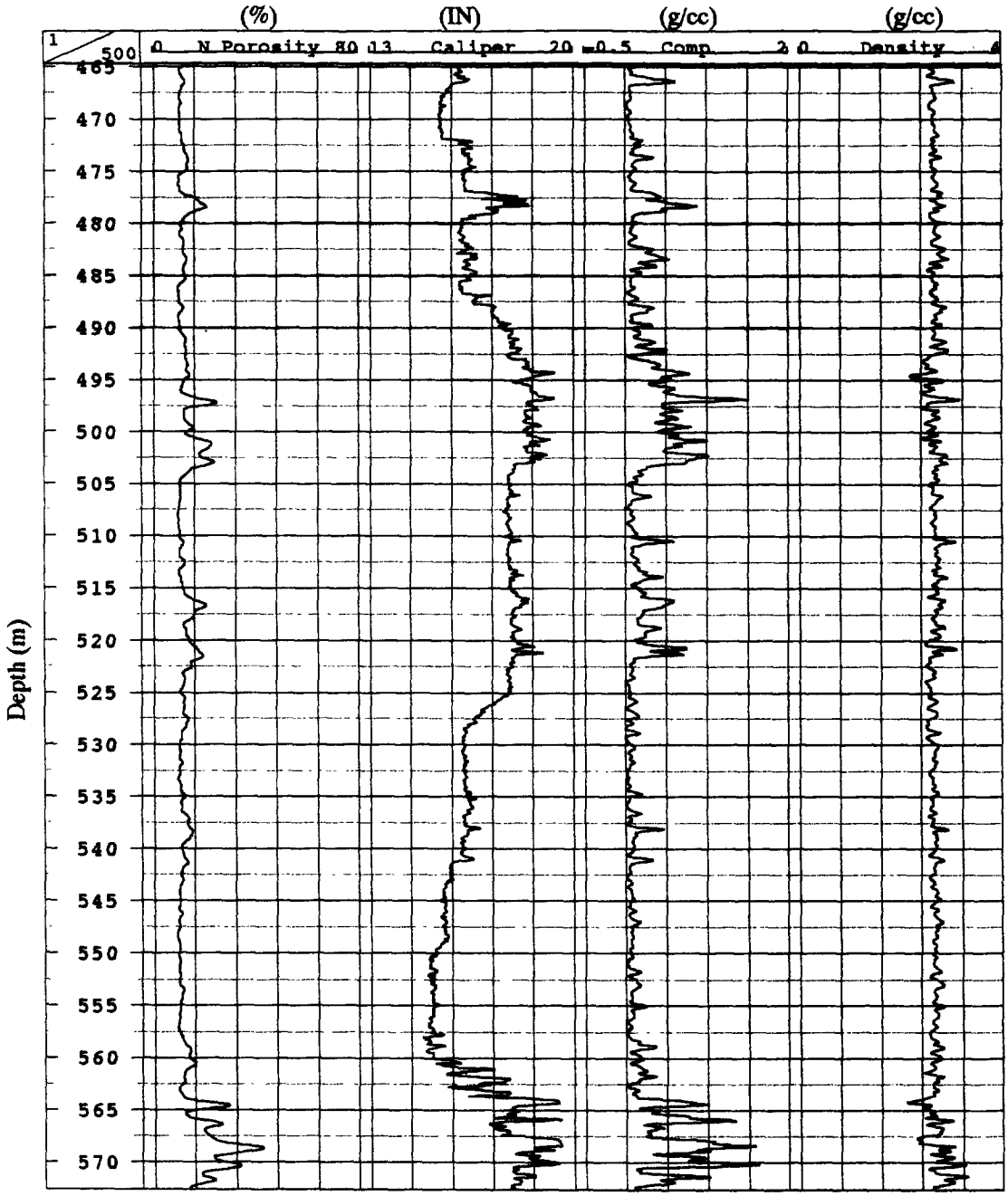

Figure HC-5.8. HC-5 neutron porosity, caliper, compensation and density logs (continued).

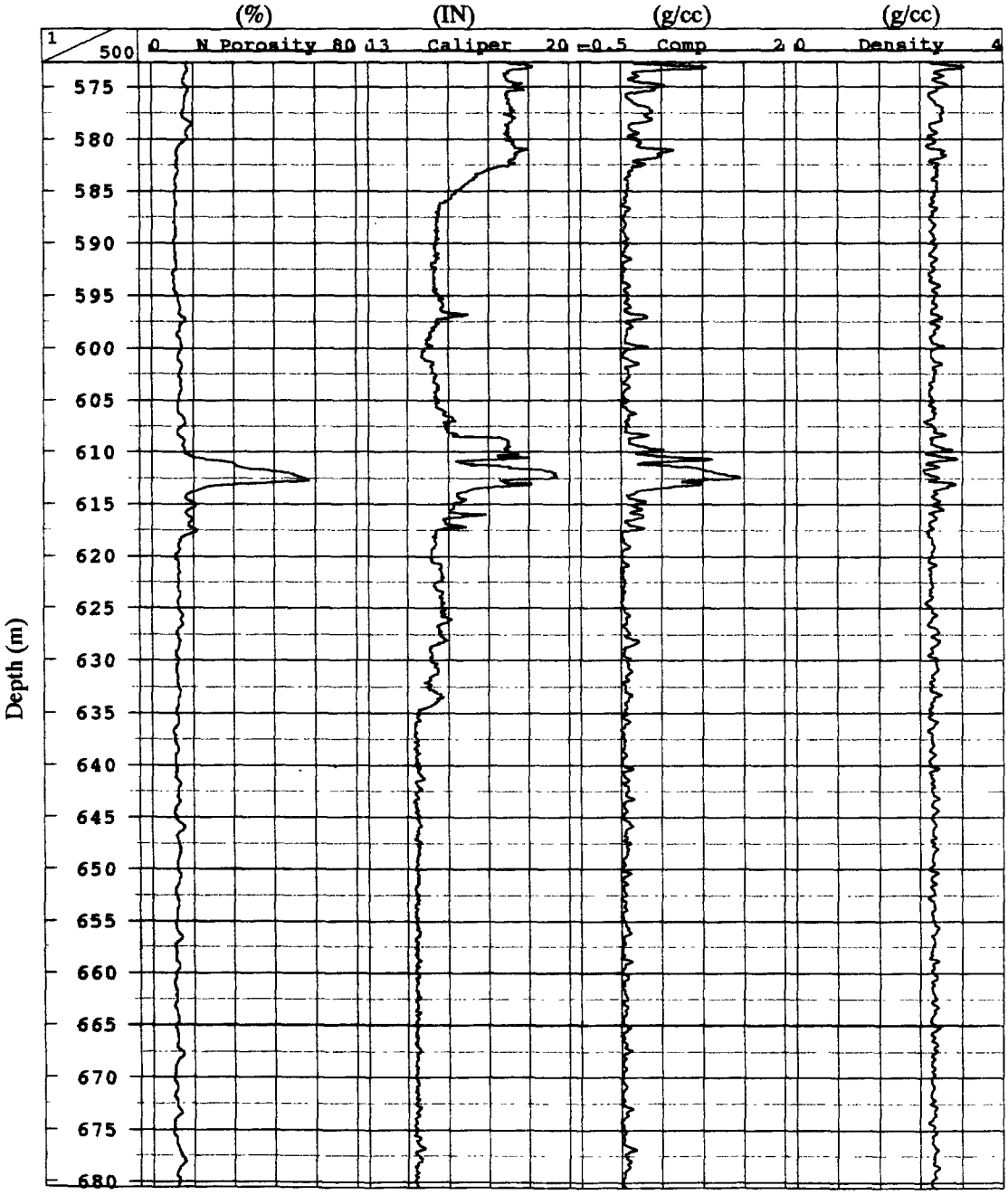

Figure HC-5.8. HC-5 neutron porosity, caliper, compensation and density logs (continued).

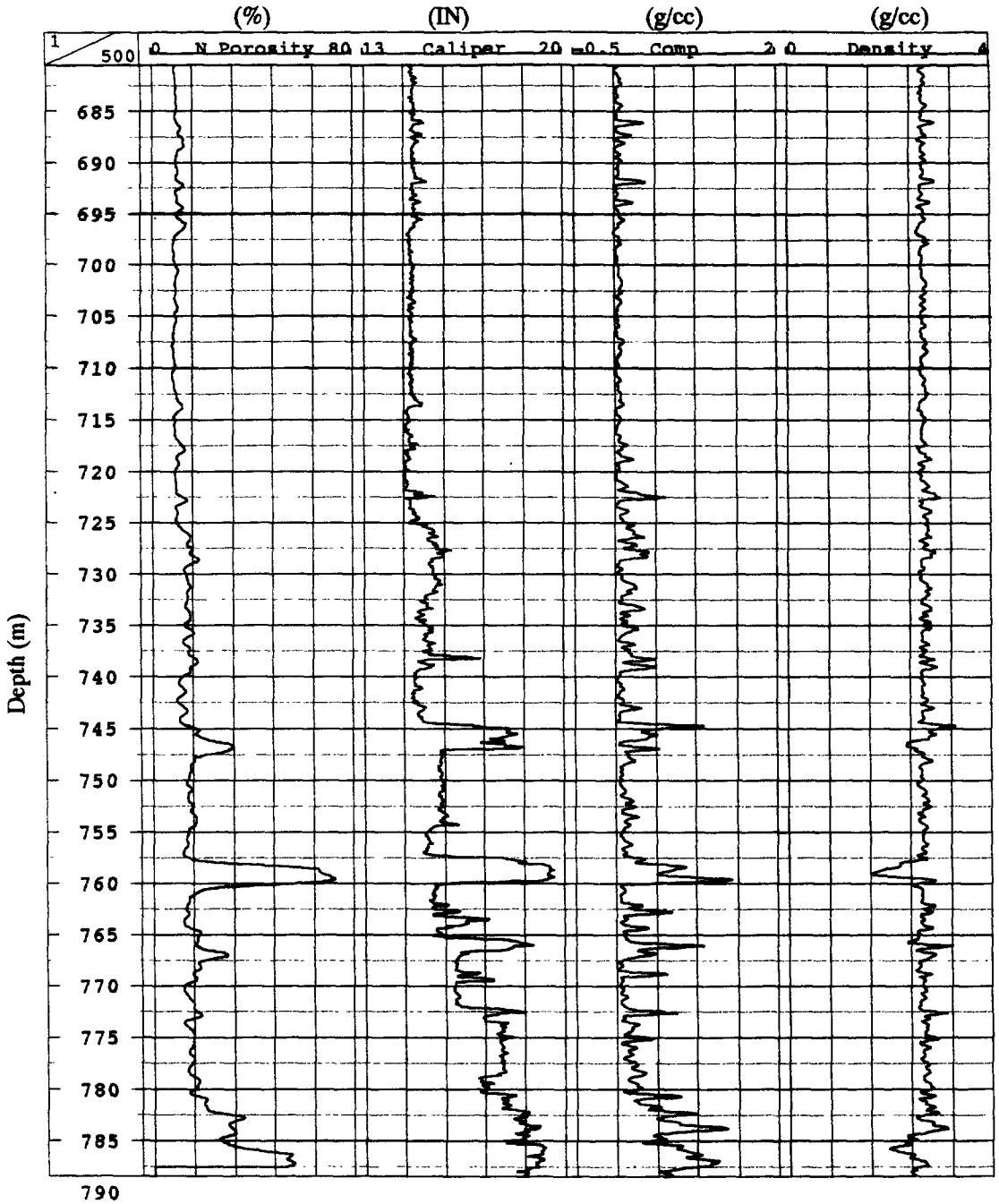

Figure HC-5.8. HC-5 neutron porosity, caliper, compensation and density logs (continued).

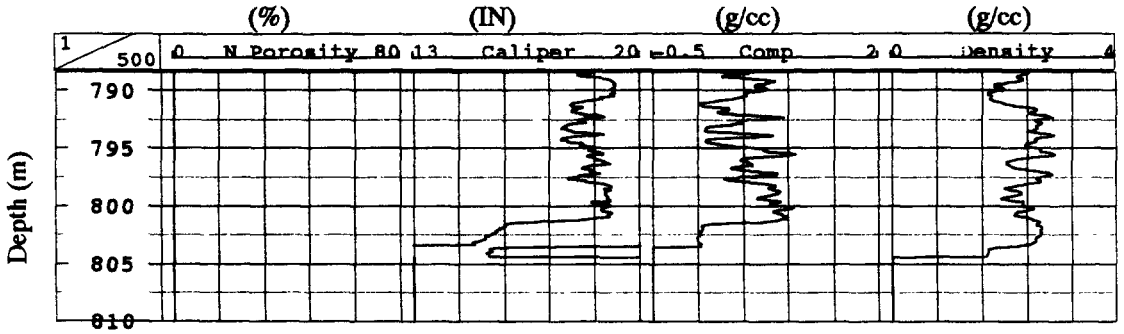

Figure HC-5.8. HC-5 neutron porosity, caliper, compensation and density logs (continued).

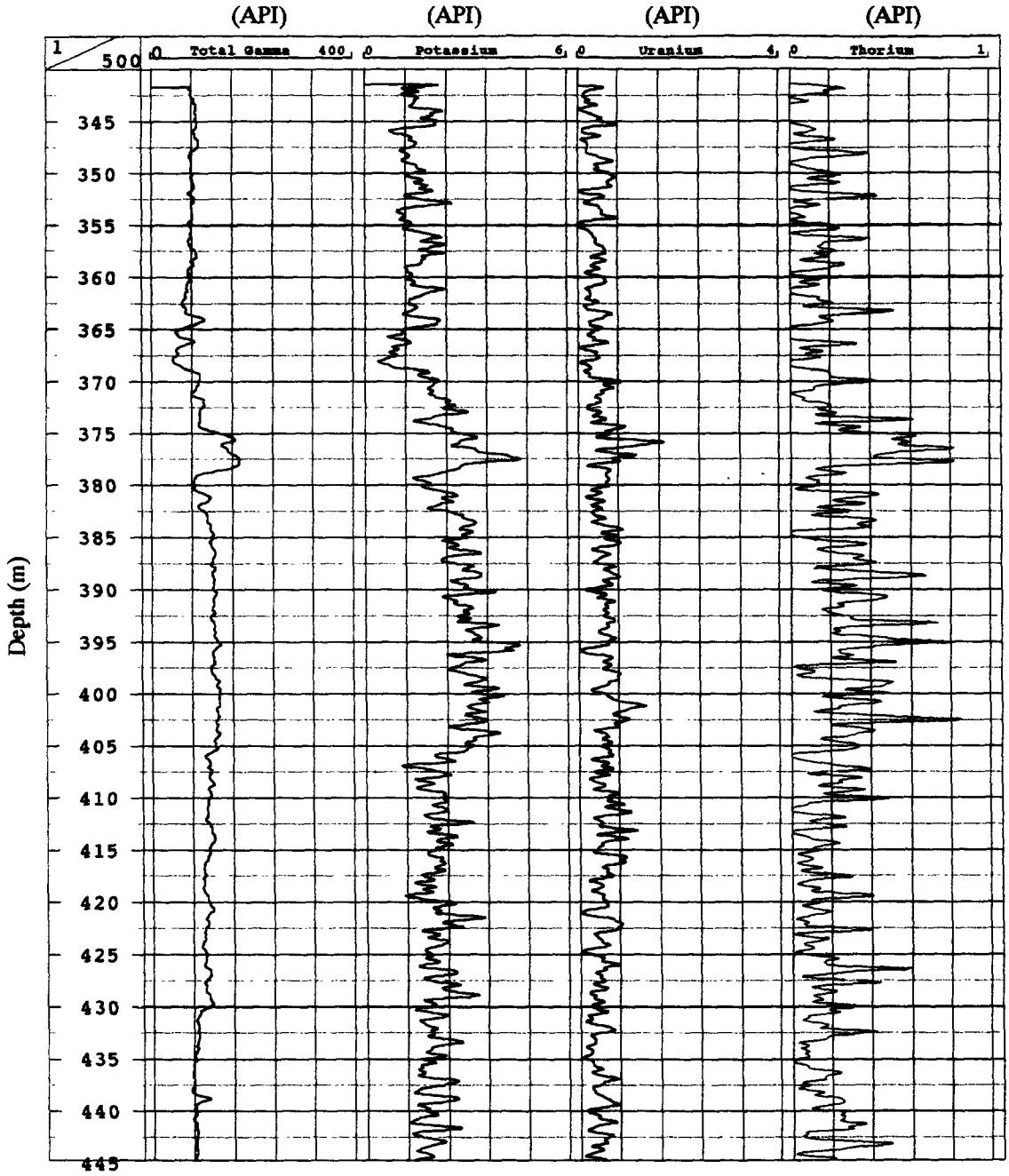

Figure HC-5.9. Spectral gamma log for HC-5.

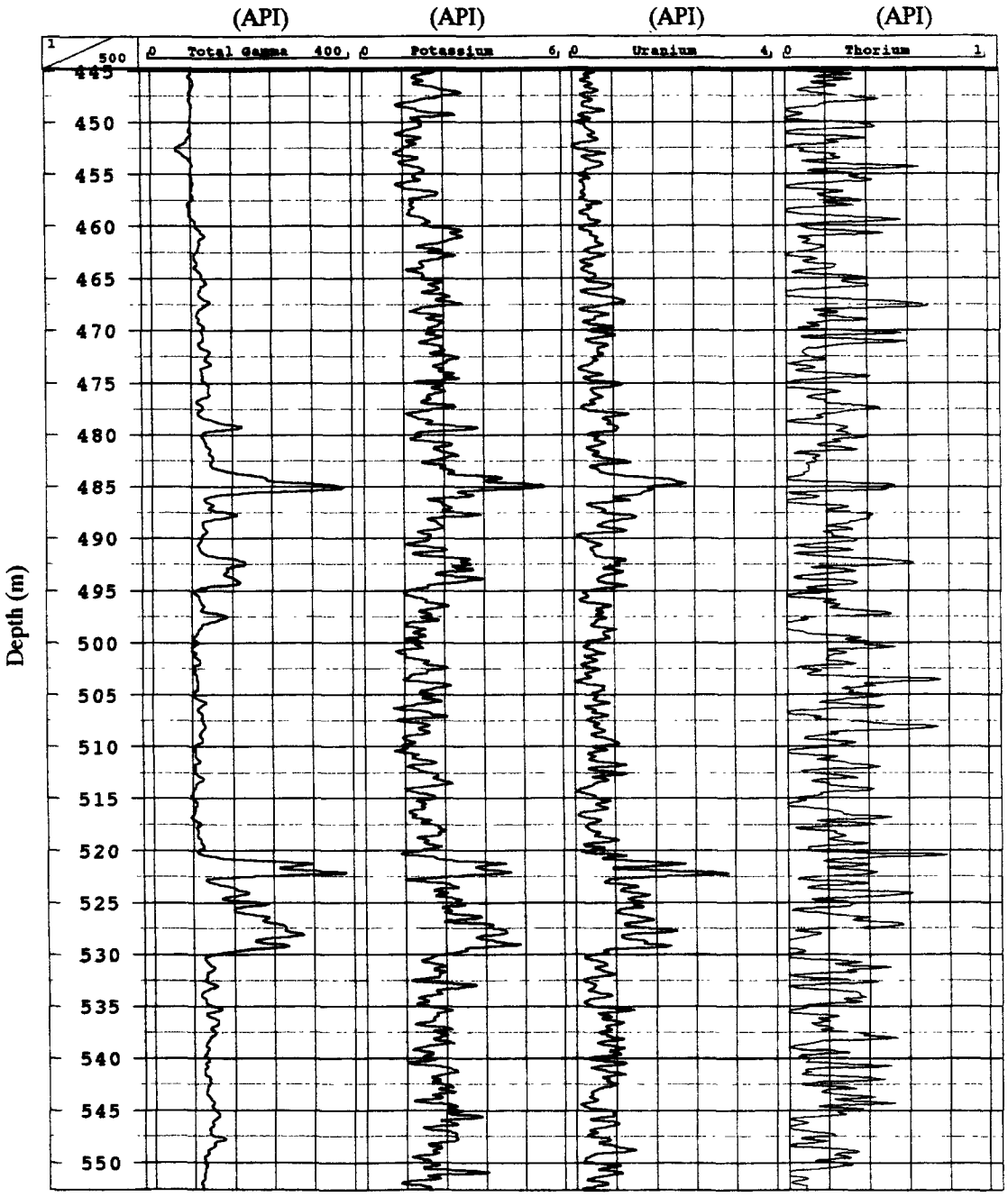

Figure HC-5.9. Spectral gamma log for HC-5 (continued).

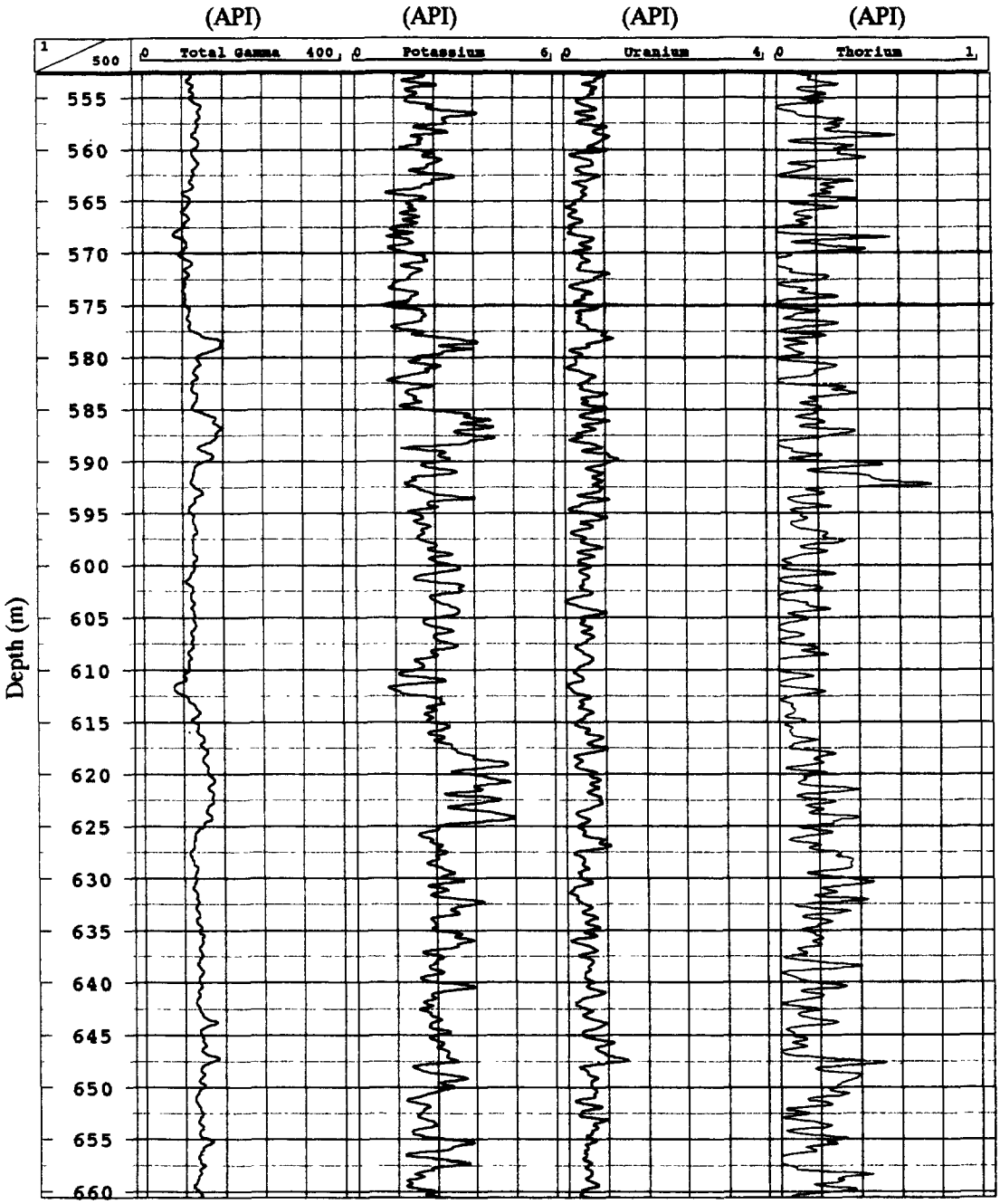

Figure HC-5.9. Spectral gamma log for HC-5 (continued).

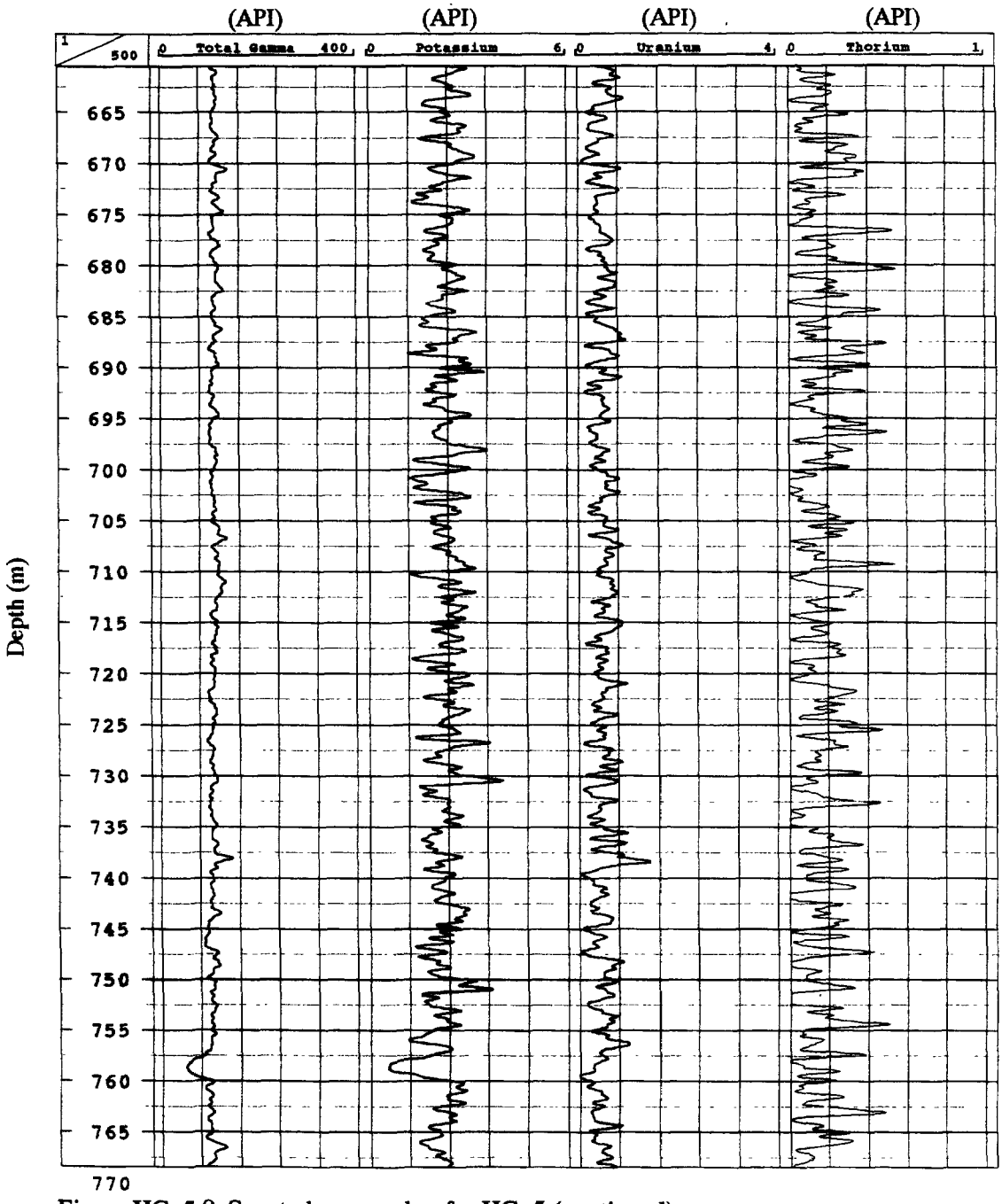

Figure HC-5.9. Spectral gamma log for HC-5 (continued).

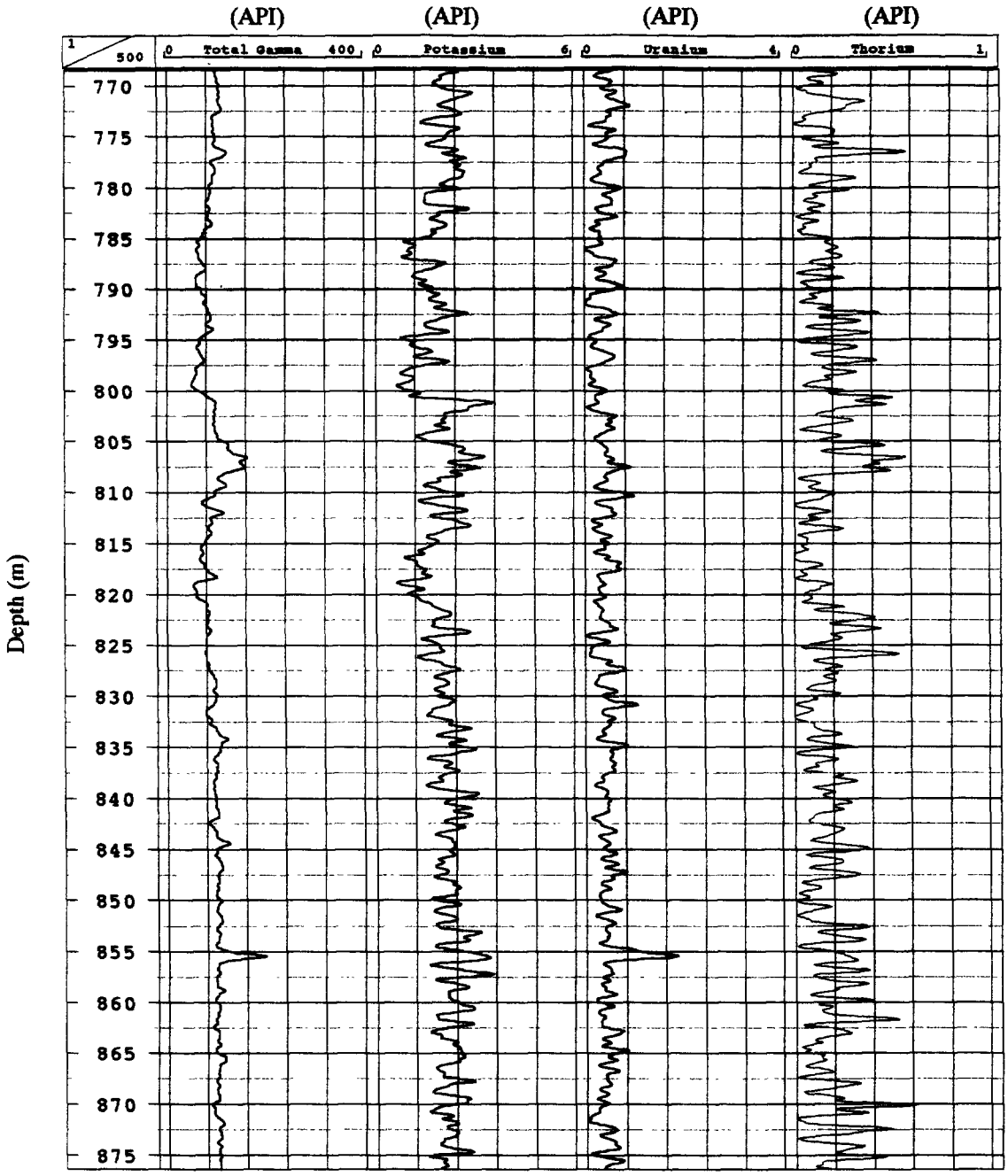

Figure HC-5.9. Spectral gamma log for HC-5 (continued).

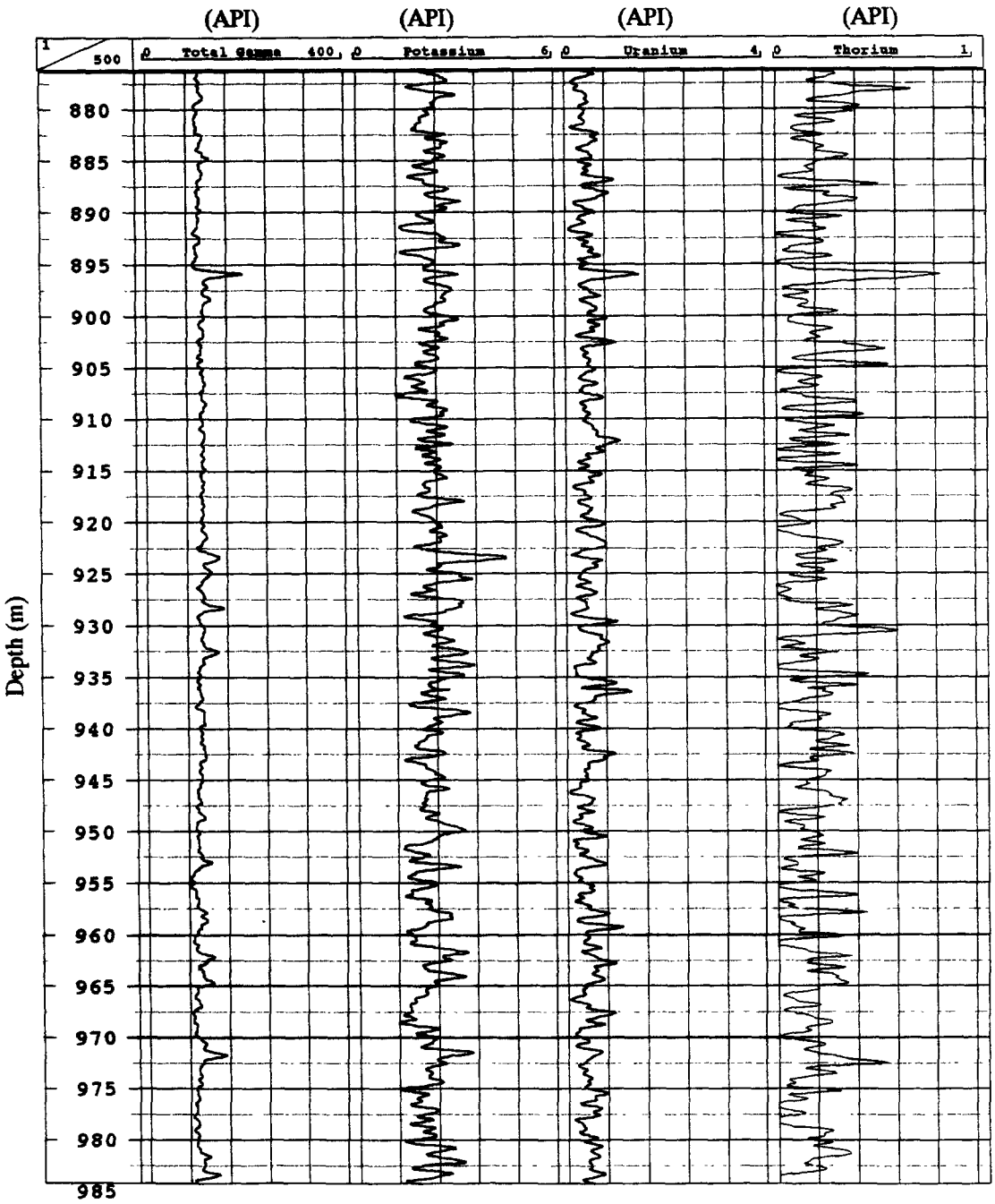

Figure HC-5.9. Spectral gamma log for HC-5 (continued).

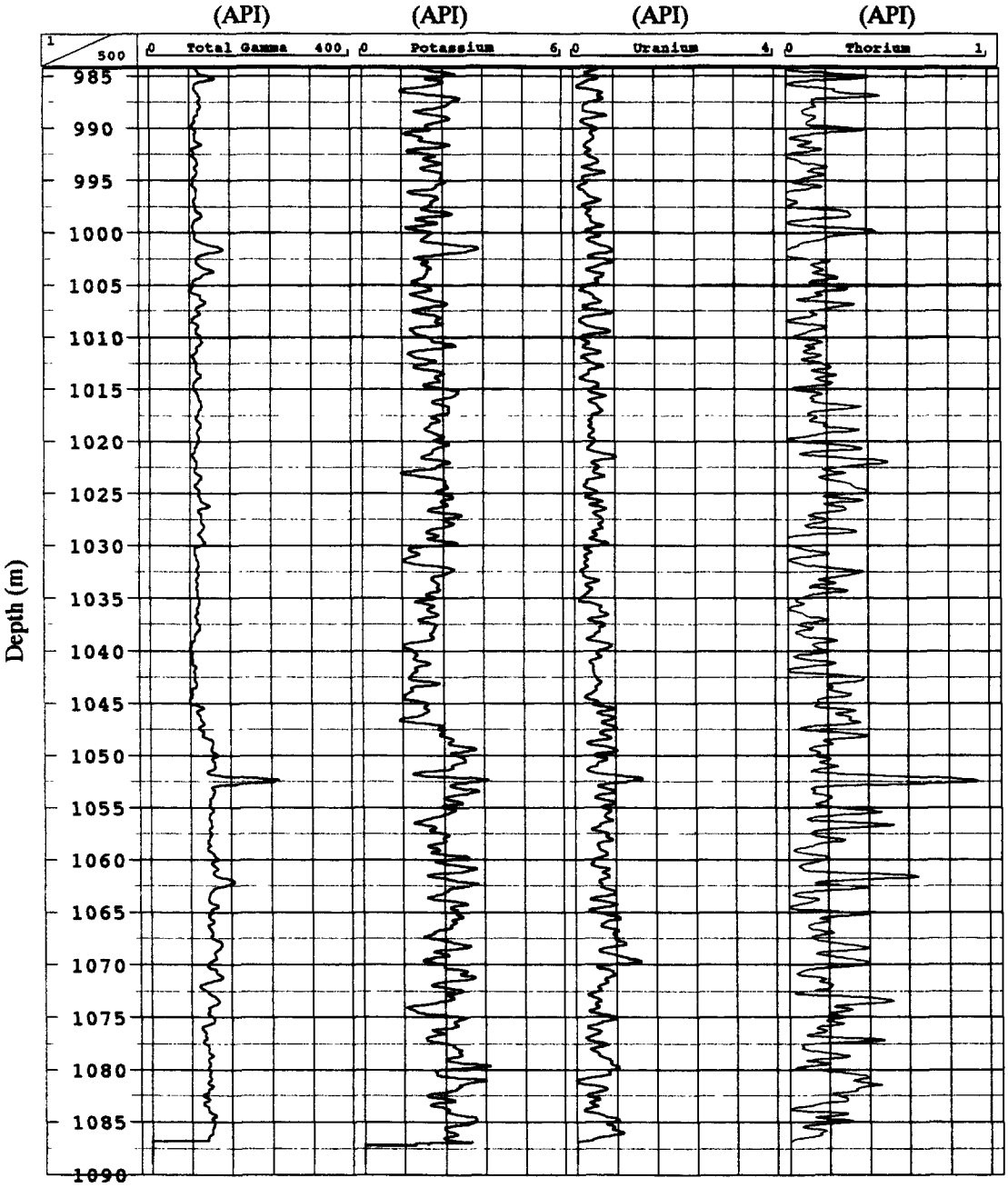

Figure HC-5.9. Spectral gamma log for HC-5 (continued).

HC-6

Available Data

- Numerical Analysis of HC-6 Pumping Test
- Water Level vs. Time
- Acoustic Televiewer
- Borehole Deviation
- Radar
- Fracture Interpretation
- Neutron Log
- Caliper Log
- Density Compensation Log
- Density Log
- DPORO Log
- Caliper Log
- Temperature Log
- Differential Temperature Log
- Natural Gamma Log
- Guard Resistivity Log
- Spectral Gamma Log (thorium, uranium, potassium)

Analysis	
Date:	10/11/1999
Specific Yield:	0.01
Screen Thickness (m):	36.6
Hydraulic Conductivity (cm/sec):	2.0E-04

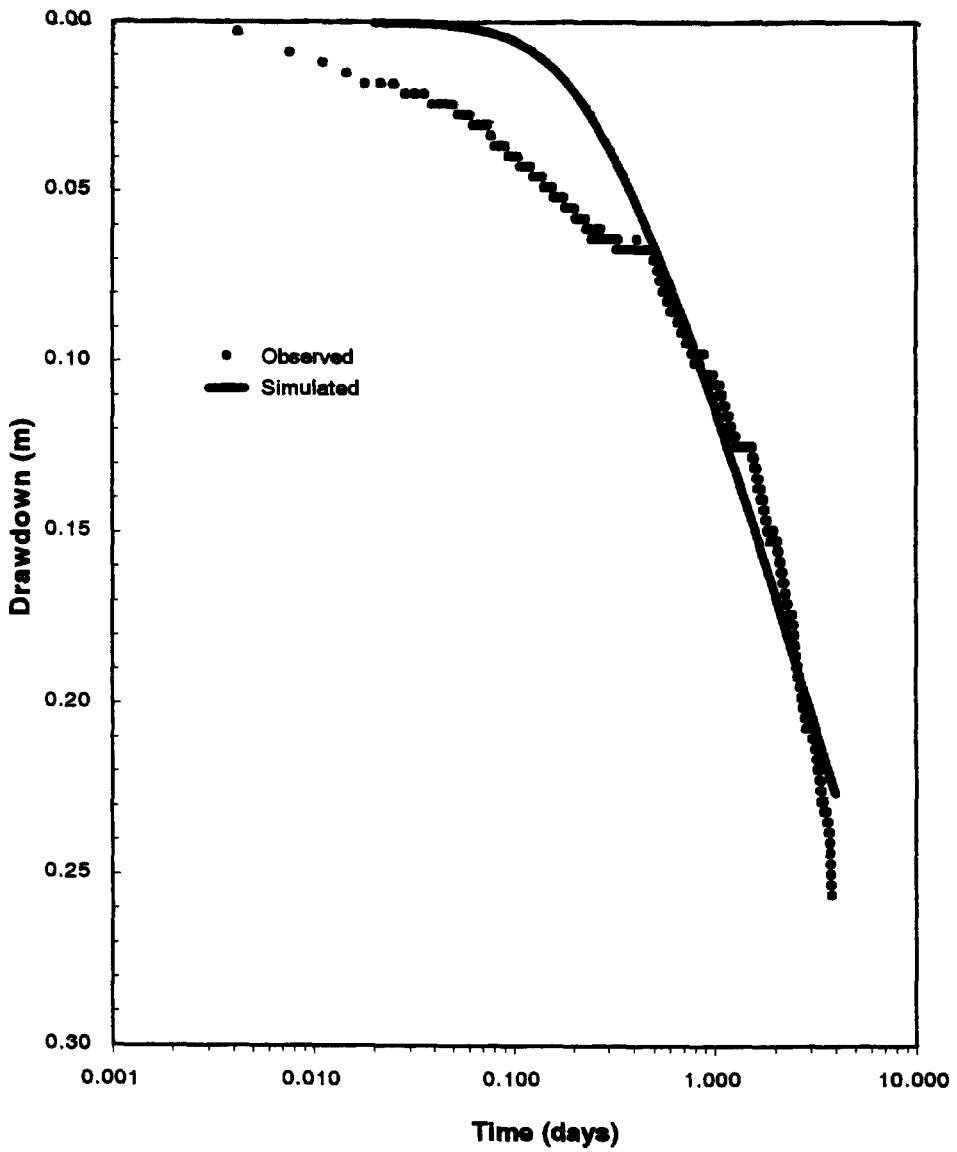

Figure HC-6.1. Numerical analysis of HC-6 pumping test (1999).

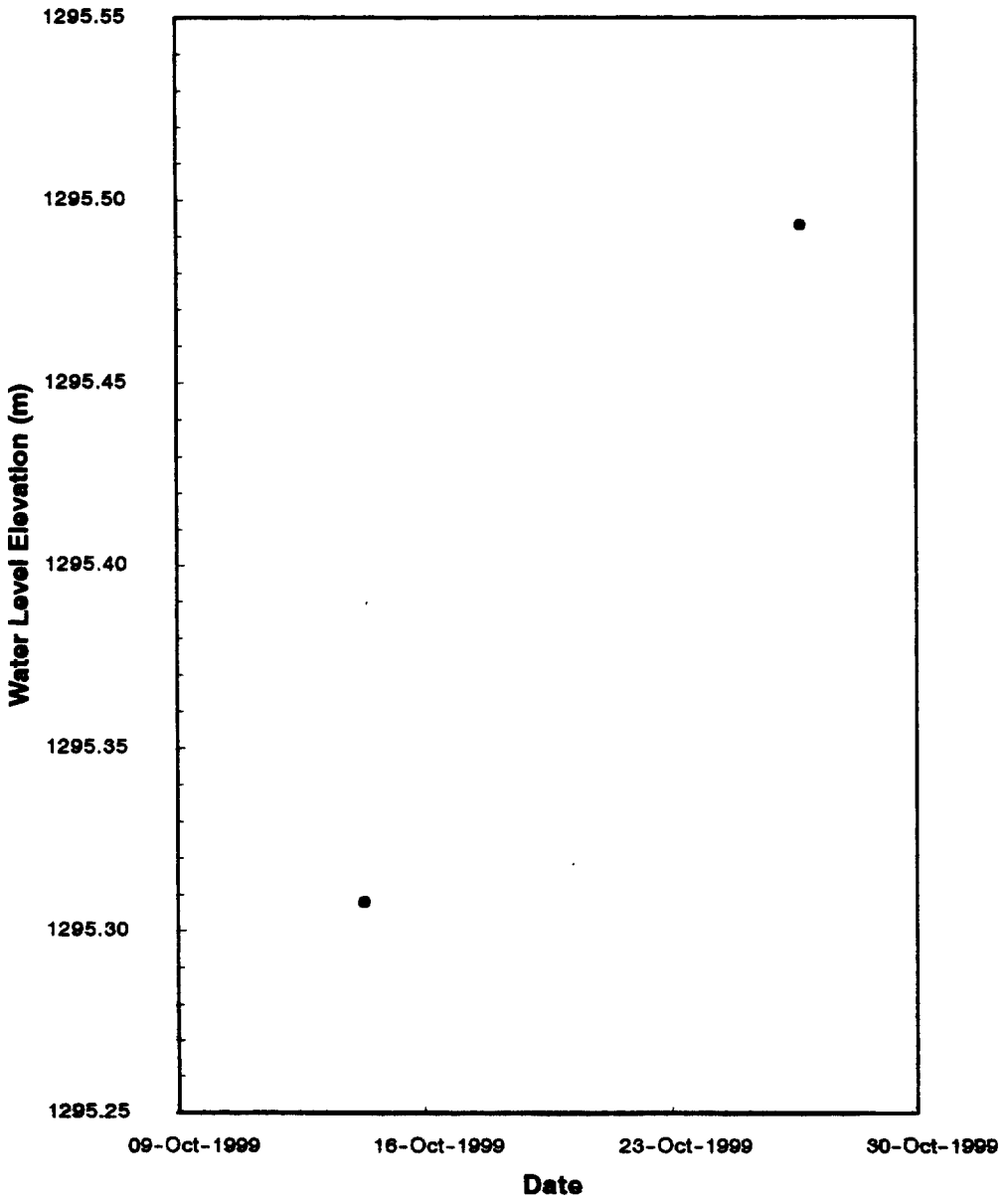

Figure HC-6.2. HC-6 water level vs. time.

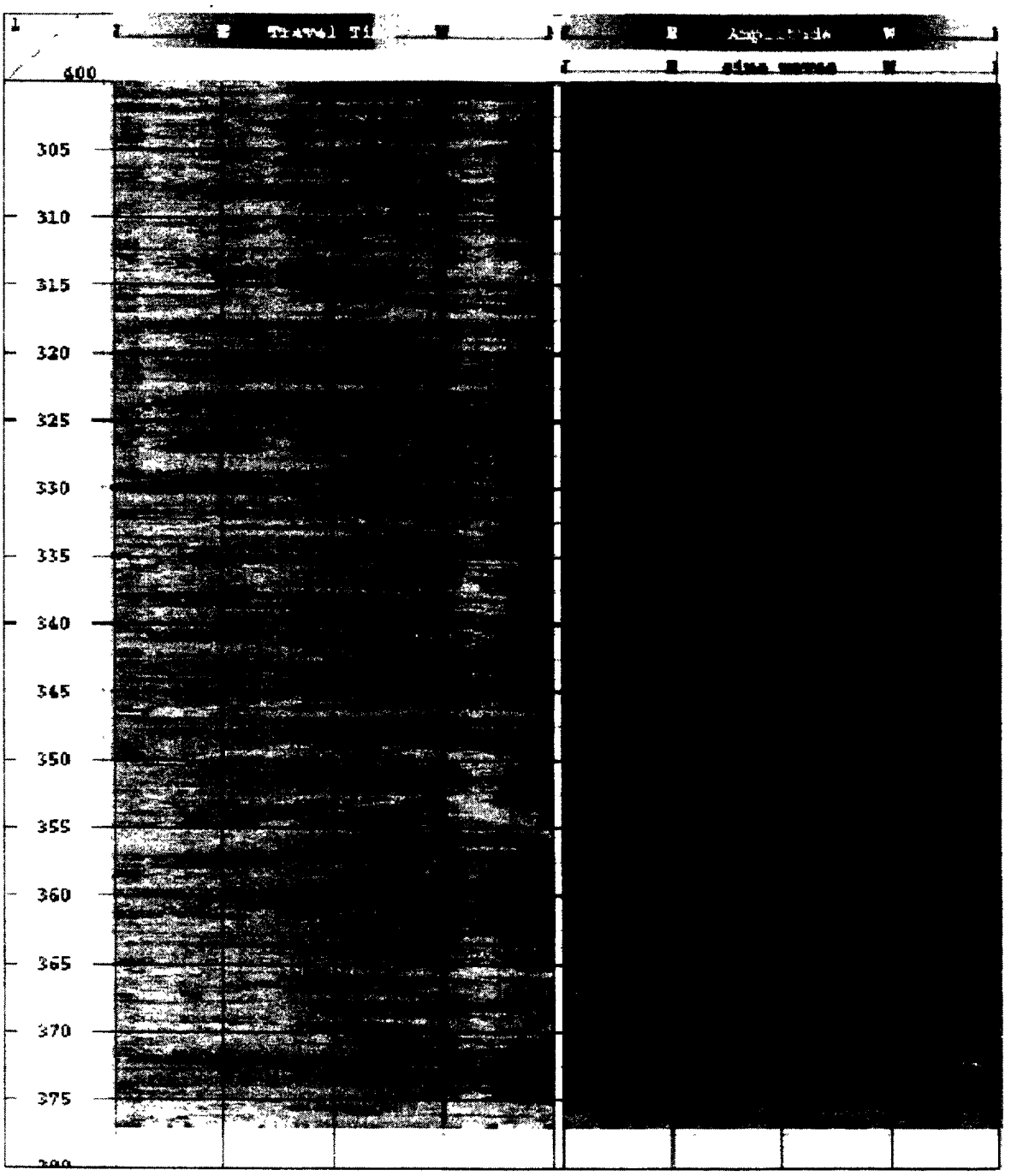

Figure HC-6.3 Acoustic televiewer log for HC-6.

Table HC-6.1 HC-6 borehole deviation.

Cable Depth (m)	True Depth (m)	Regression True Depth (m)	Absolute Error (m)
274.32	274.08	274.08	0.0002
281.94	281.69	281.69	0.0017
289.56	289.29	289.29	0.0004
297.18	296.88	296.89	0.0075
304.80	304.48	304.48	0.0025
312.42	312.08	312.08	0.0012
320.04	319.68	319.67	0.0125
327.66	327.26	327.26	0.0050
335.28	334.85	334.85	0.0050
342.90	342.45	342.45	0.0024
350.52	350.05	350.04	0.0051
358.14	357.63	357.64	0.0020
365.76	365.23	365.23	0.0062
373.38	372.81	372.81	0.0018

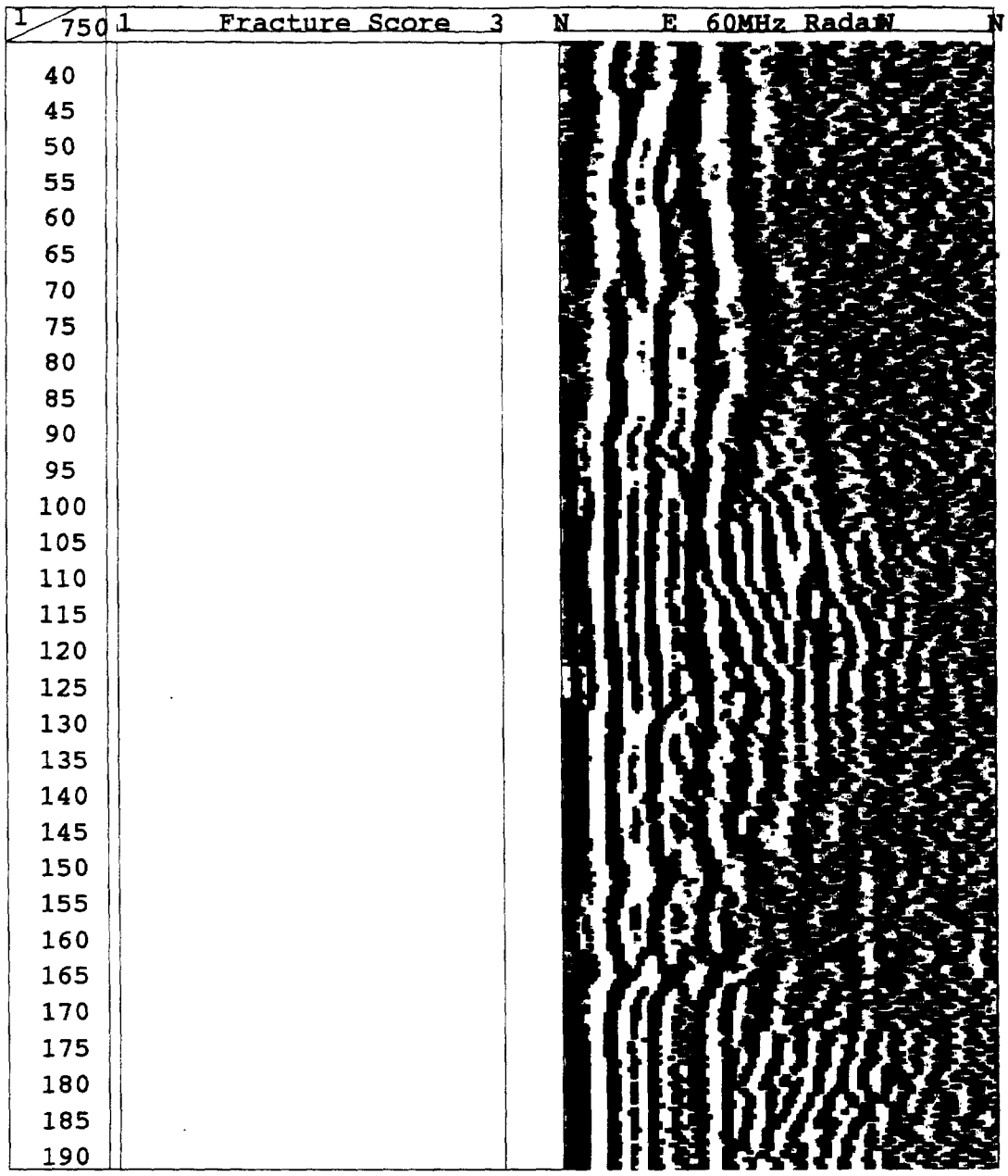

Figure HC-6.4. Fracture score (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) and dipole radar log for HC-6 from 35 to 375 m.

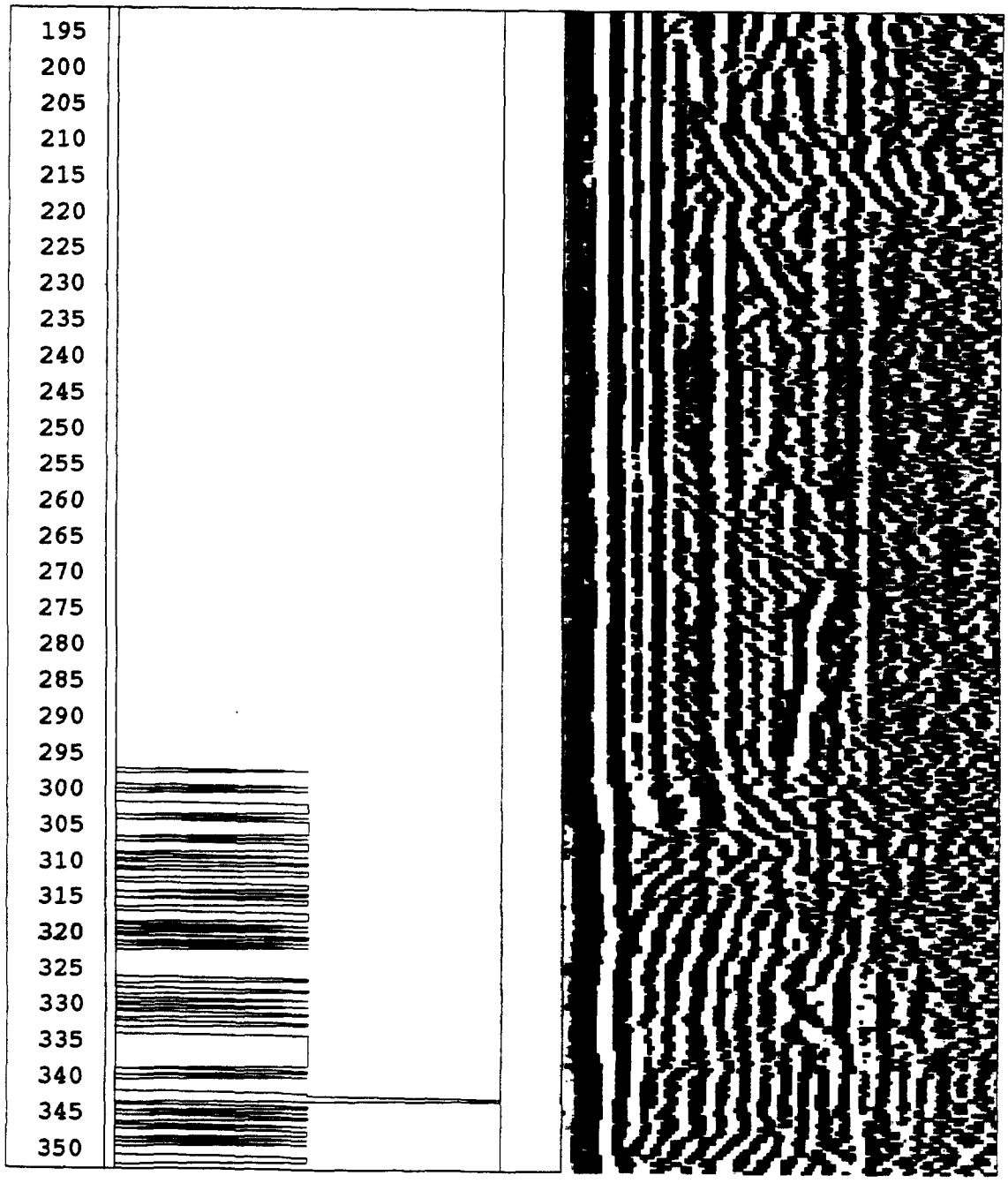

Figure HC-6.4. Fracture score (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) and dipole radar log for HC-6 from 35 to 375 m (continued).

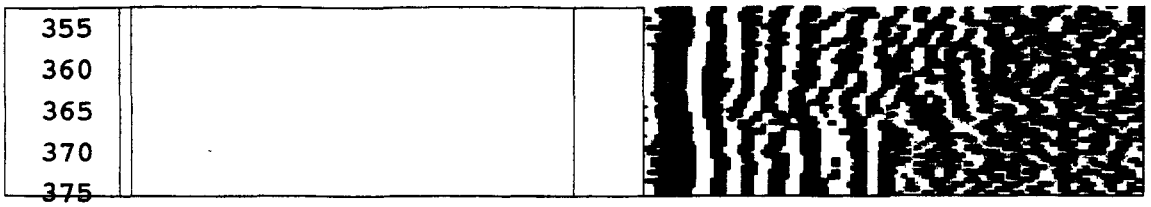

Figure HC-6.4. Fracture score (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) and dipole radar log for HC-6 from 35 to 375 m (continued).

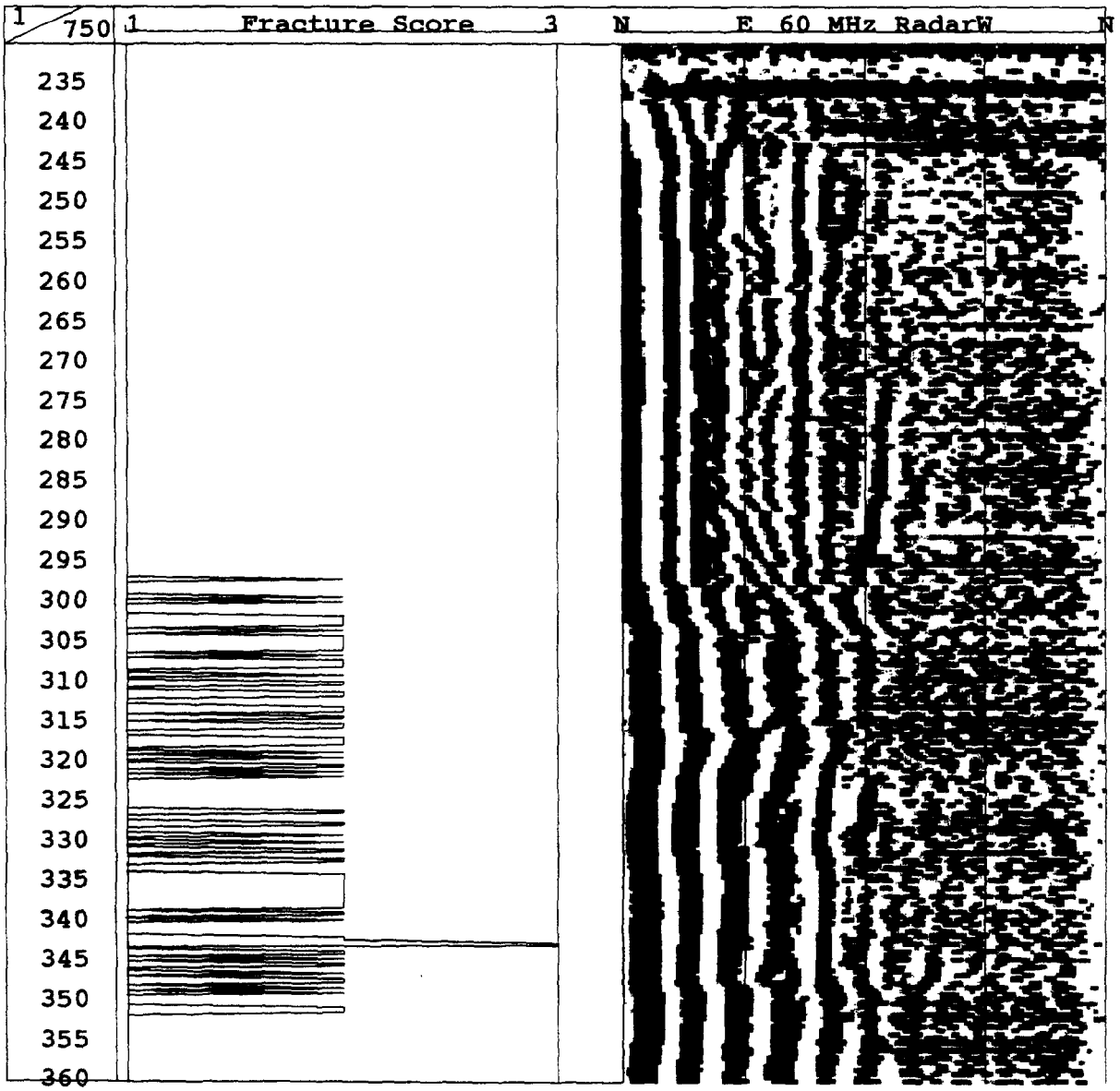

Figure HC-6.5. Fracture score (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) and dipole component of directional radar for HC-6 from 230 to 360 m.

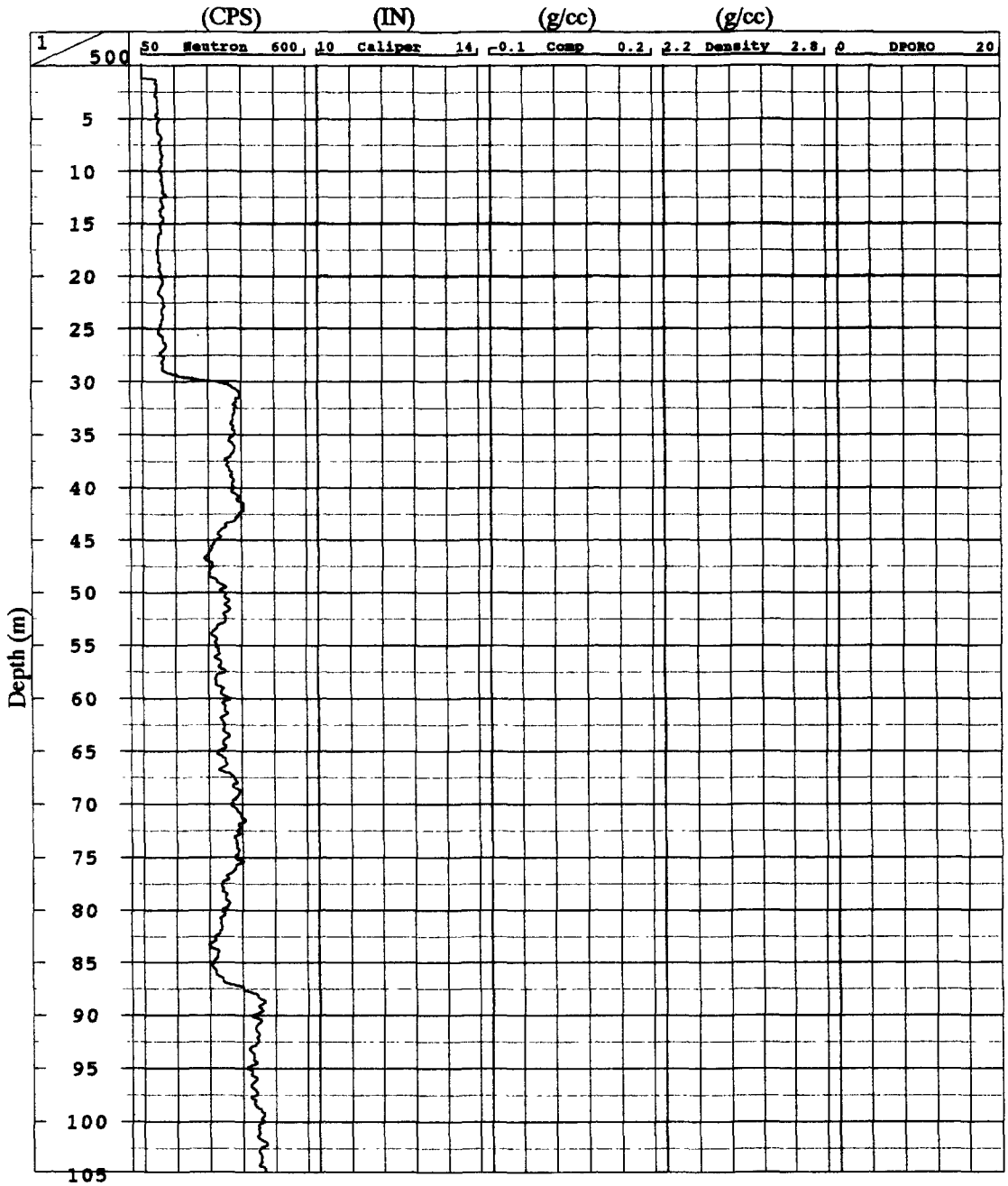

Figure HC-6.6. HC-6 neutron, caliper, density compensation and density and DPORO logs.

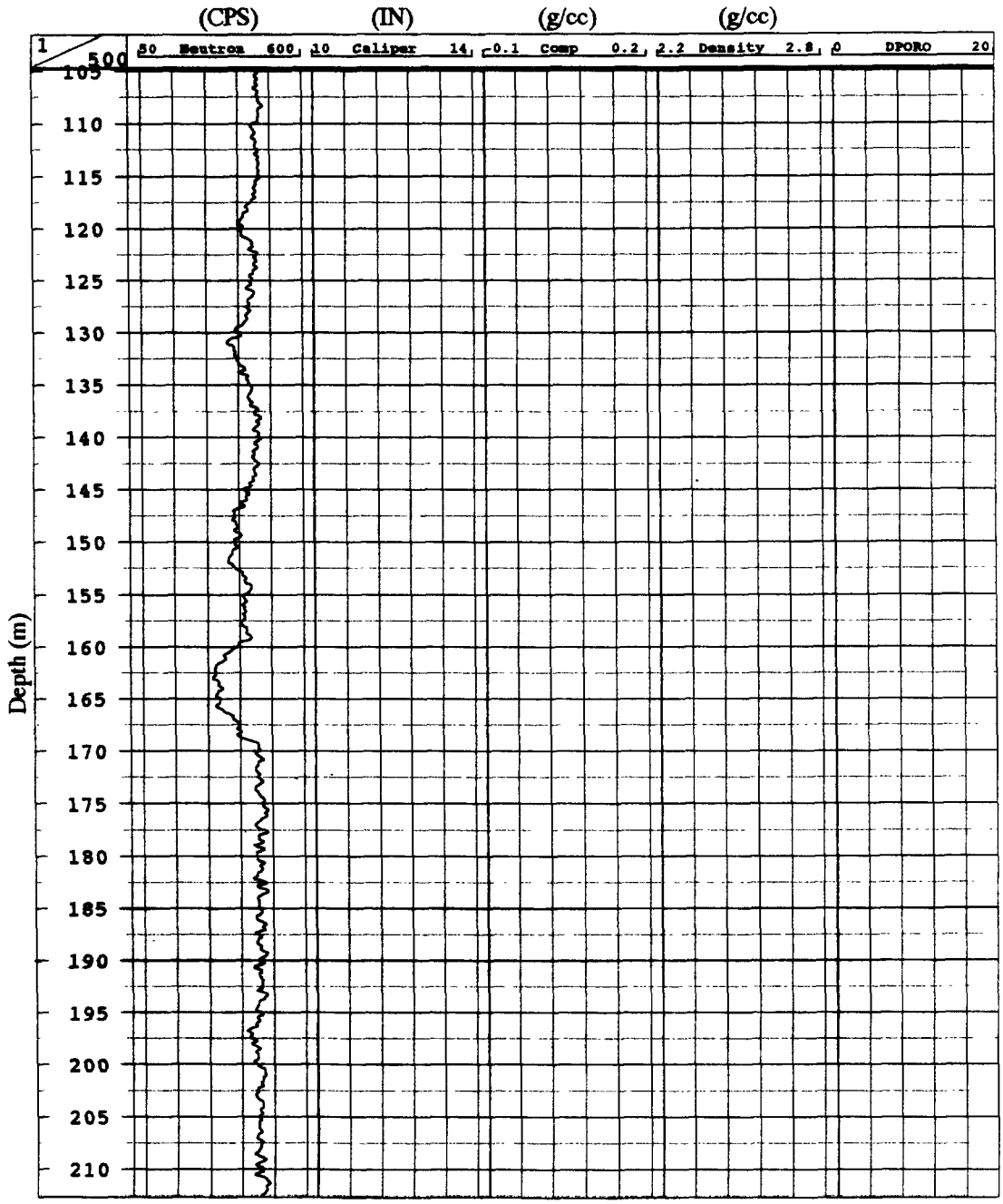

Figure HC-6.6. HC-6 neutron, caliper, density compensation and density and DPORO logs (continued).

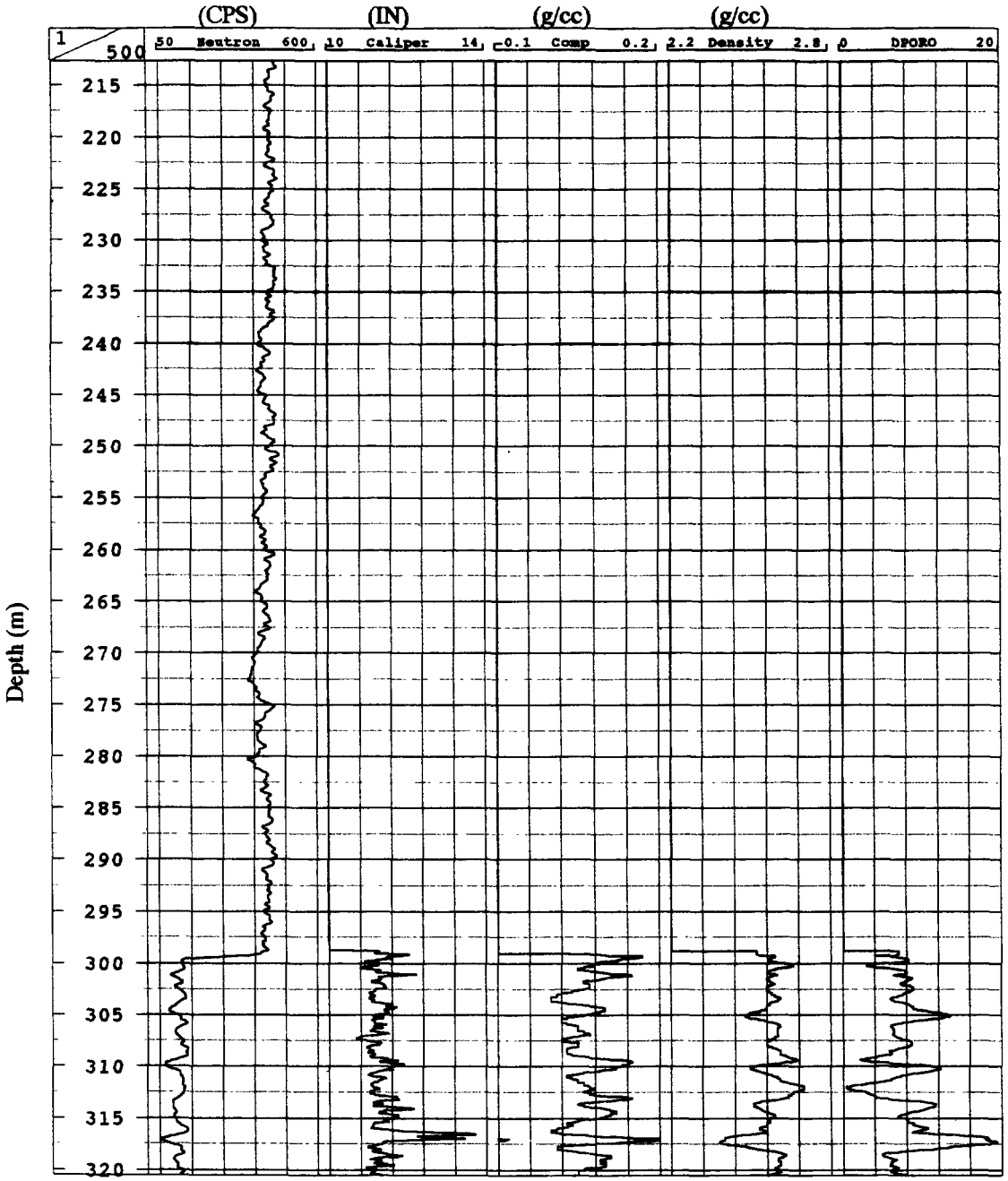

Figure HC-6.6. HC-6 neutron, caliper, density compensation and density and DPORO logs (continued).

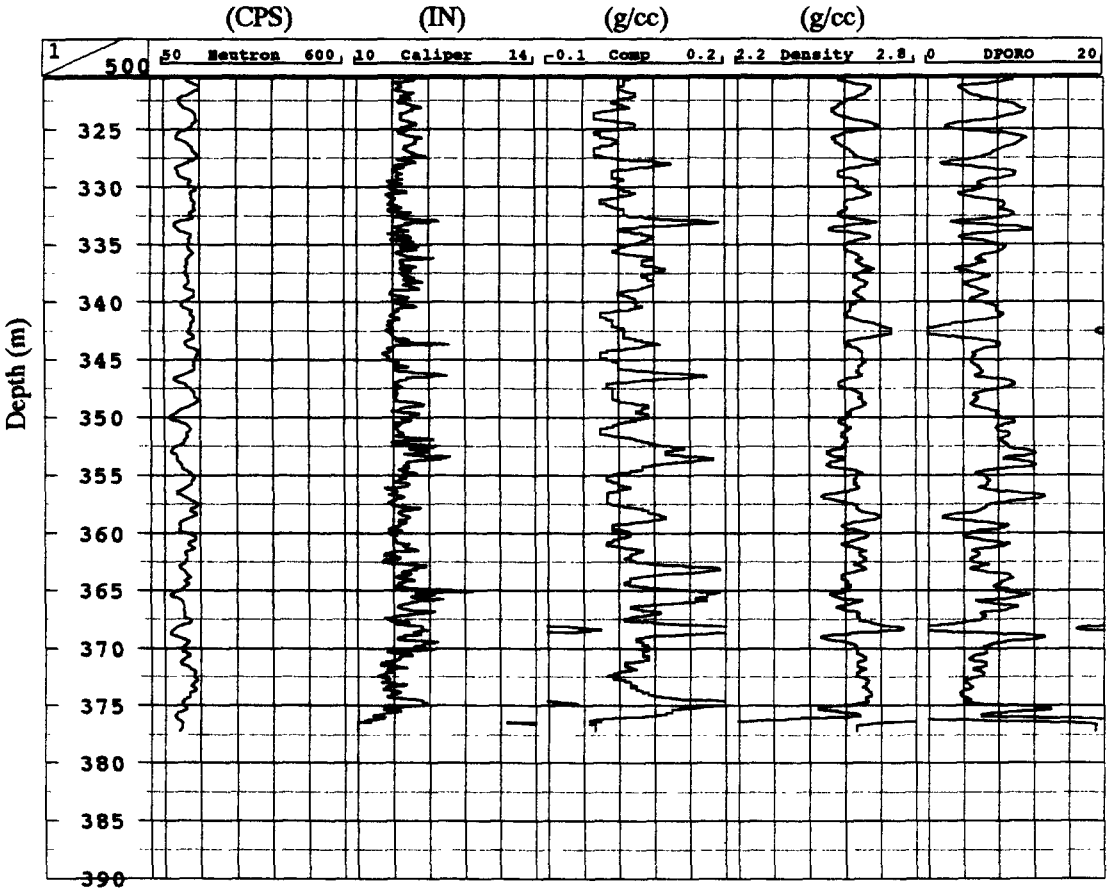

Figure HC-6.6. HC-6 neutron, caliper, density compensation and density and DPORO logs (continued).

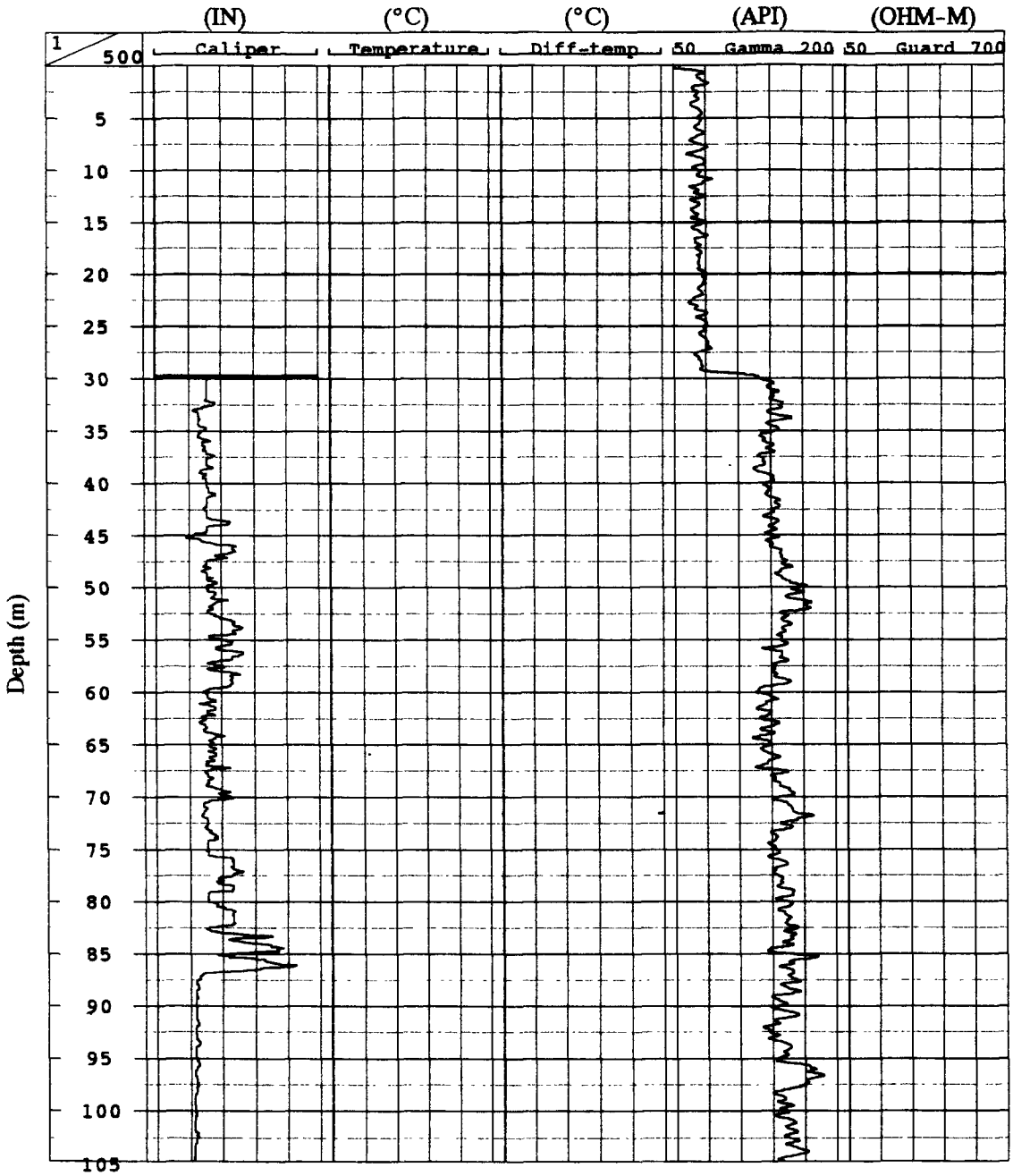

Figure HC-6.7. HC-6 caliper, temperature, differential temperature, natural gamma and guard resistivity logs.

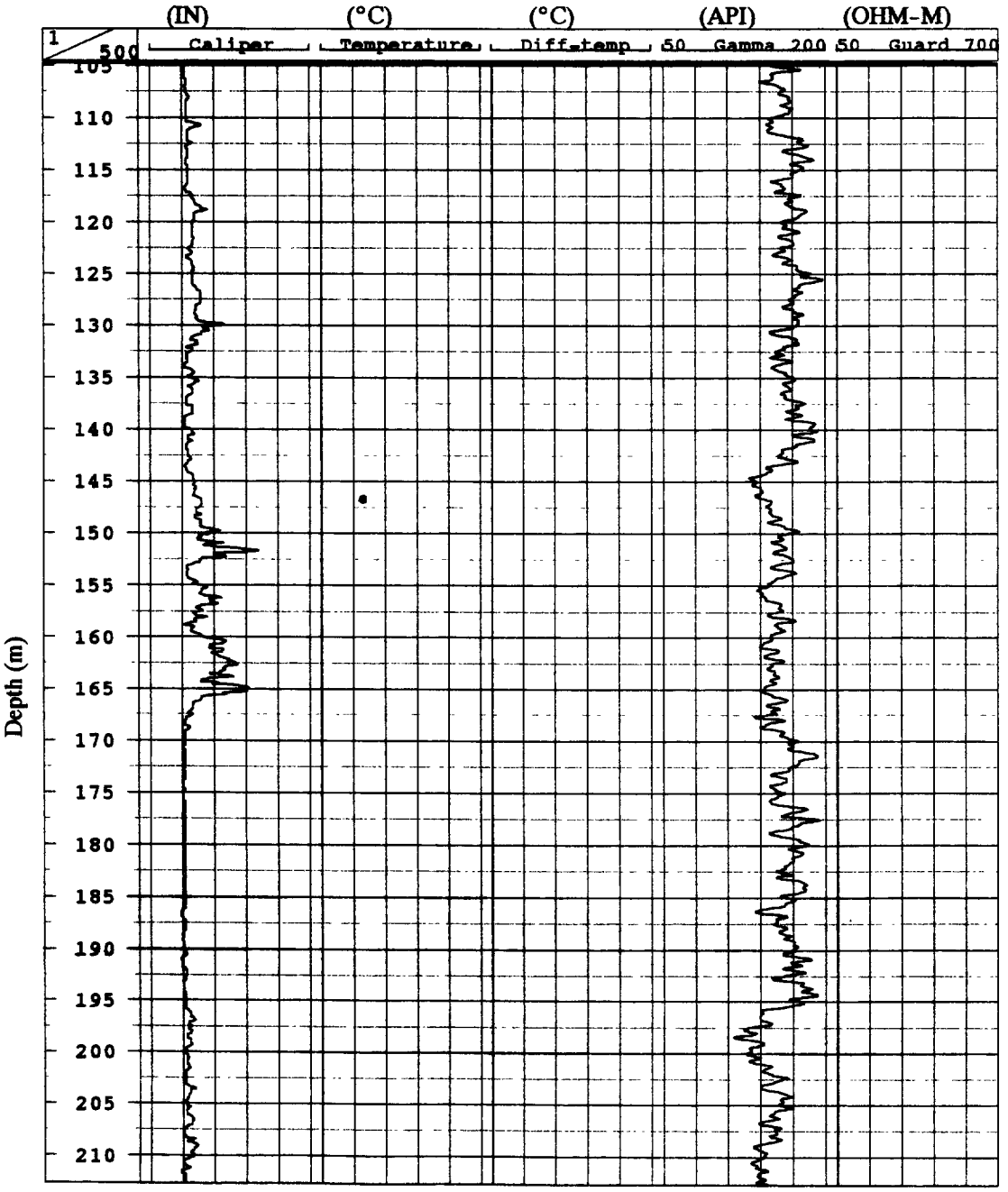

Figure HC-6.7. HC-6 caliper, temperature, differential temperature, natural gamma and guard resistivity logs (continued).

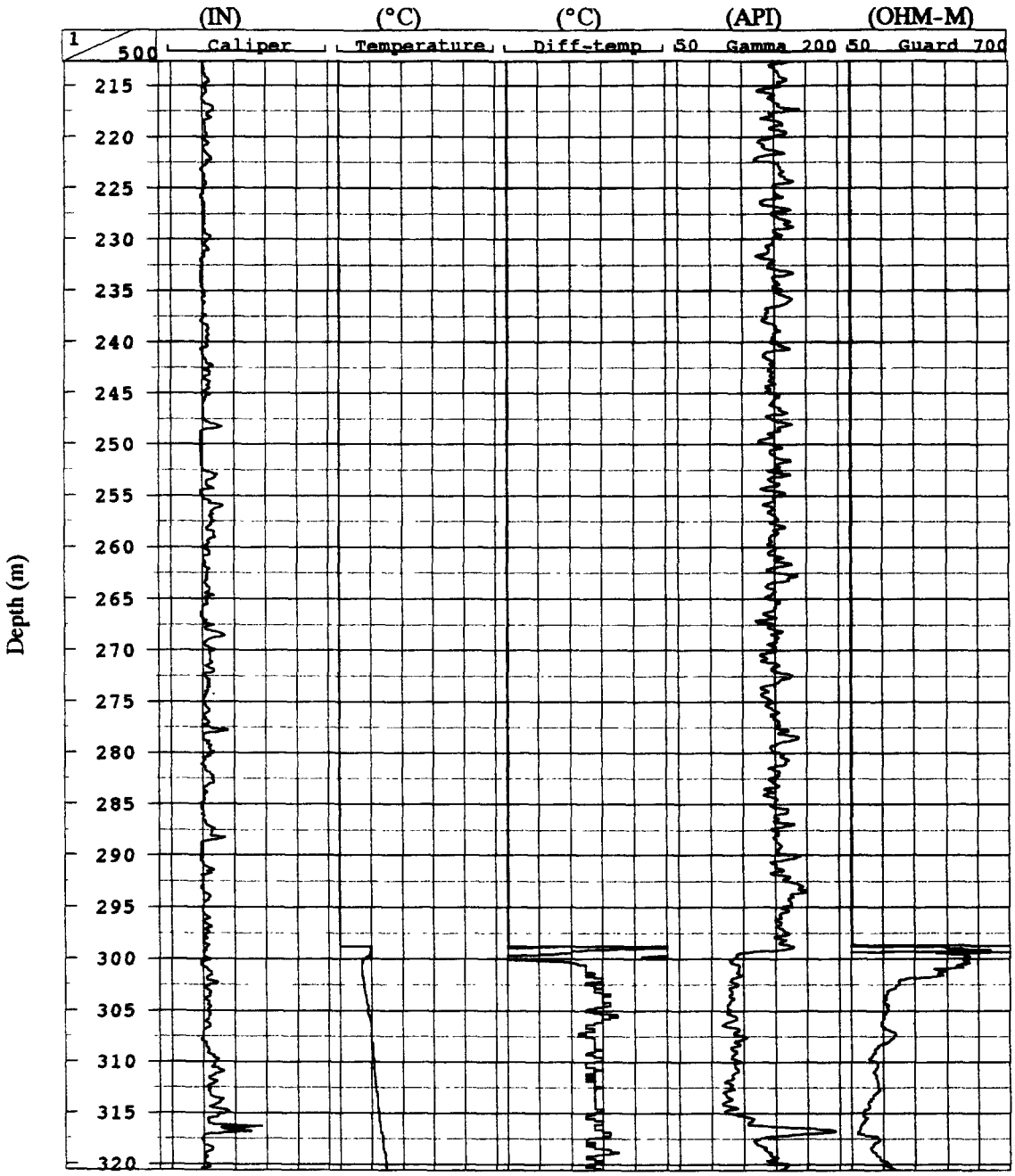

Figure HC-6.7. HC-6 caliper, temperature, differential temperature, natural gamma and guard resistivity logs (continued).

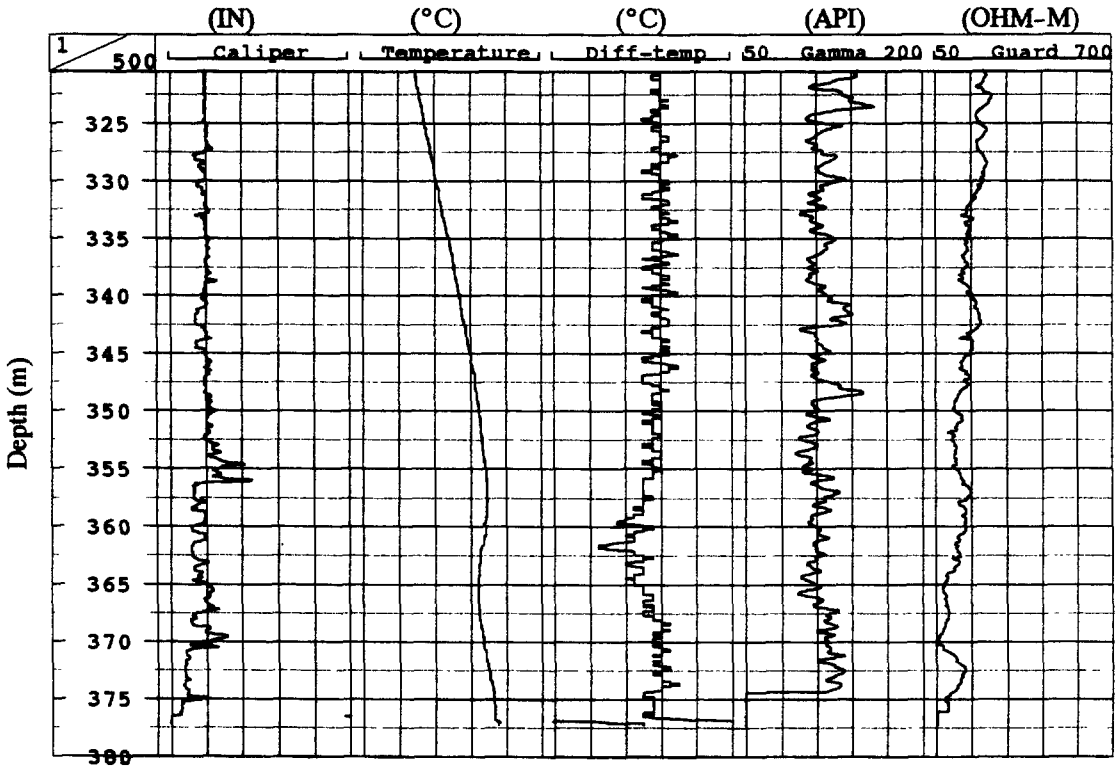

Figure HC-6.7. HC-6 caliper, temperature, differential temperature, natural gamma and guard resistivity logs (continued).

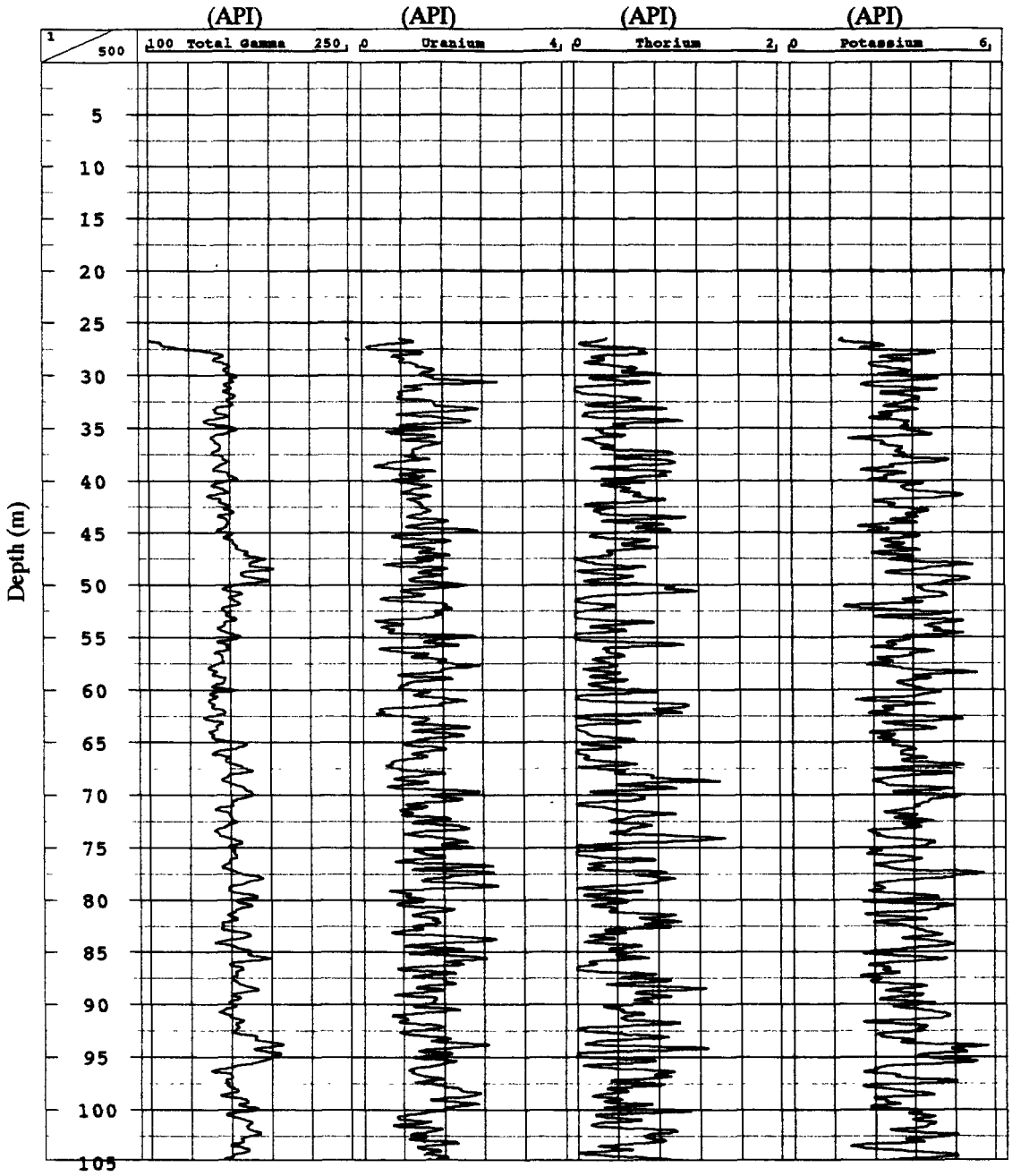

Figure HC-6.8. Spectral gamma log for HC-6.

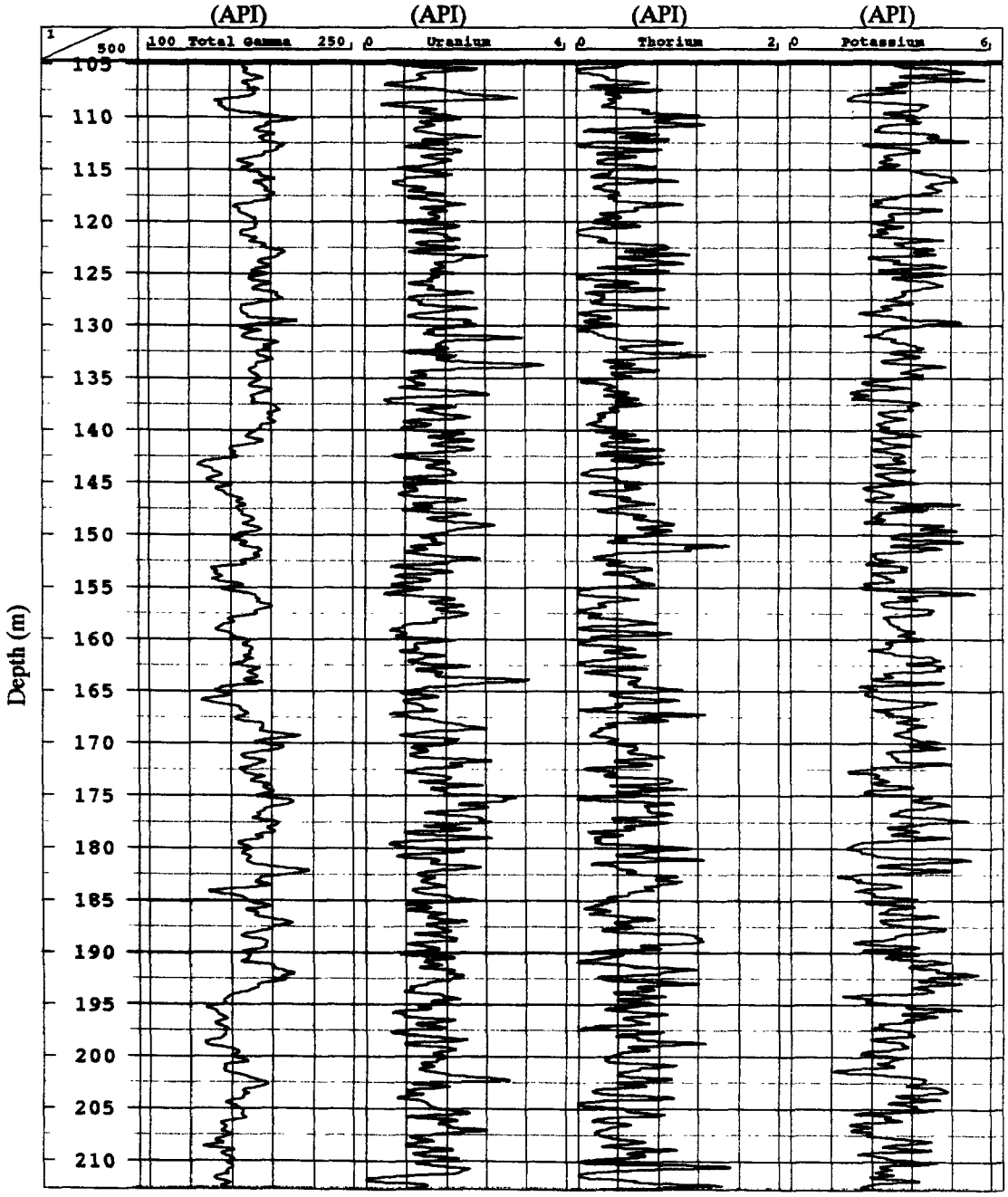

Figure HC-6.8. Spectral gamma log for HC-6 (continued).

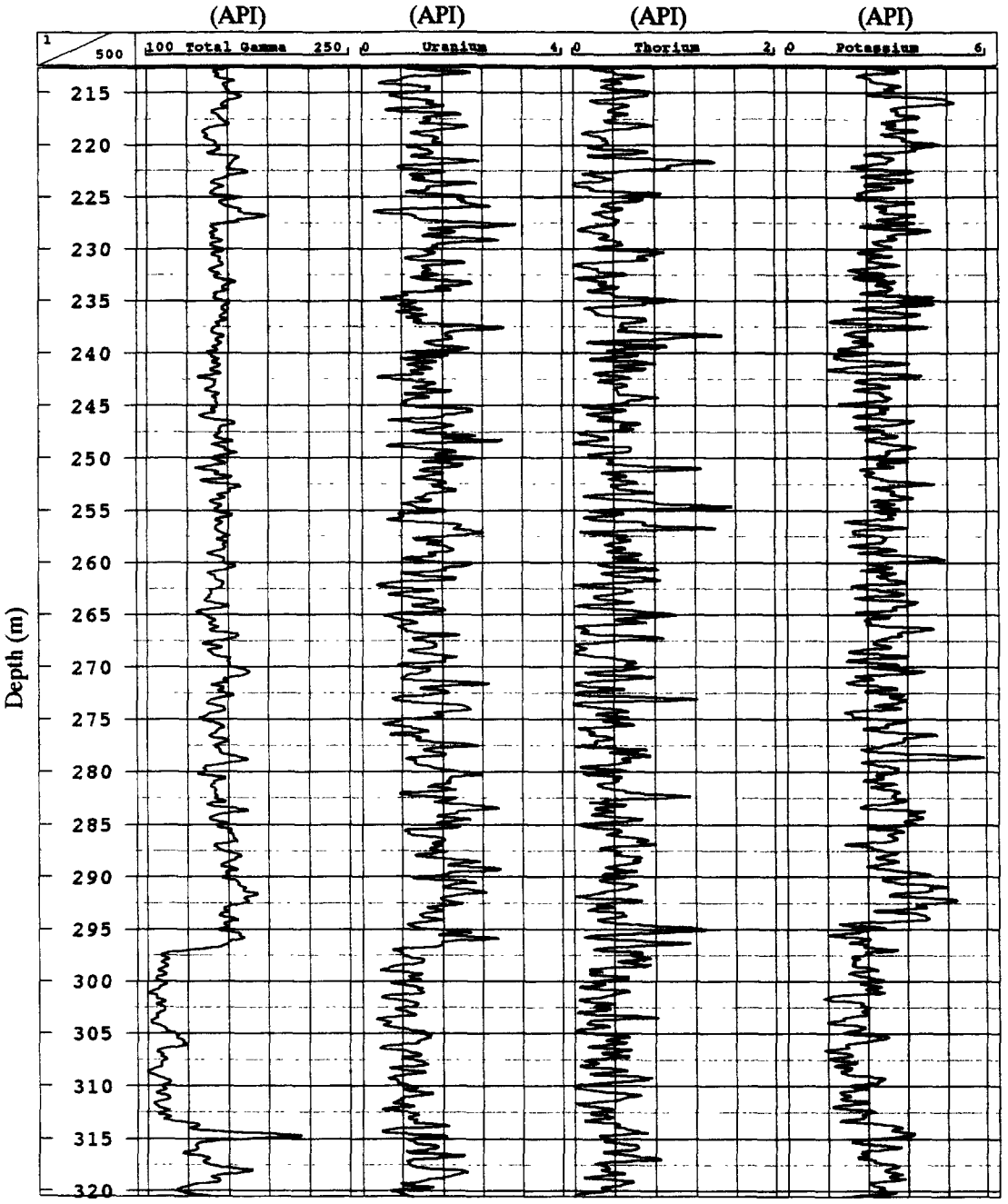

Figure HC-6.8. Spectral gamma log for HC-6 (continued).

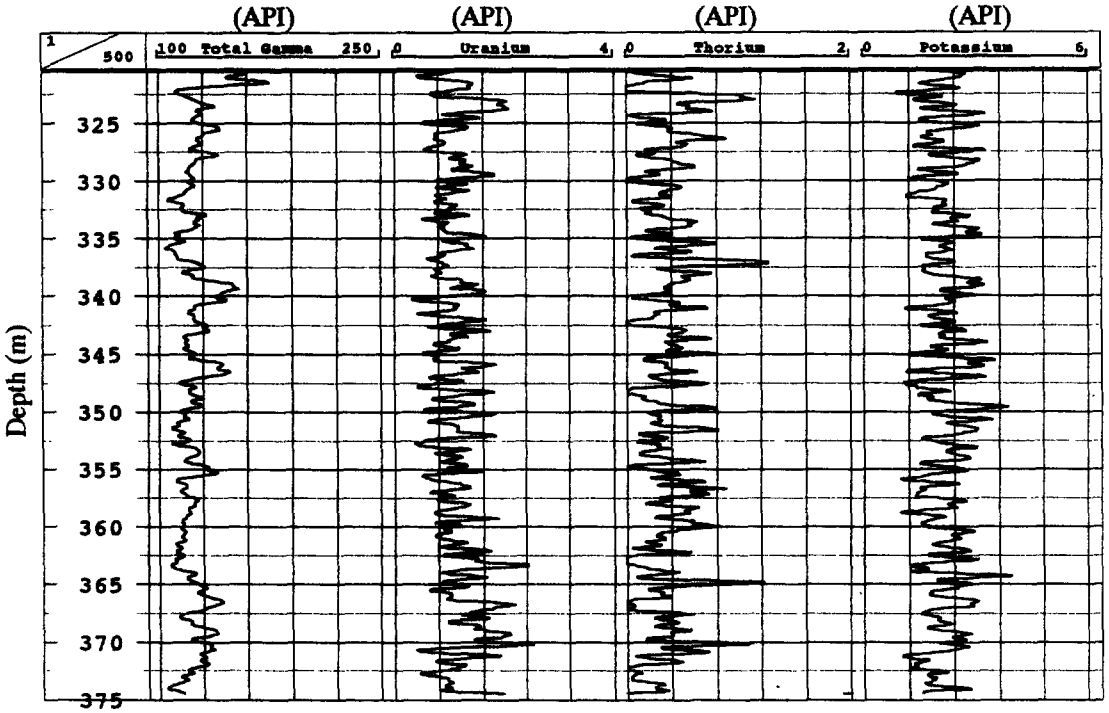

Figure HC-6.8. Spectral gamma log for HC-6 (continued).

HC-7

Available Data

- Water Level vs. Time
- Radar
- Acoustic Televiewer
- Borehole Deviation
- Temperature Log
- Differential Temperature Log
- Caliper Log
- Natural Gamma Log
- Guard Resistivty Log
- Neutron Log
- Caliper Log
- Density Compensation Log
- Density Log
- DPORO Log
- Spectral Gamma Log

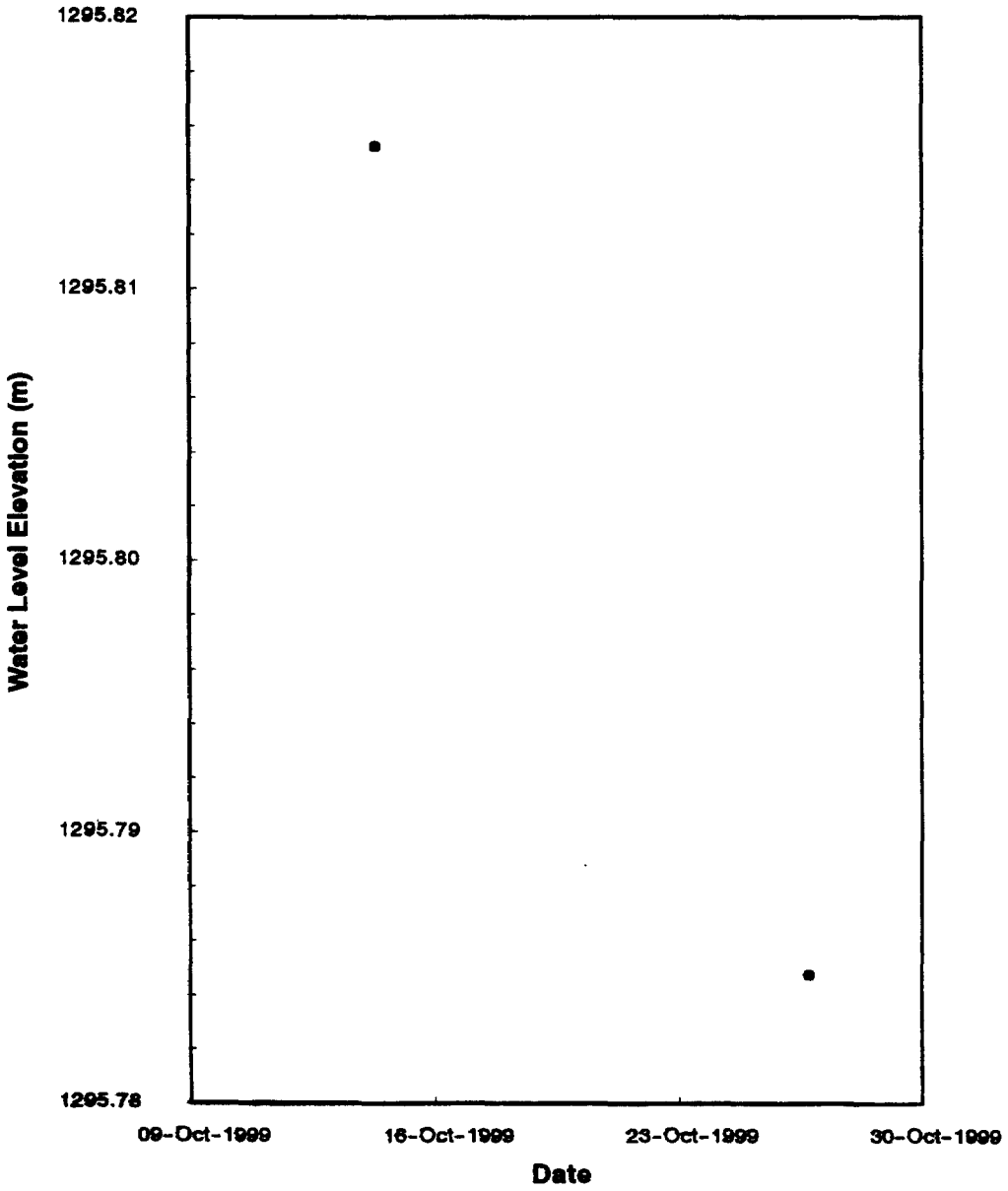

Figure HC-7.1. HC-7 water level vs. time.

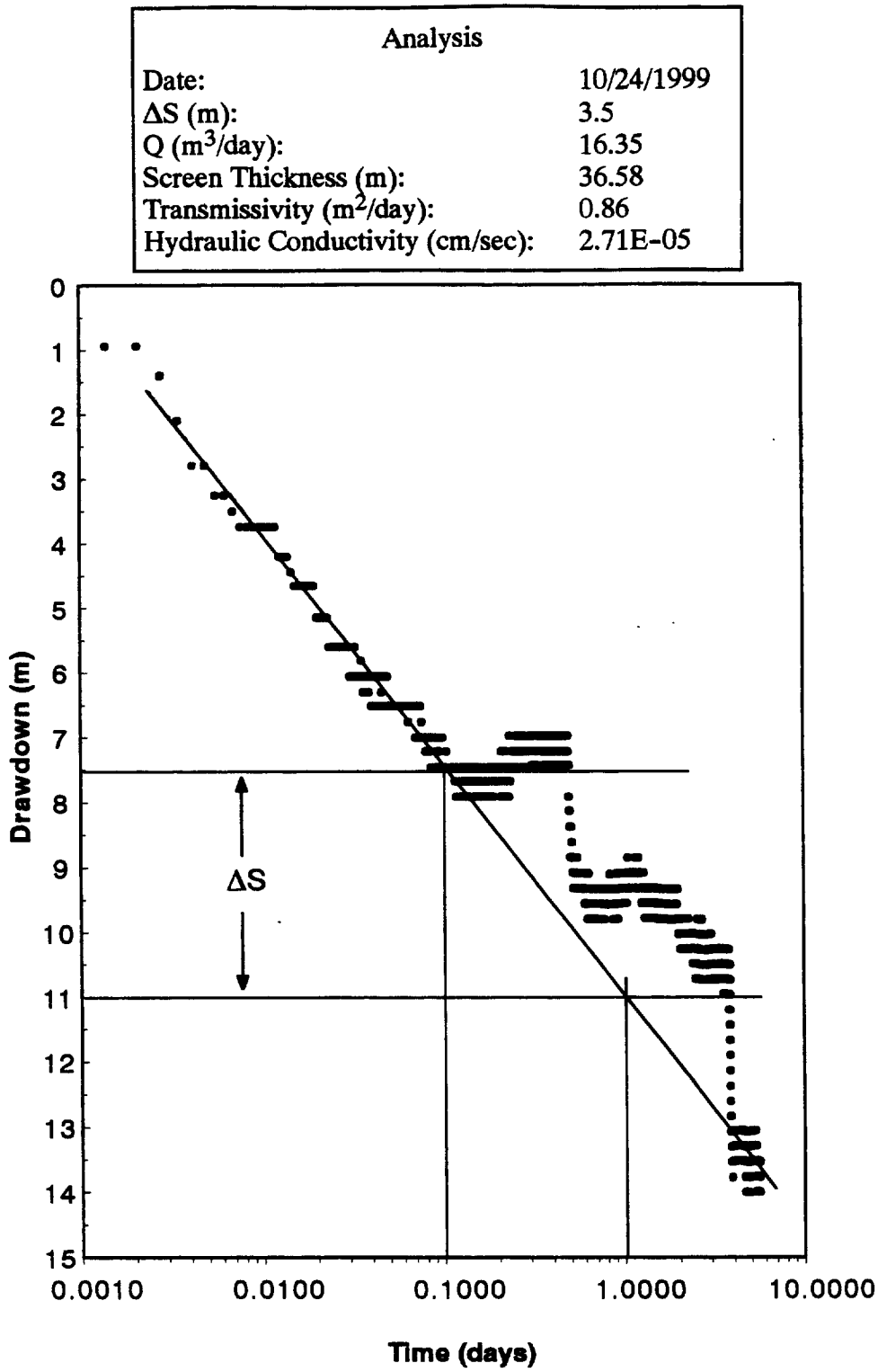

Figure HC-7.2. HC-7 pumping test analysis.

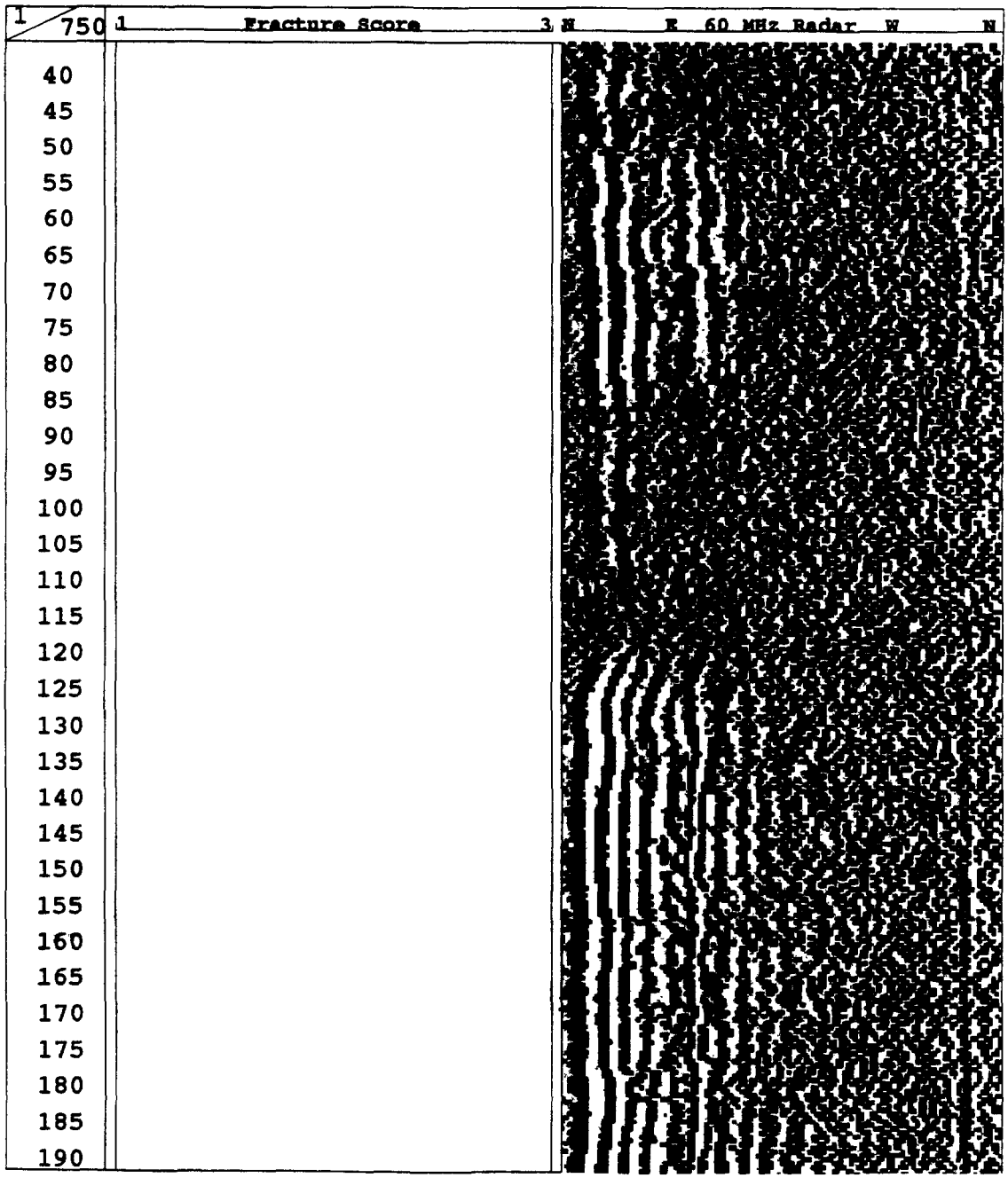

Figure HC-7.3. Fracture score (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) and dipole radar log for HC-7 from 35 to 375 m.

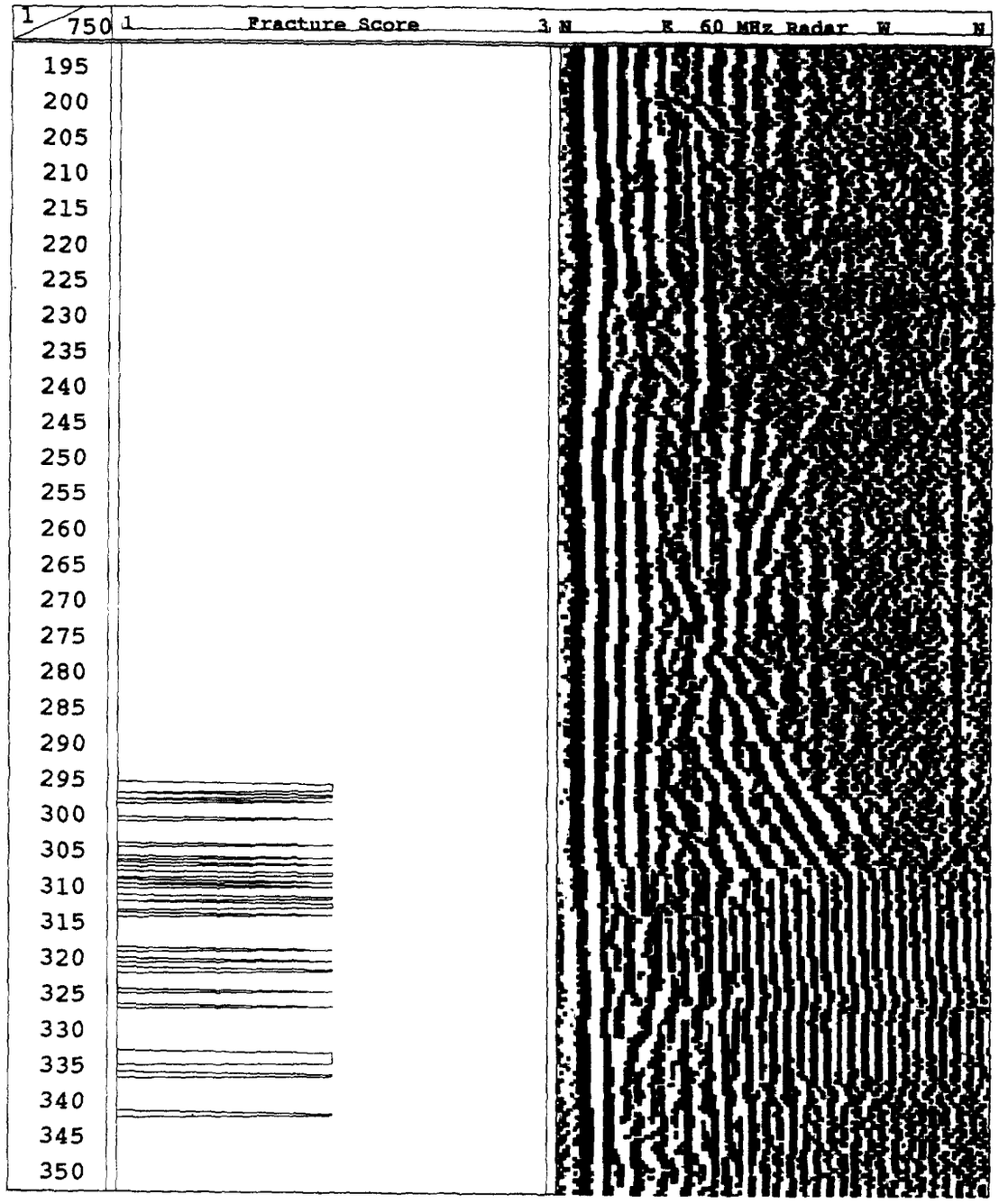

Figure HC-7.3. Fracture score (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) and dipole radar log for HC-7 from 35 to 375 m (condinuted).

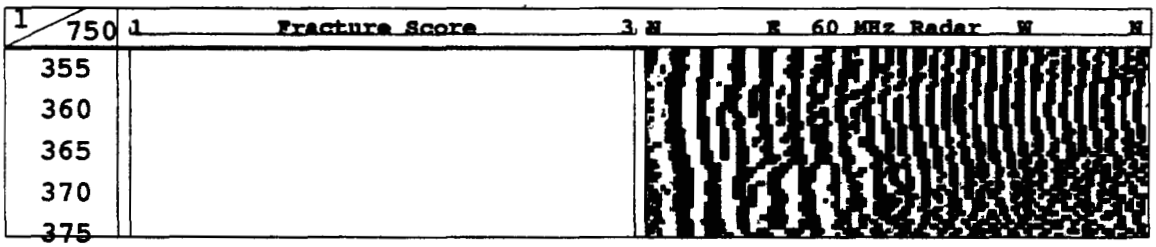

Figure HC-7.3. Fracture score (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) and dipole radar log for HC-7 from 35 to 375 m (condinuted).

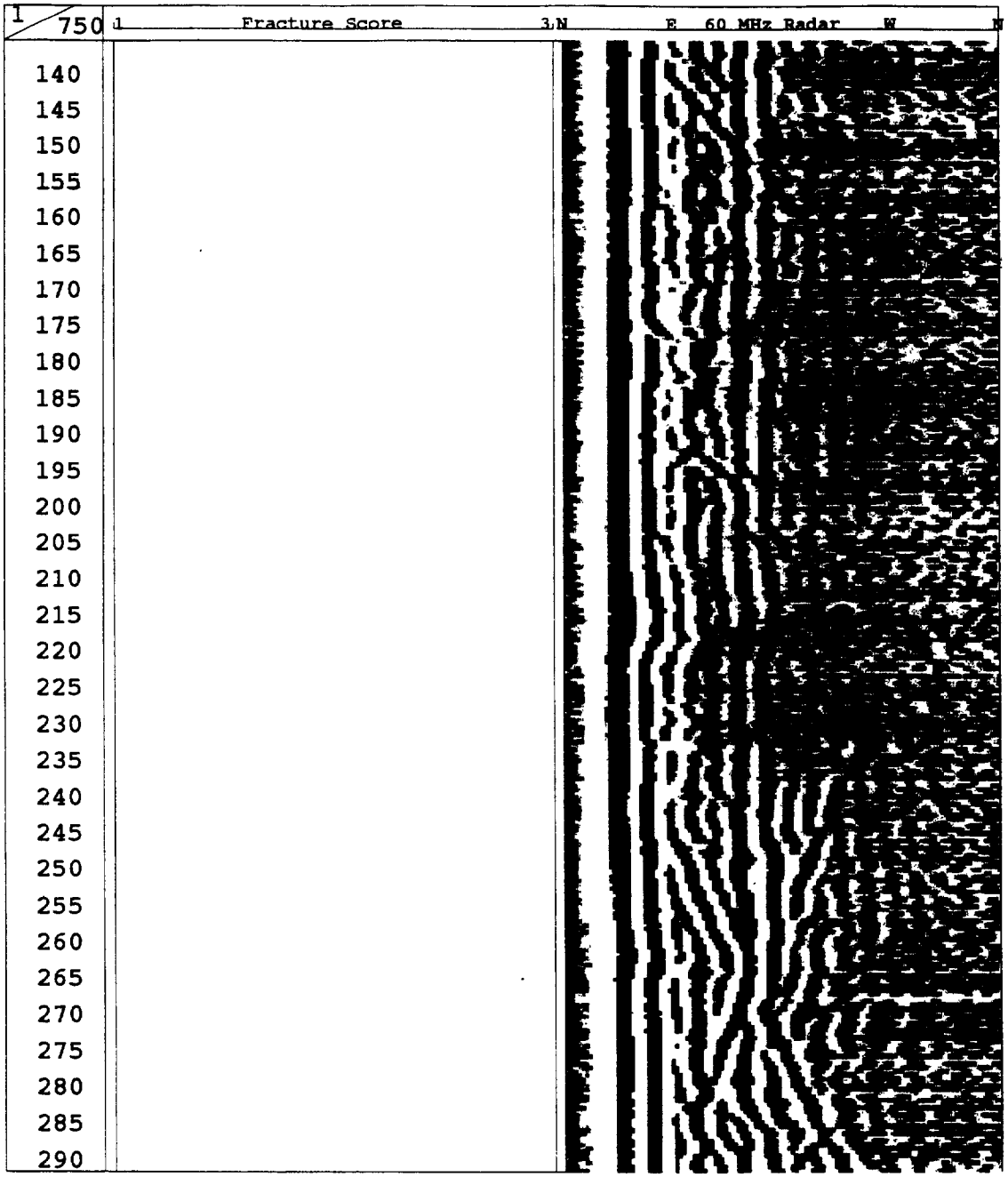

Figure HC-7.4. Fracture score (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) and dipole component of directional radar log for HC-7 from 135 to 375 m.

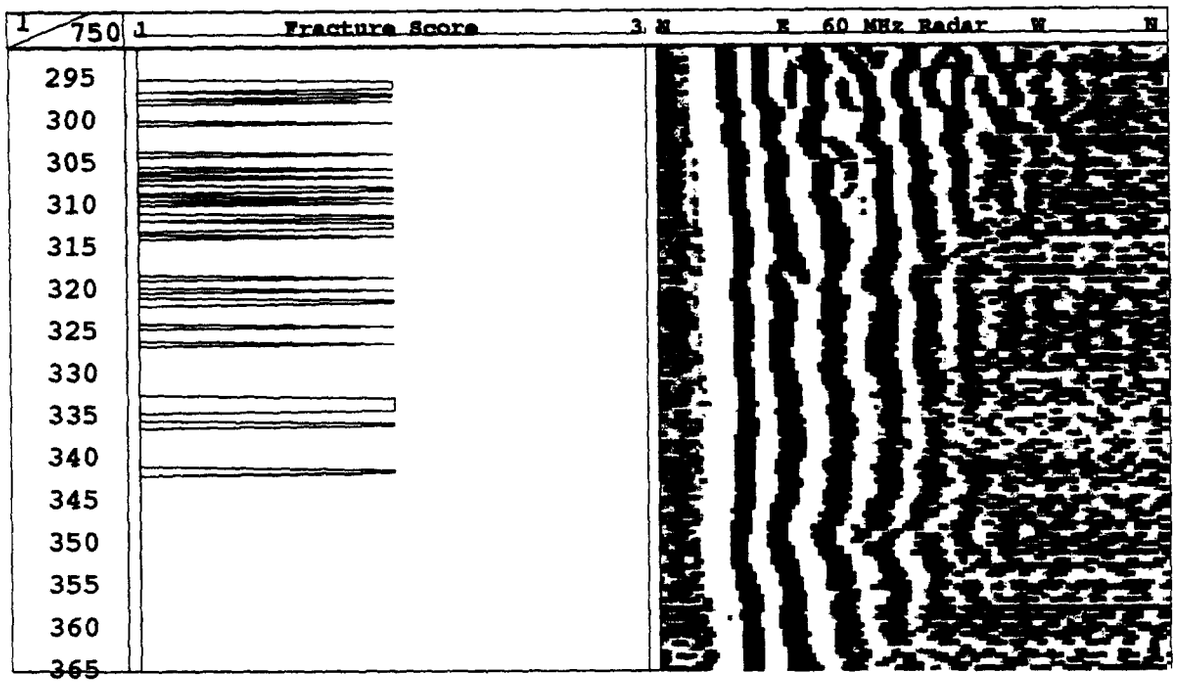

Figure HC-7.4. Fracture score (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) and dipole component of directional radar log for HC-7 from 135 to 375 m (continued).

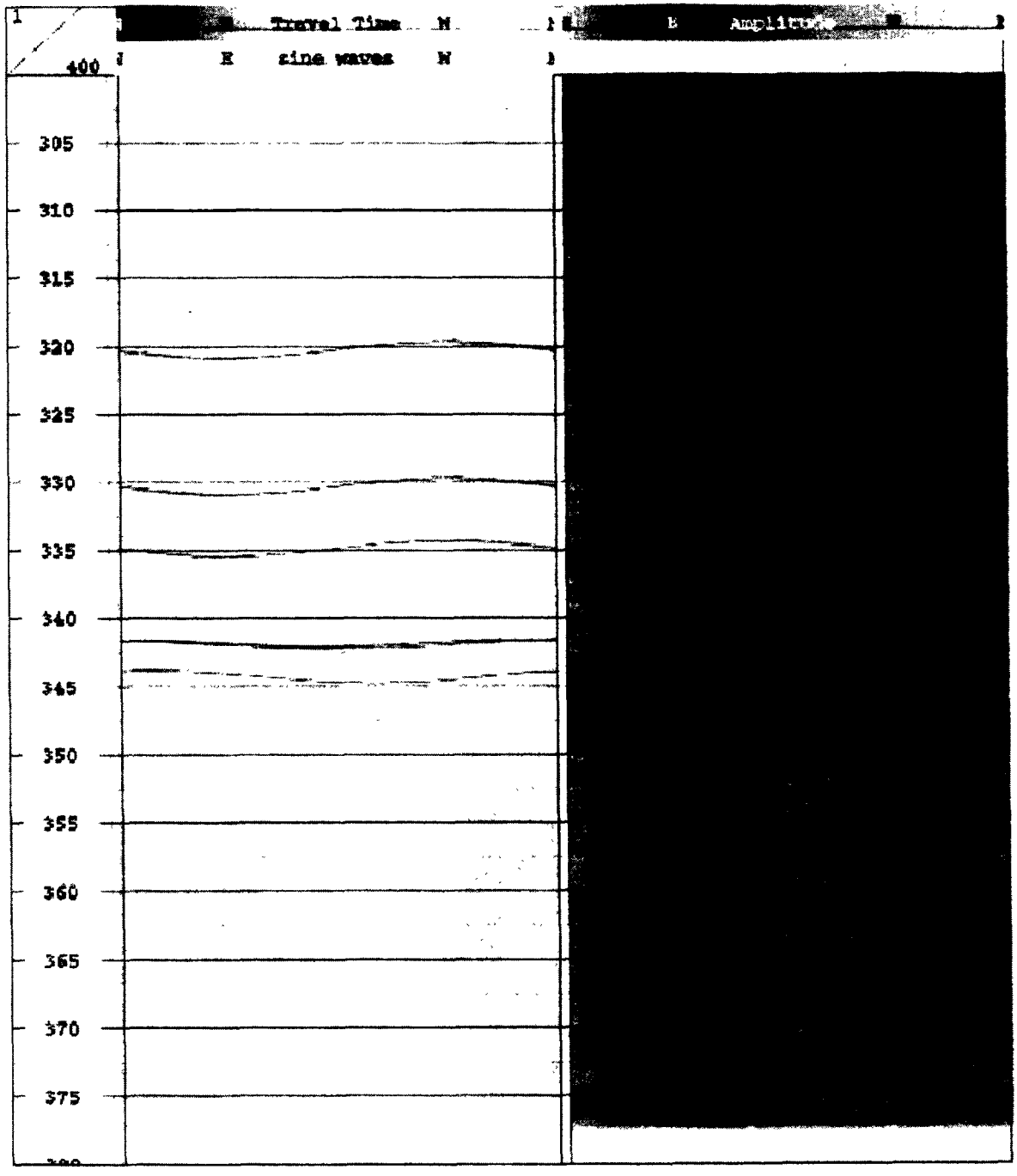

Figure HC-7.5. HC-7 acoustic televiewer data.

Table HC-7.1. HC-7 borehole deviation.

Cable Depth (m)	True Depth (m)	Regression True Depth (m)	Absolute Error (m)
274.32	274.26	274.26	0.0003
281.94	281.87	281.88	0.0059
289.56	289.49	289.49	0.0029
297.18	297.11	297.11	0.0002
304.80	304.73	304.73	0.0006
312.42	312.34	312.34	0.0018
320.04	319.95	319.96	0.0039
327.66	327.57	327.57	0.0025
335.28	335.19	335.19	0.0037
342.90	342.80	342.80	0.0015
350.52	350.42	350.42	0.0020
358.14	358.03	358.03	0.0010
365.76	365.64	365.65	0.0049
376.43	376.30	376.30	0.0017

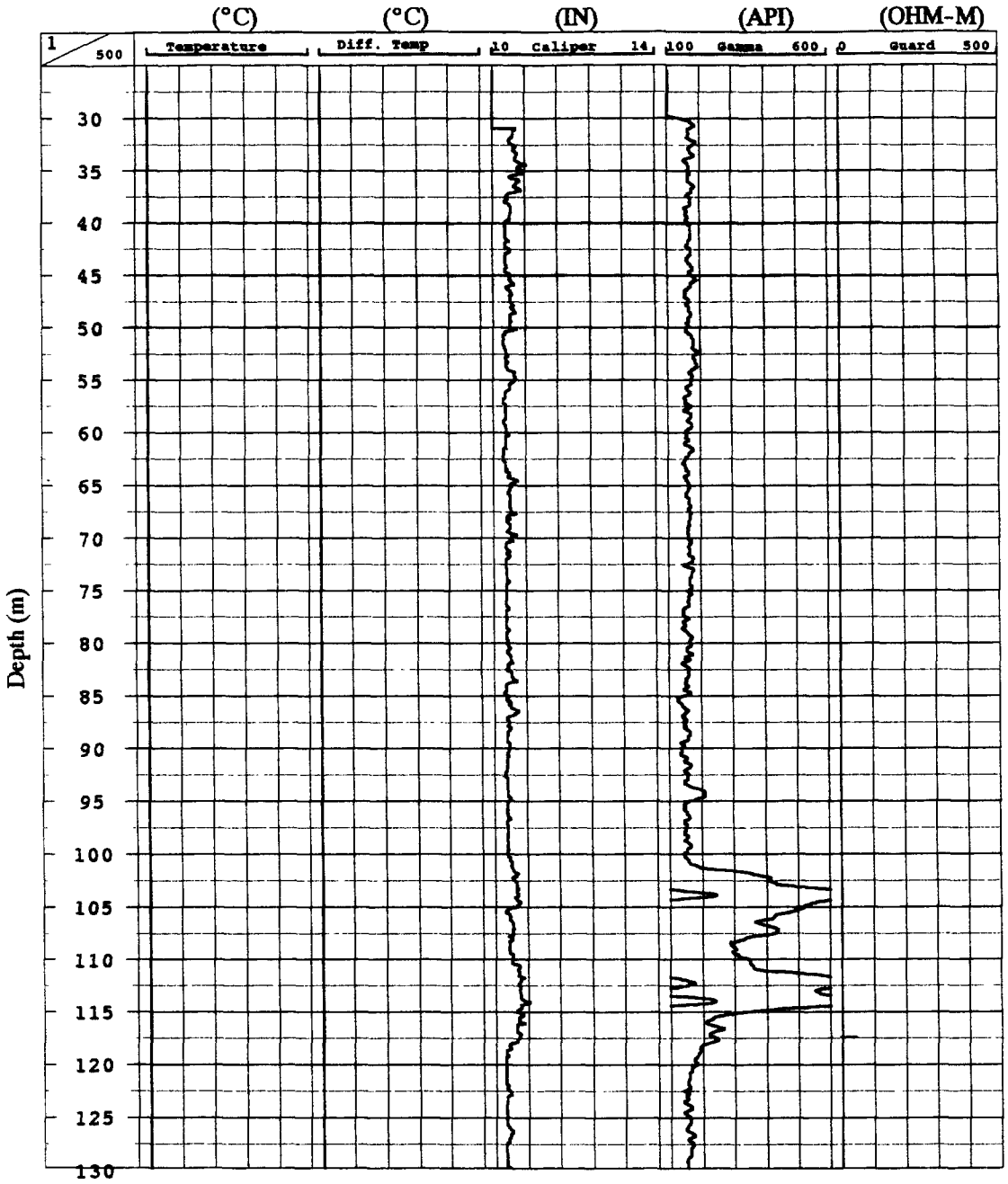

Figure HC-7.6. HC-7 temperature, differential temperature, caliper, natural gamma and guard resistivity logs.

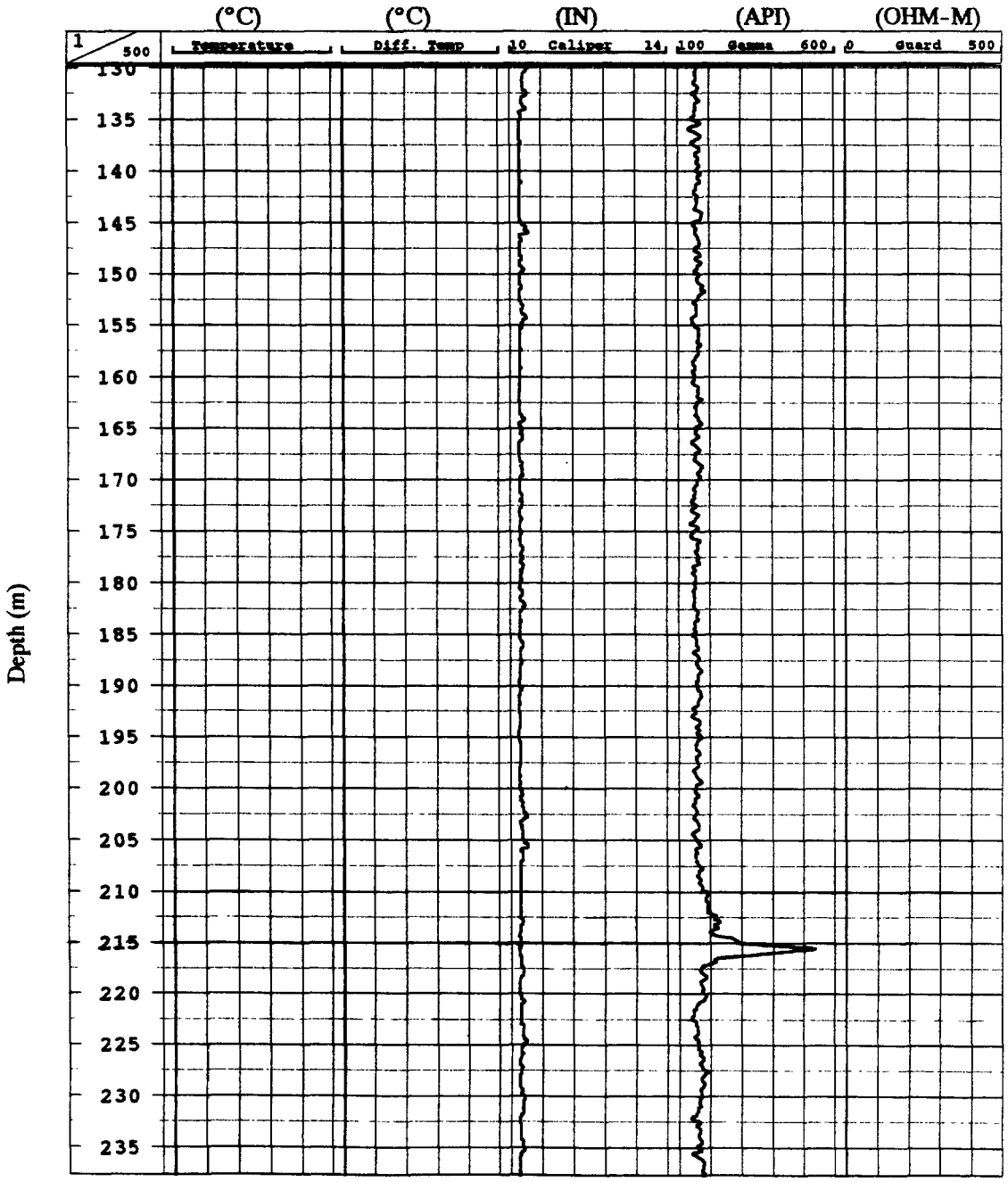

Figure HC-7.6. HC-7 temperature, differential temperature, caliper, natural gamma and guard resistivity logs (continued).

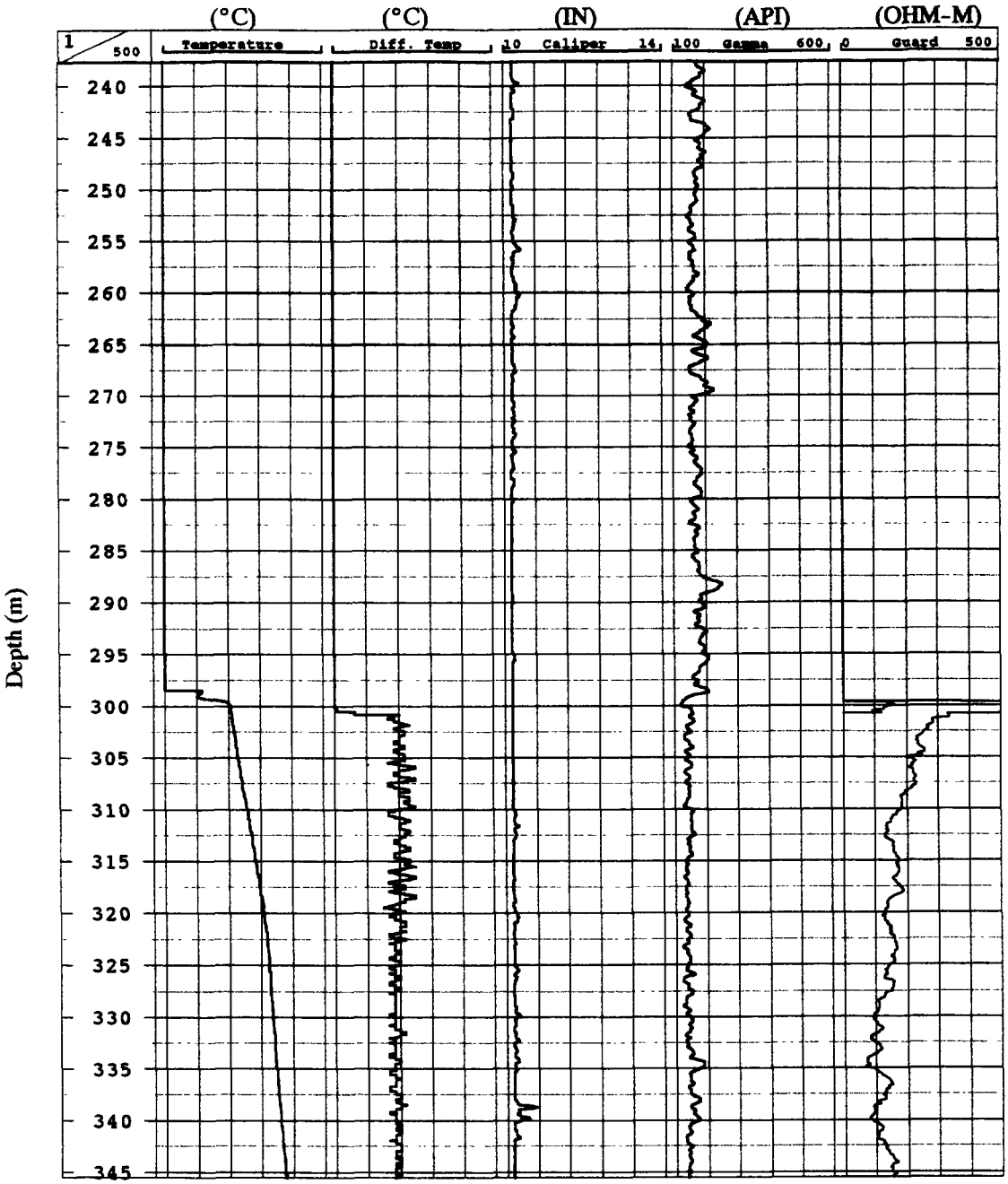

Figure HC-7.6. HC-7 temperature, differential temperature, caliper, natural gamma and guard resistivity logs (continued).

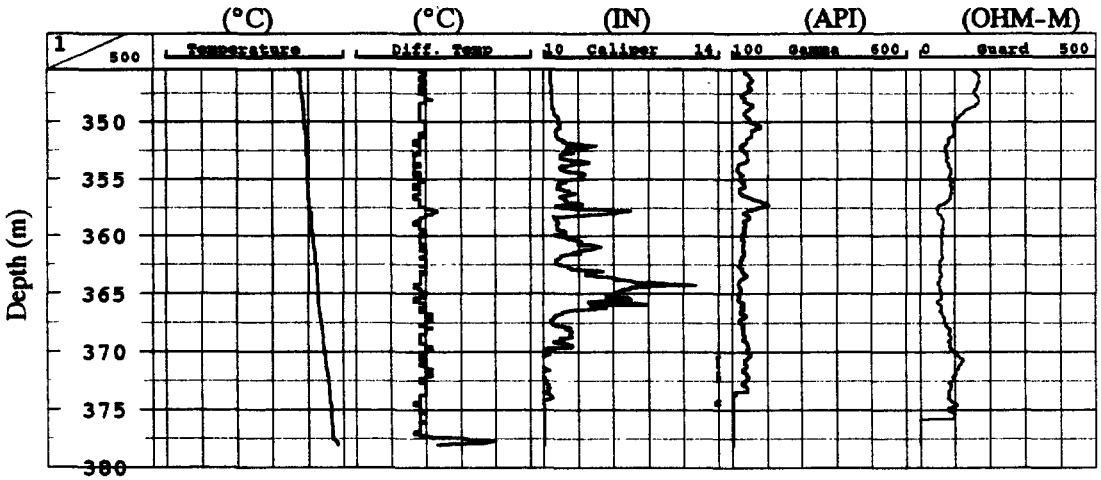

Figure HC-7.6. HC-7 temperature, differential temperature, caliper, natural gamma and guard resistivity logs (continued).

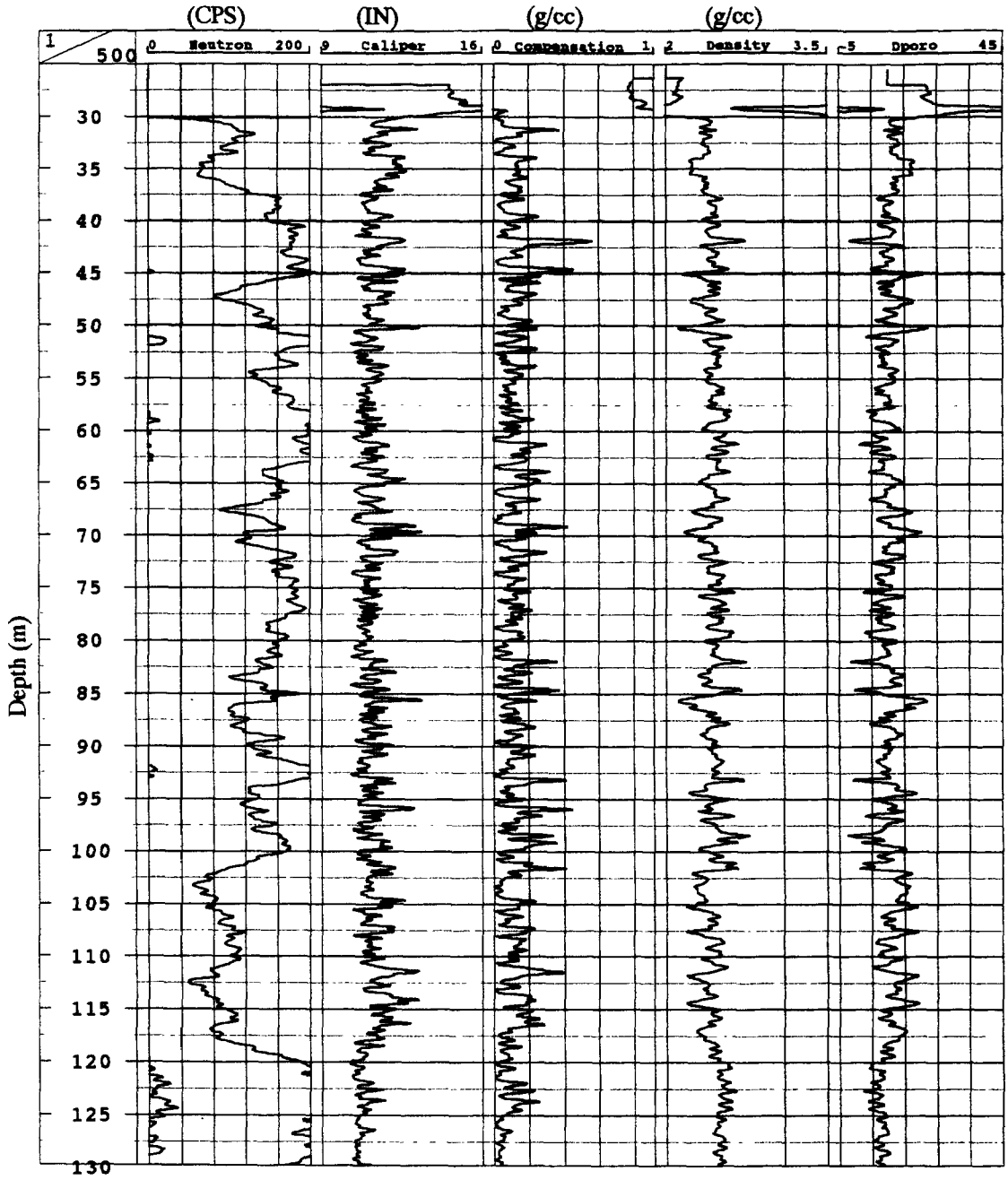

Figure HC-7.7. HC-7 neutron, caliper, density compensation, density and DPORO logs.

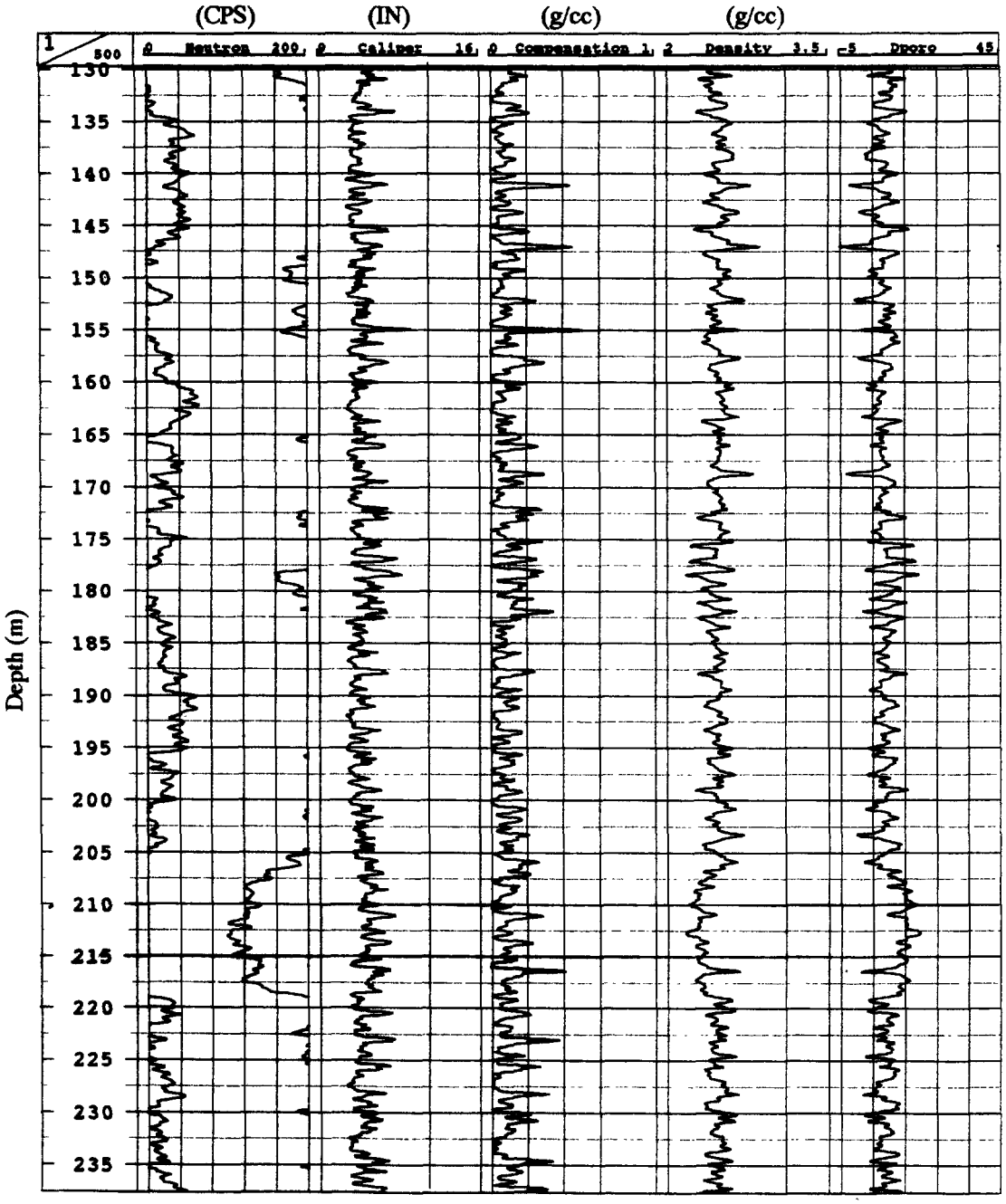

Figure HC-7.7. HC-7 neutron, caliper, density compensation, density and DPORO logs (continued).

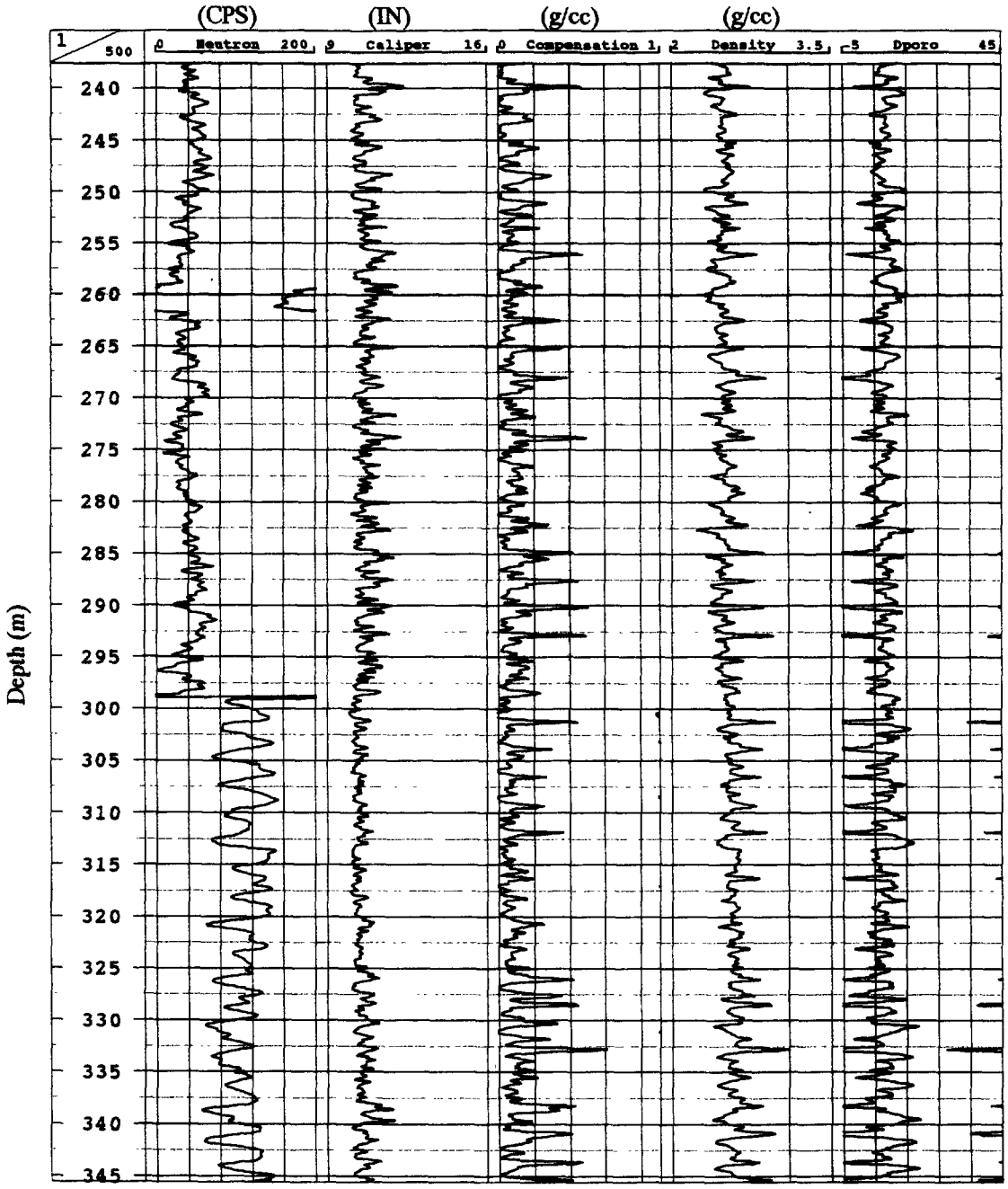

Figure HC-7.7. HC-7 neutron, caliper, density compensation, density and DPORO logs (continued).

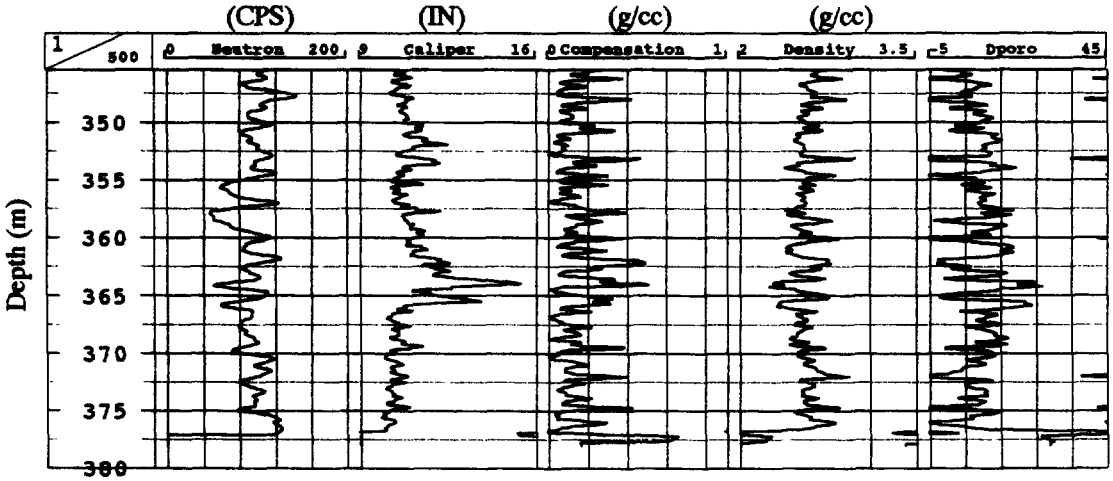

Figure HC-7.7. HC-7 neutron, caliper, density compensation, density and DPORO logs (continued).

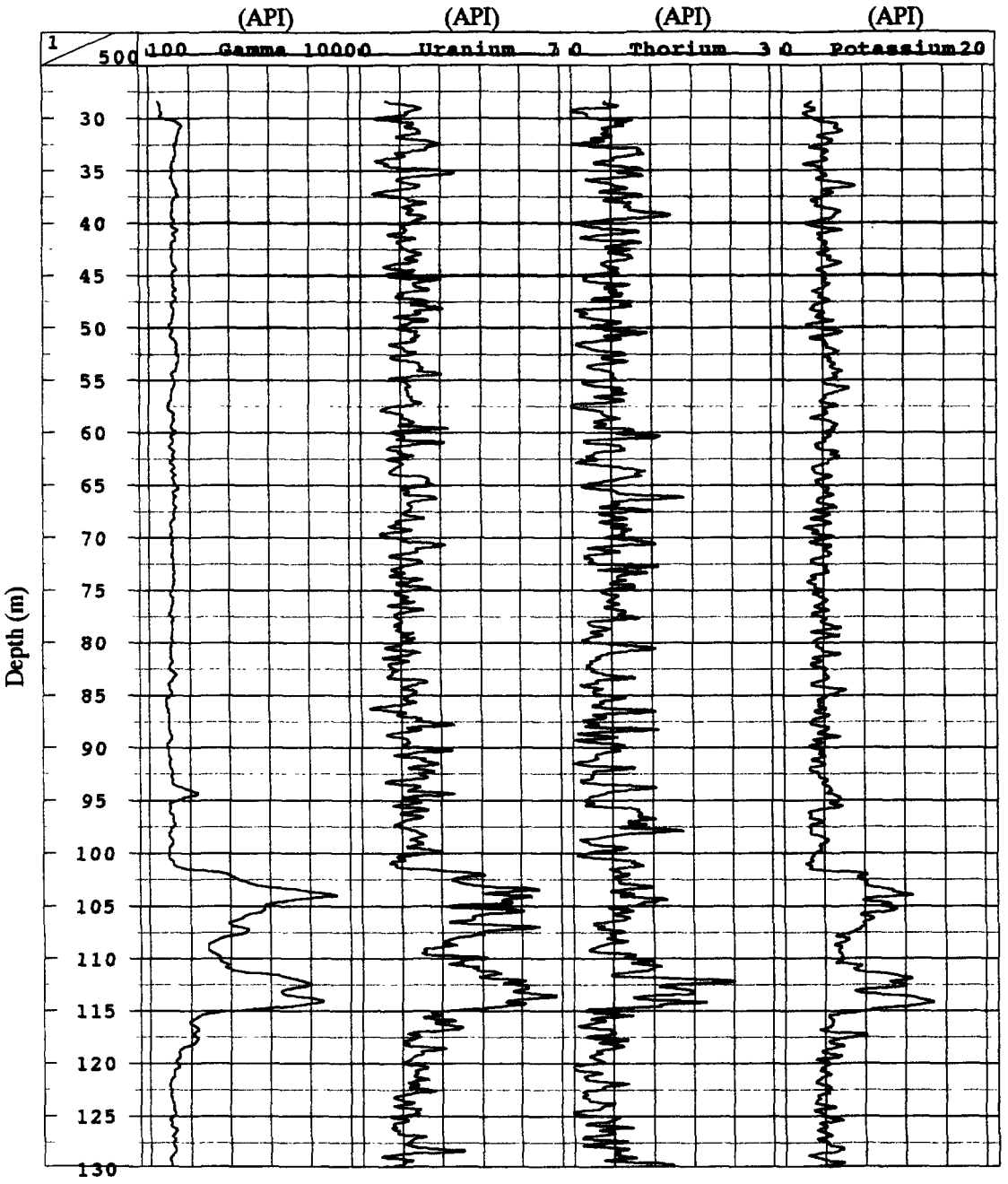

Figure HC-7.8. HC-7 spectral gamma logs.

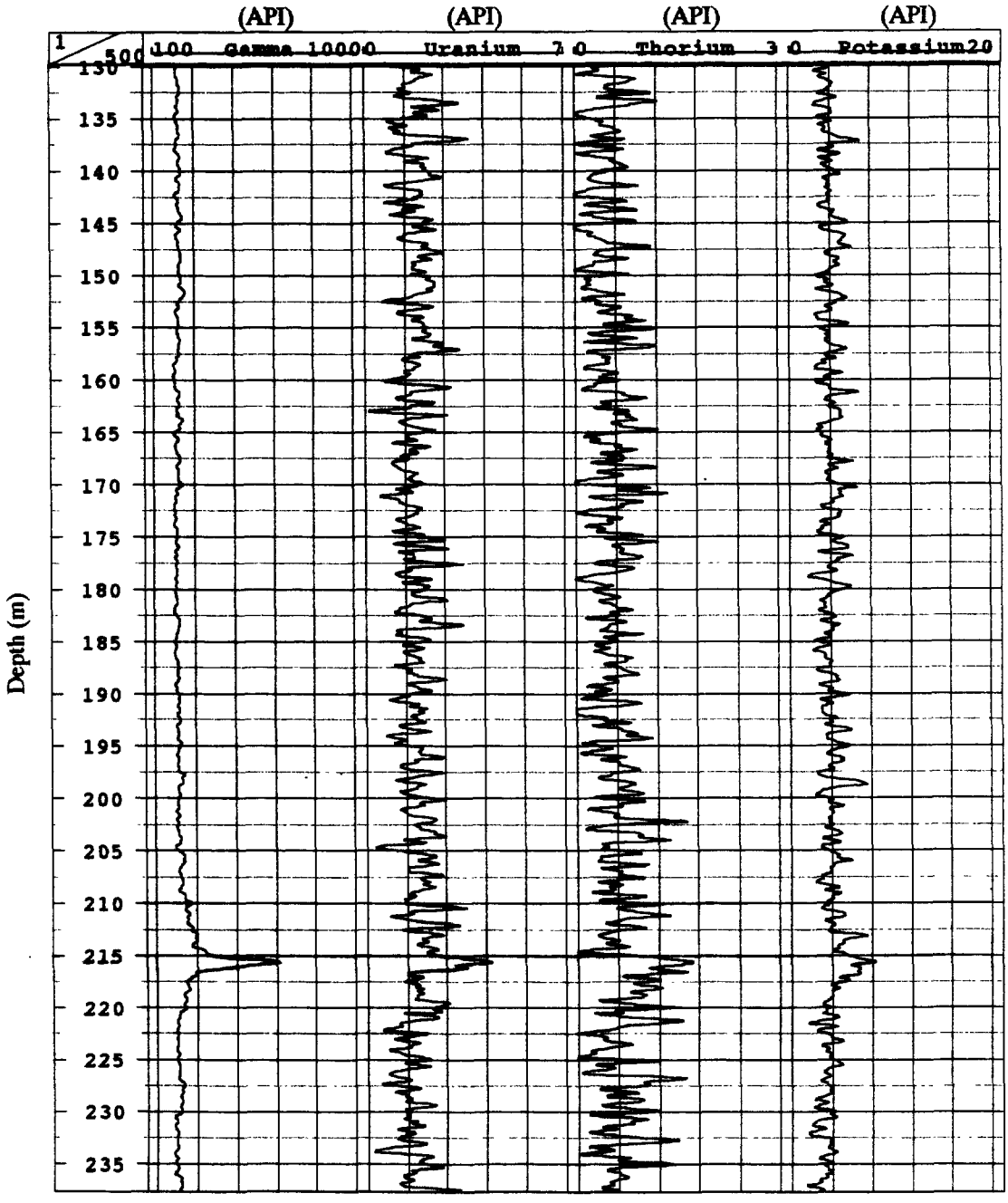

Figure HC-7.8. HC-7 spectral gamma logs (continued).

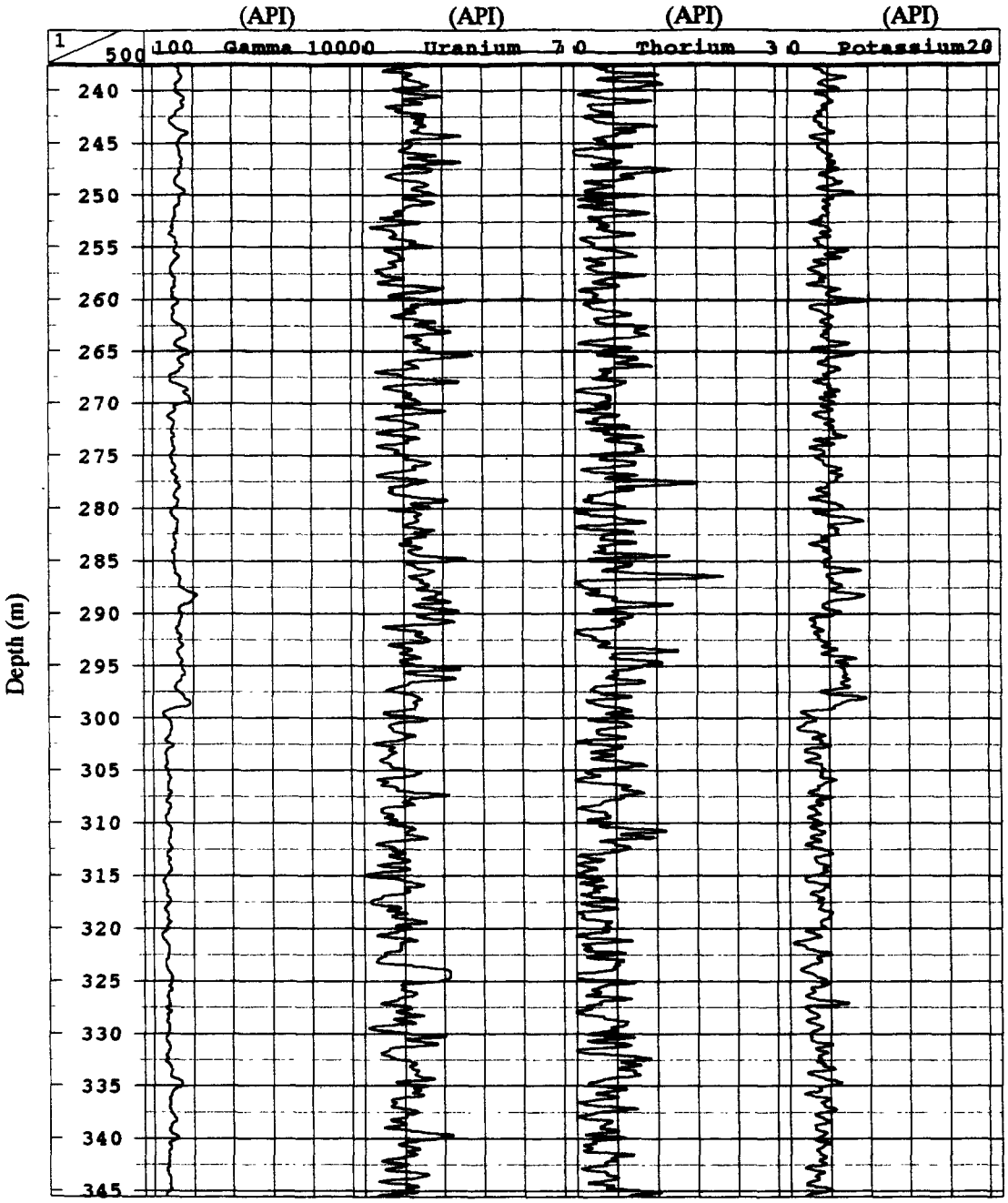

Figure HC-7.8. HC-7 spectral gamma logs (continued).

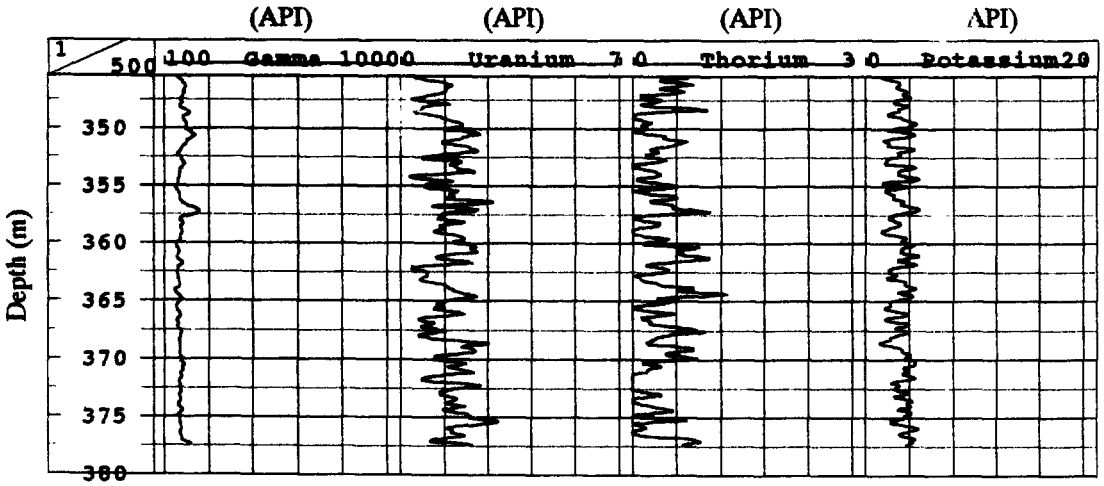

Figure HC-7.8. HC-7 spectral gamma logs (continued).

HC-8

Available Data

- Pumping Test
- Water Level vs. Time
- Fracture Interpretation
- Radar Log
- Acoustic Televiewer
- Borehole Deviation
- Temperature Log
- Differential Temperature Log
- Caliper Log
- Natural Gamma Log
- Resistivity Log
- Neutron Porosity Log
- Density Calibration Log
- Density Compensation Log
- Density Log

Analysis	
Date:	11/11/1999
ΔS (m):	90.0
Q (m^3/day):	14.99
Screen Thickness (m):	36.6
Transmissivity (m^2/day):	0.03
Hydraulic Conductivity (cm/sec):	9.6E-07

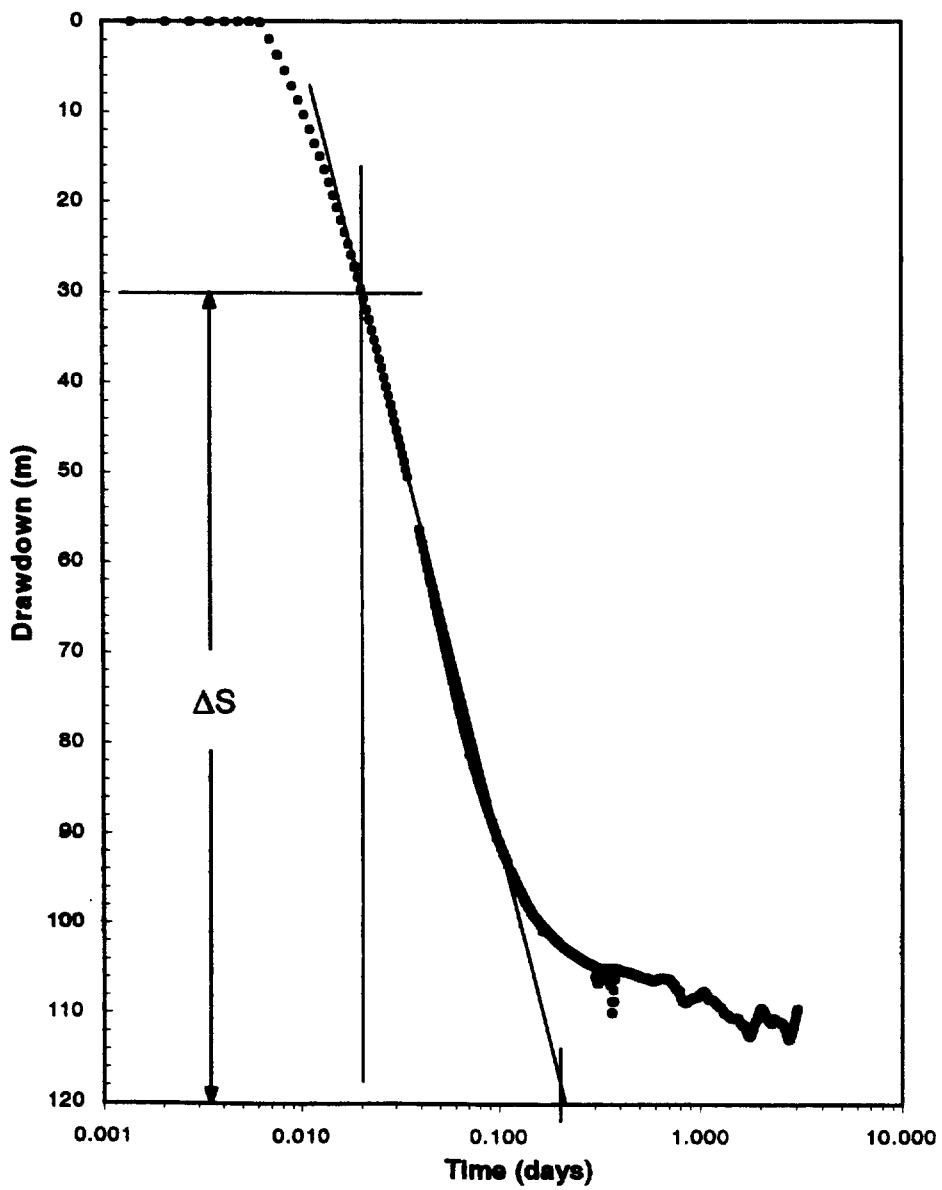

Figure HC-8.1 HC-8 pumping test analysis (1999).

Analysis	
Date:	11/14/1999
ΔS (m):	79.50
Q (m^3/day):	14.99
Screen Thickness (m):	36.6
Transmissivity (m^2/day):	0.03
Hydraulic Conductivity (cm/sec):	1.1E-06

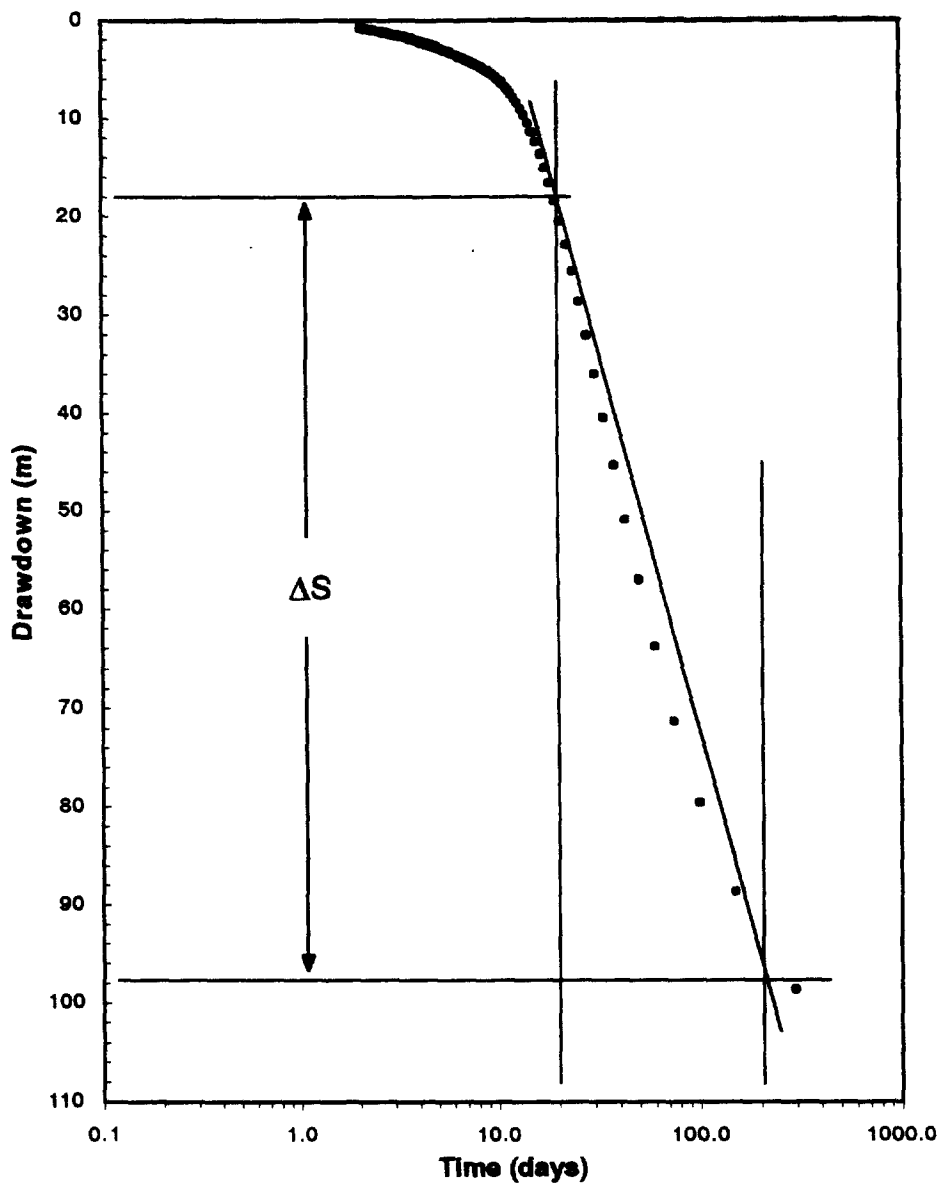

Figure HC-8.2. HC-8 recovery analysis (1997).

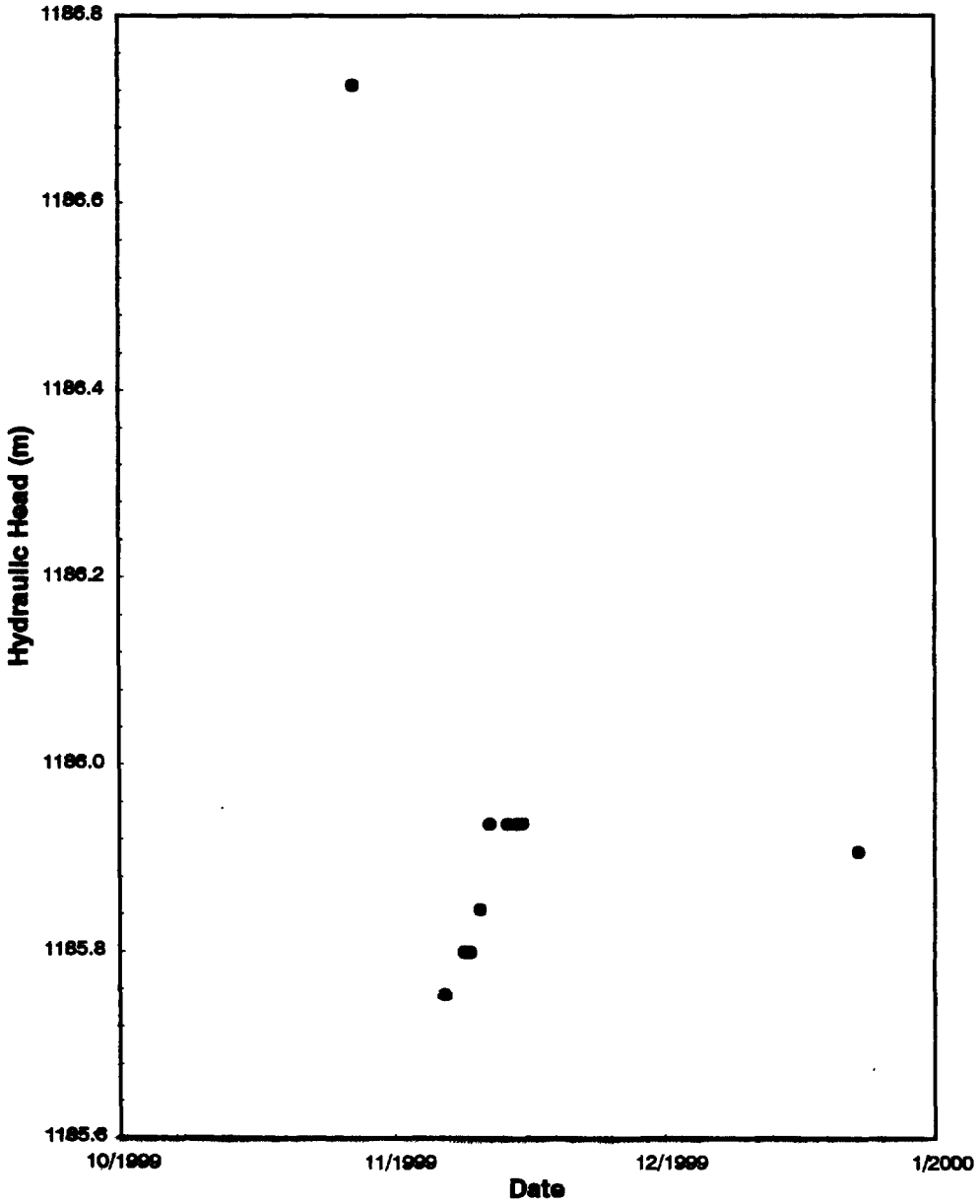

Figure HC-8.3. HC-8 hydraulic head vs. time.

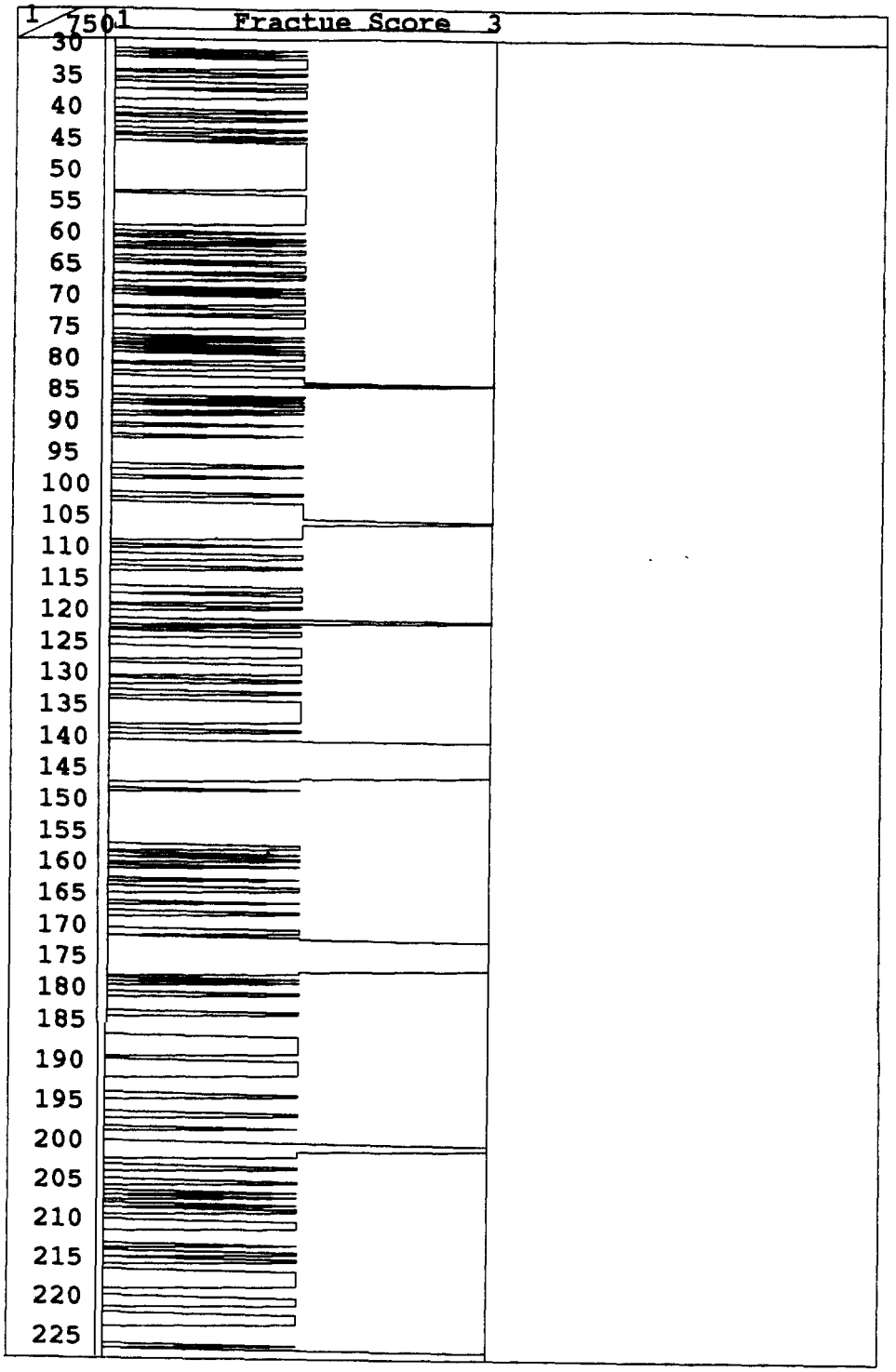

Figure HC-8.4. Fracture score (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) for HC-8.

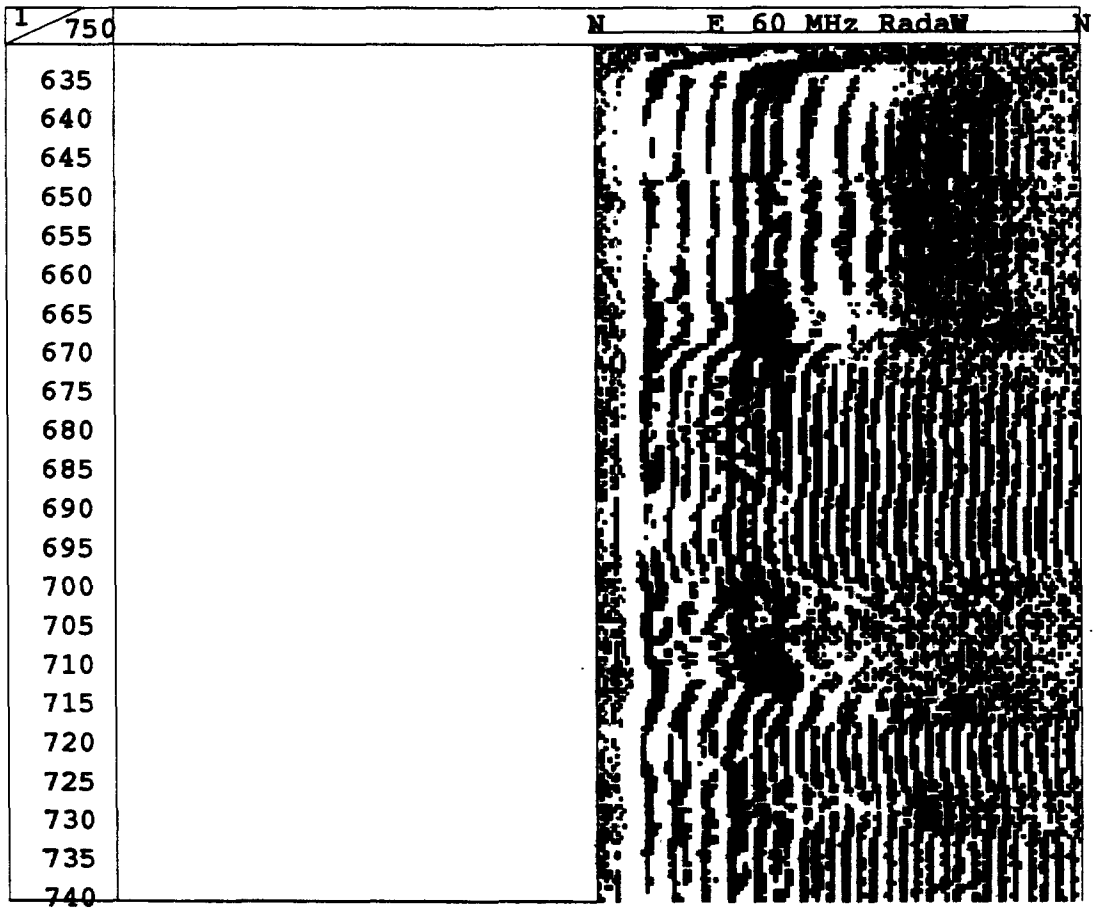

Figure HC-8.5. Dipole radar log for HC-8.

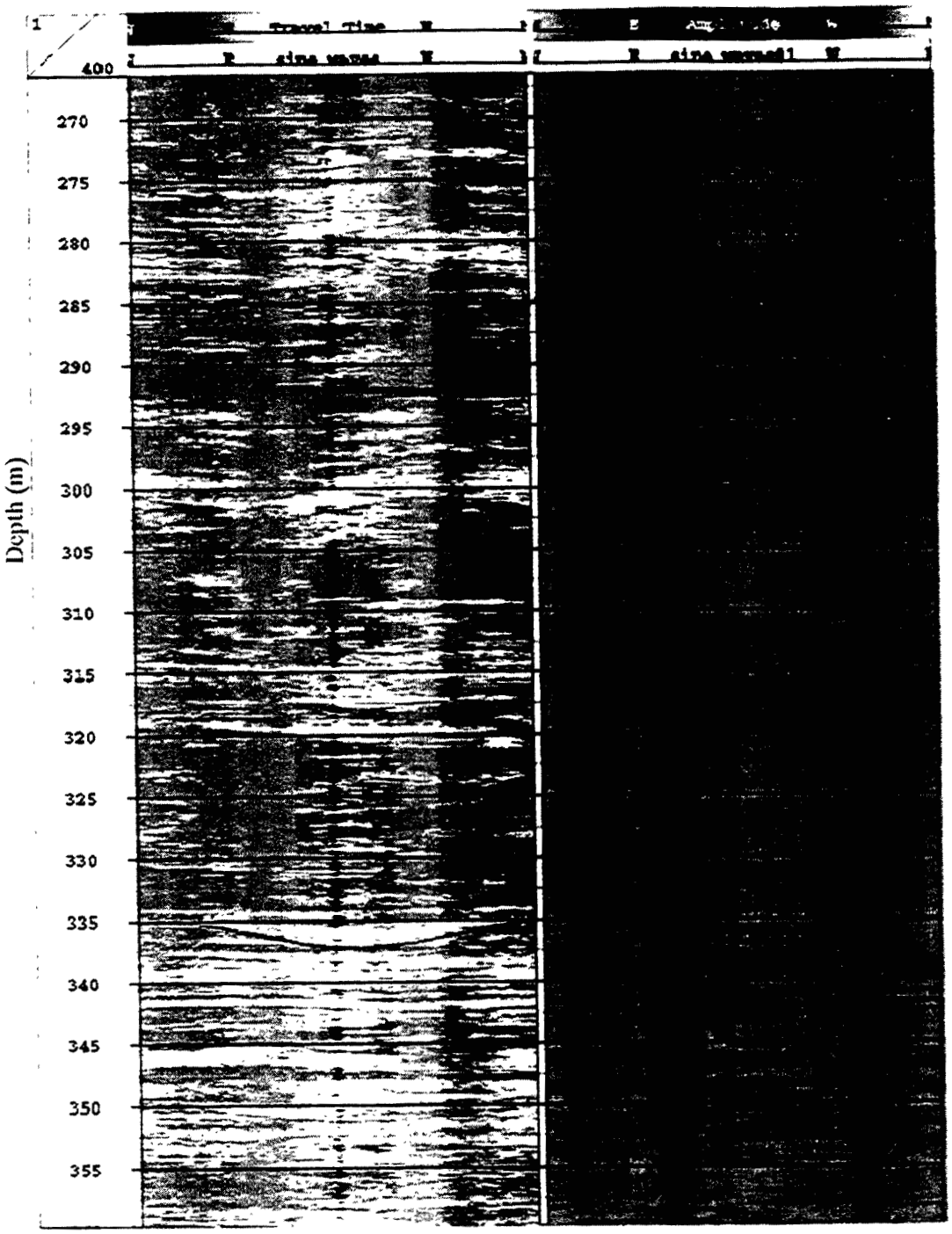

Figure HC-8.6. Acoustic televiewer log for HC-8.

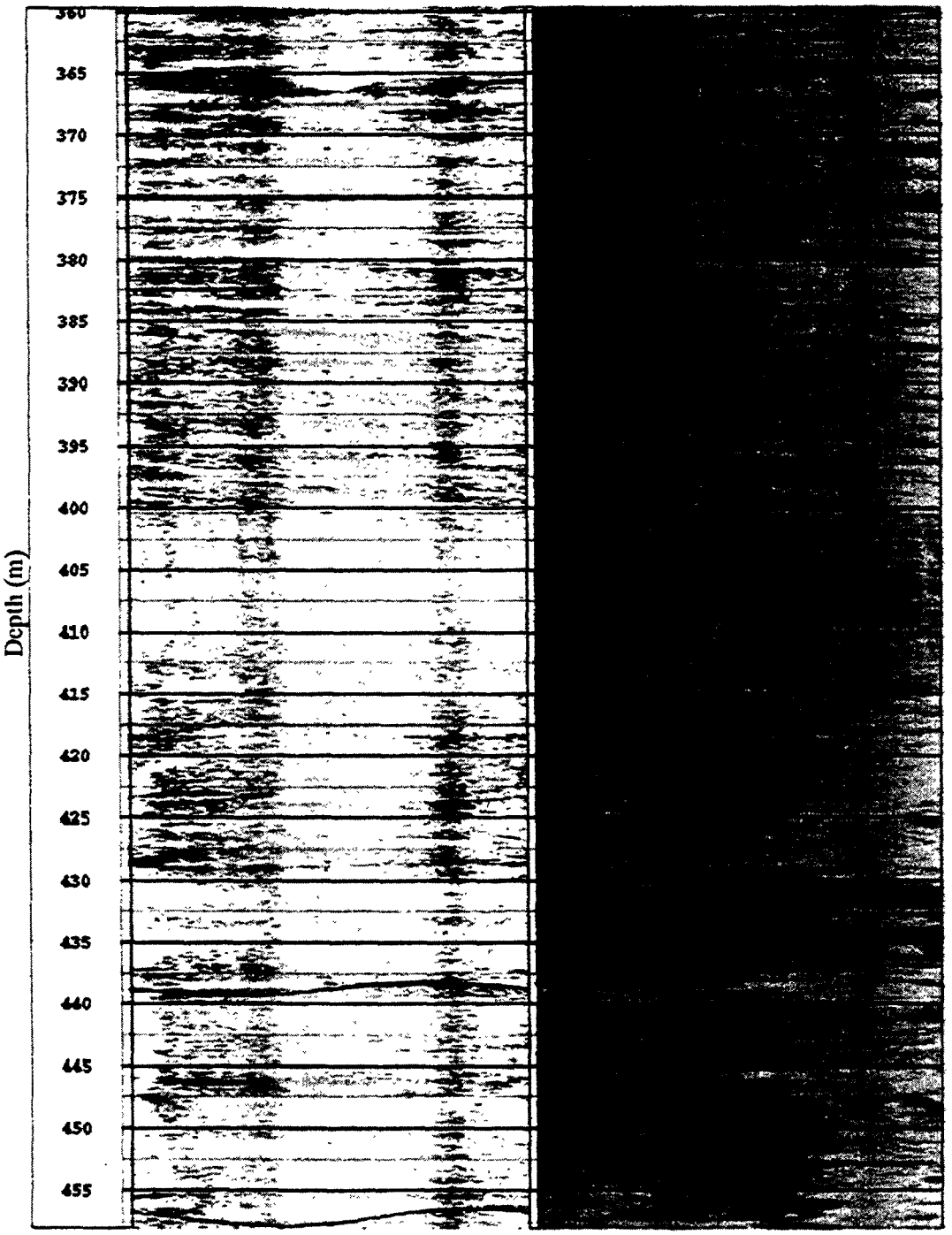

Figure HC-8.6. Acoustic televiewer log for HC-8 (continued).

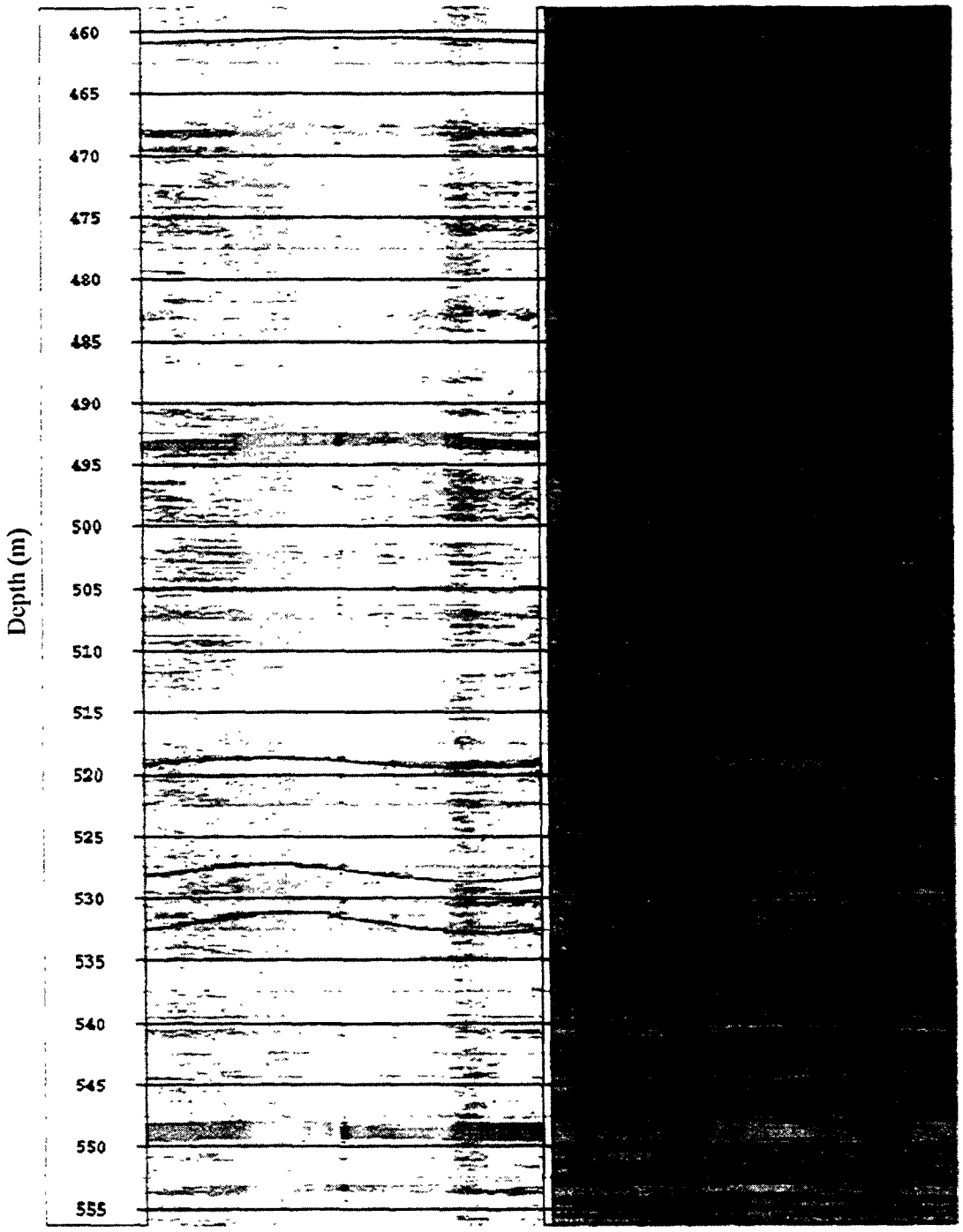

Figure HC-8.6. Acoustic televiewer log for HC-8 (continued).

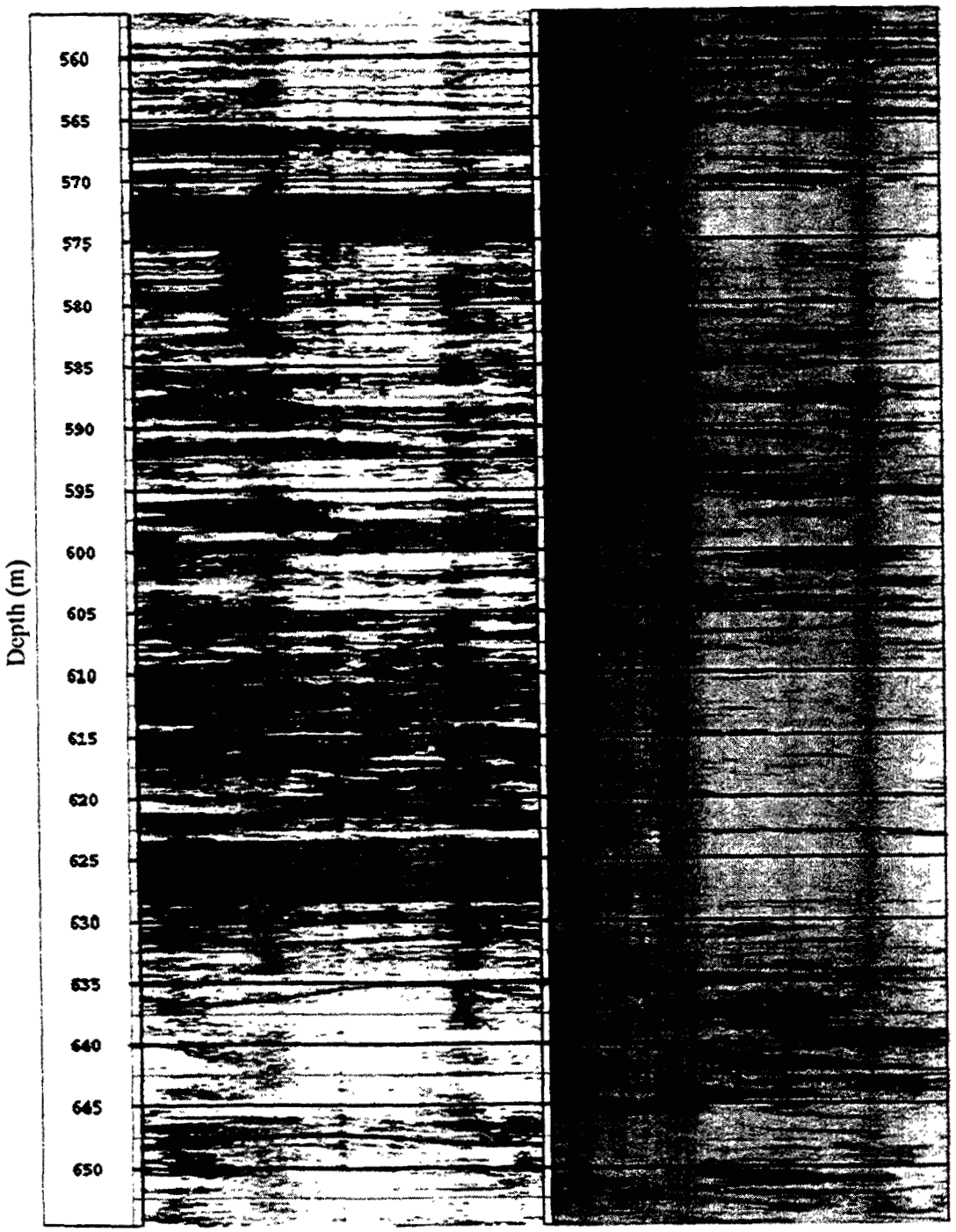

Figure HC-8.6. Acoustic televiewer log for HC-8 (continued).

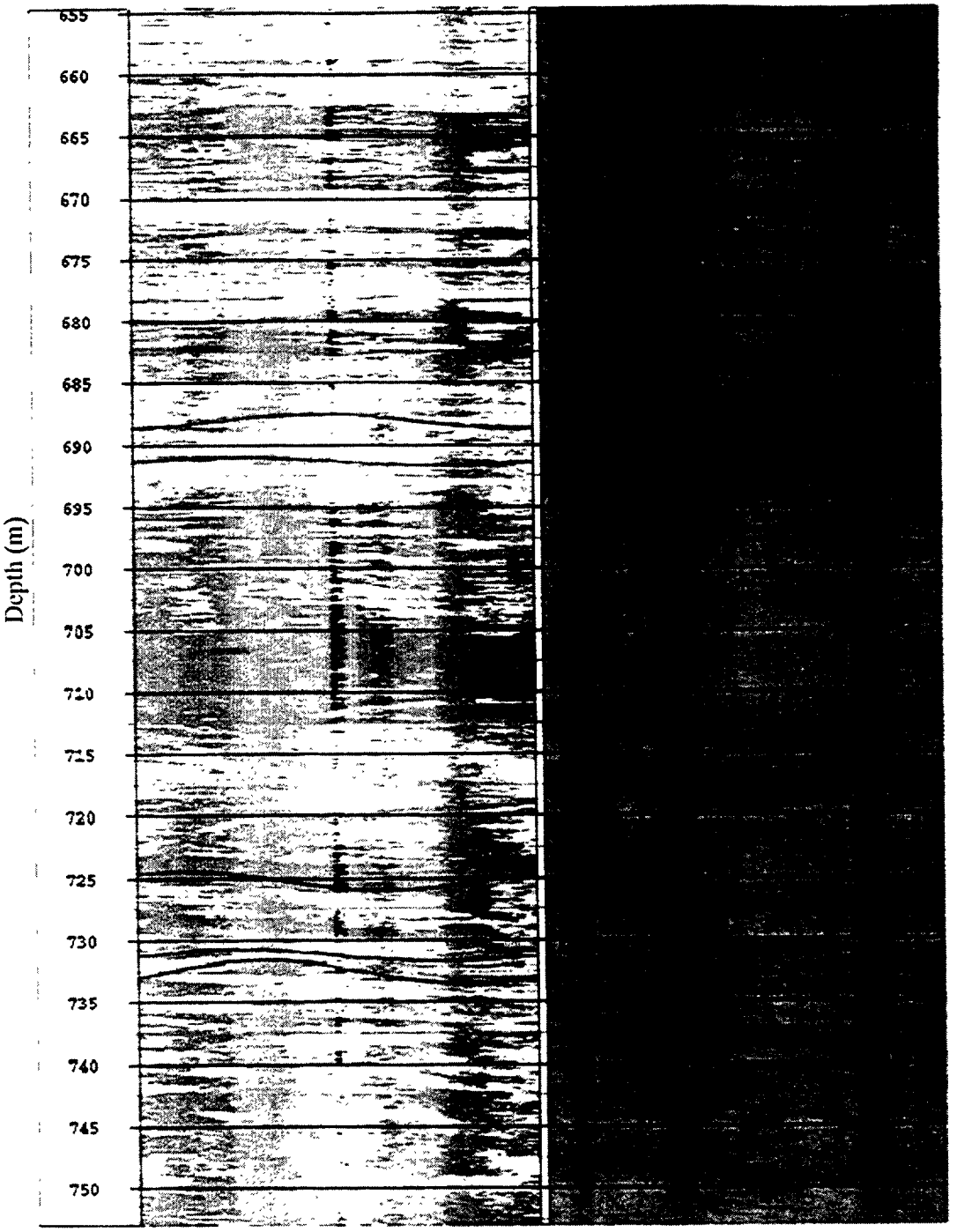

Figure HC-8.6. Acoustic televiewer log for HC-8 (continued).

Table HC-8.1. HC-8 borehole deviation.

Cable Depth (m)	True Depth (m)	Regression True Depth (m)	Absolute Error (m)
365.76	365.62	365.62	0.0001
373.38	373.24	373.24	0.0001
381.00	380.86	380.86	0.0007
388.62	388.47	388.47	0.0003
396.24	396.08	396.09	0.0018
403.86	403.70	403.70	0.0009
411.48	411.32	411.31	0.0020
419.10	418.93	418.93	0.0008
426.72	426.54	426.54	0.0013
434.34	434.16	434.16	0.0002
441.96	441.77	441.77	0.0012
449.58	449.38	449.38	0.0001
457.20	456.99	456.99	0.0004
464.82	464.61	464.61	0.0001
472.44	472.22	472.22	0.0025
480.06	479.84	479.85	0.0112
487.68	487.45	487.48	0.0280
495.30	495.06	495.12	0.0598
502.92	502.68	502.78	0.1061
511.15	510.90	511.08	0.1823

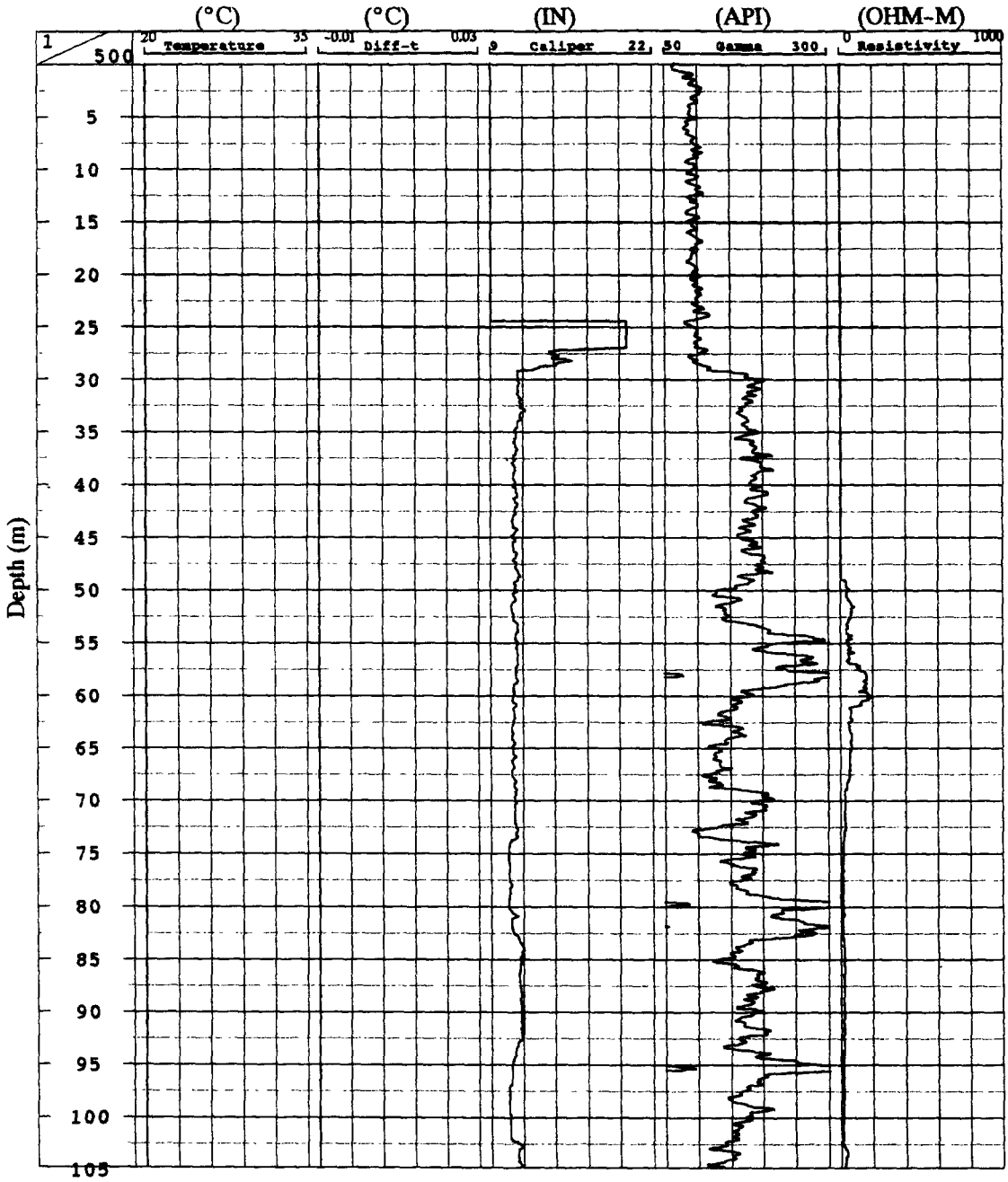

Figure HC-8.7. HC-8 temperature, differential temperature, caliper, natural gamma and guard resistivity logs.

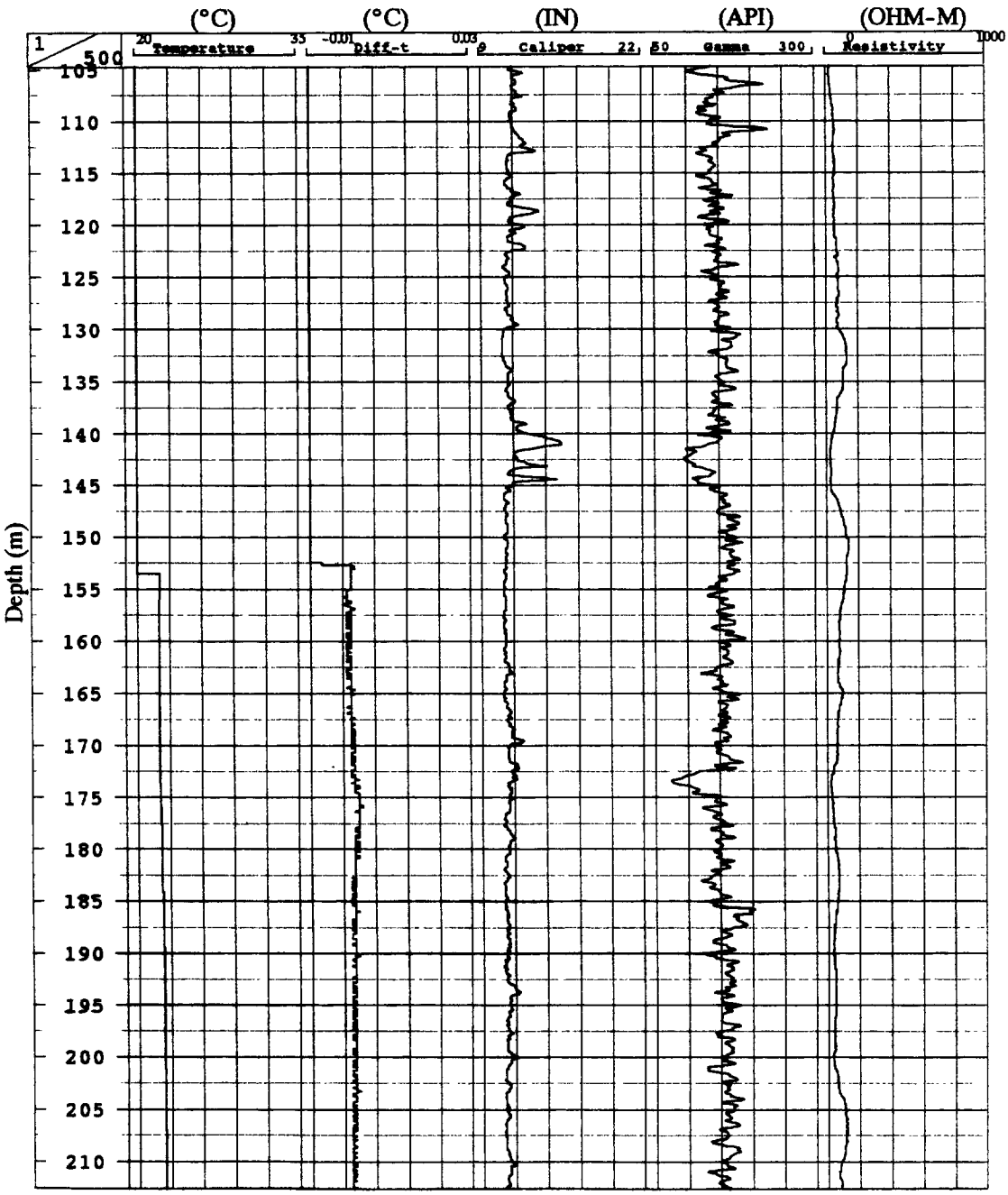

Figure HC-8.7. HC-8 temperature, differential temperature, caliper, natural gamma and guard resistivity logs (continued).

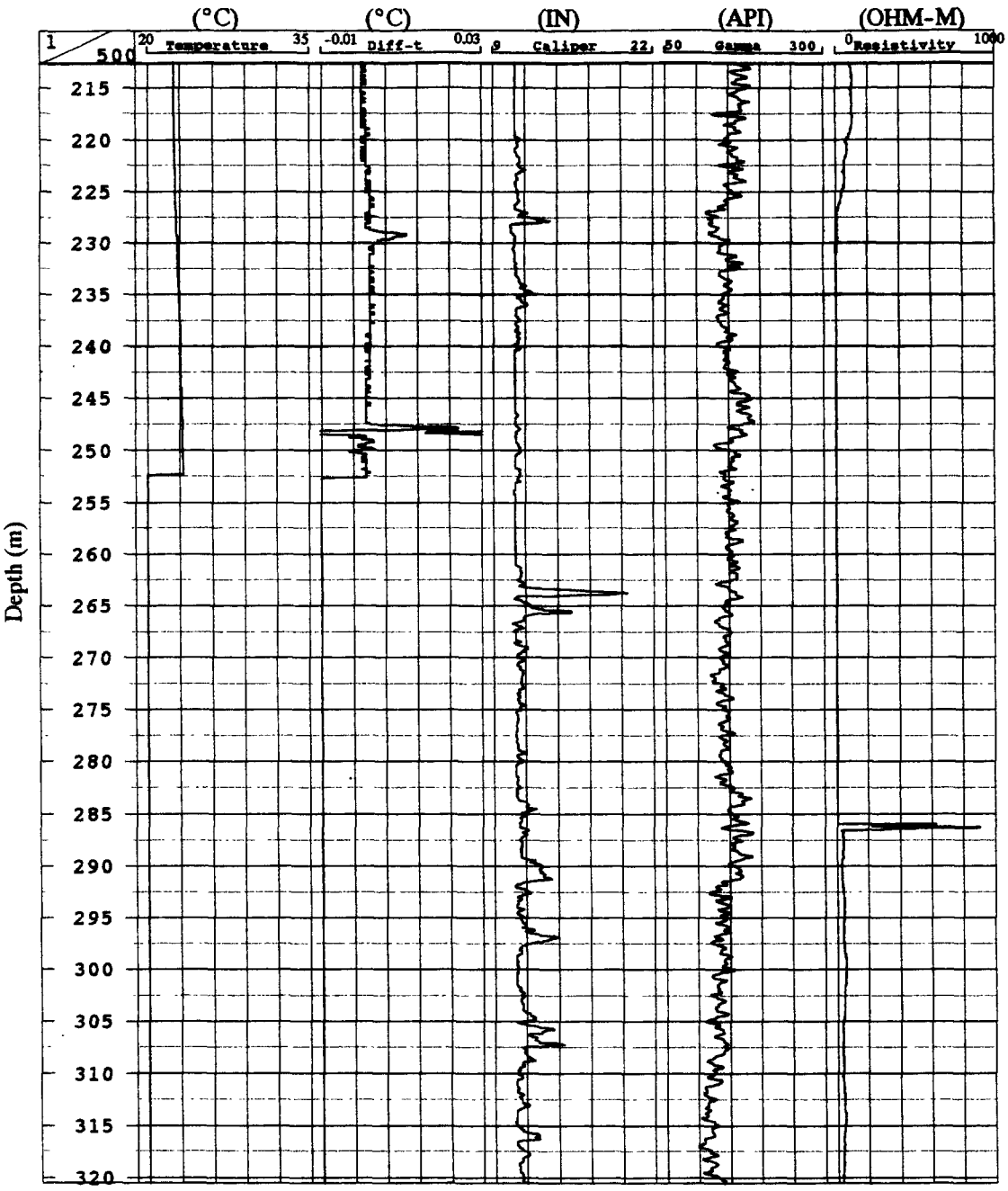

Figure HC-8.7. HC-8 temperature, differential temperature, caliper, natural gamma and guard resistivity logs (continued).

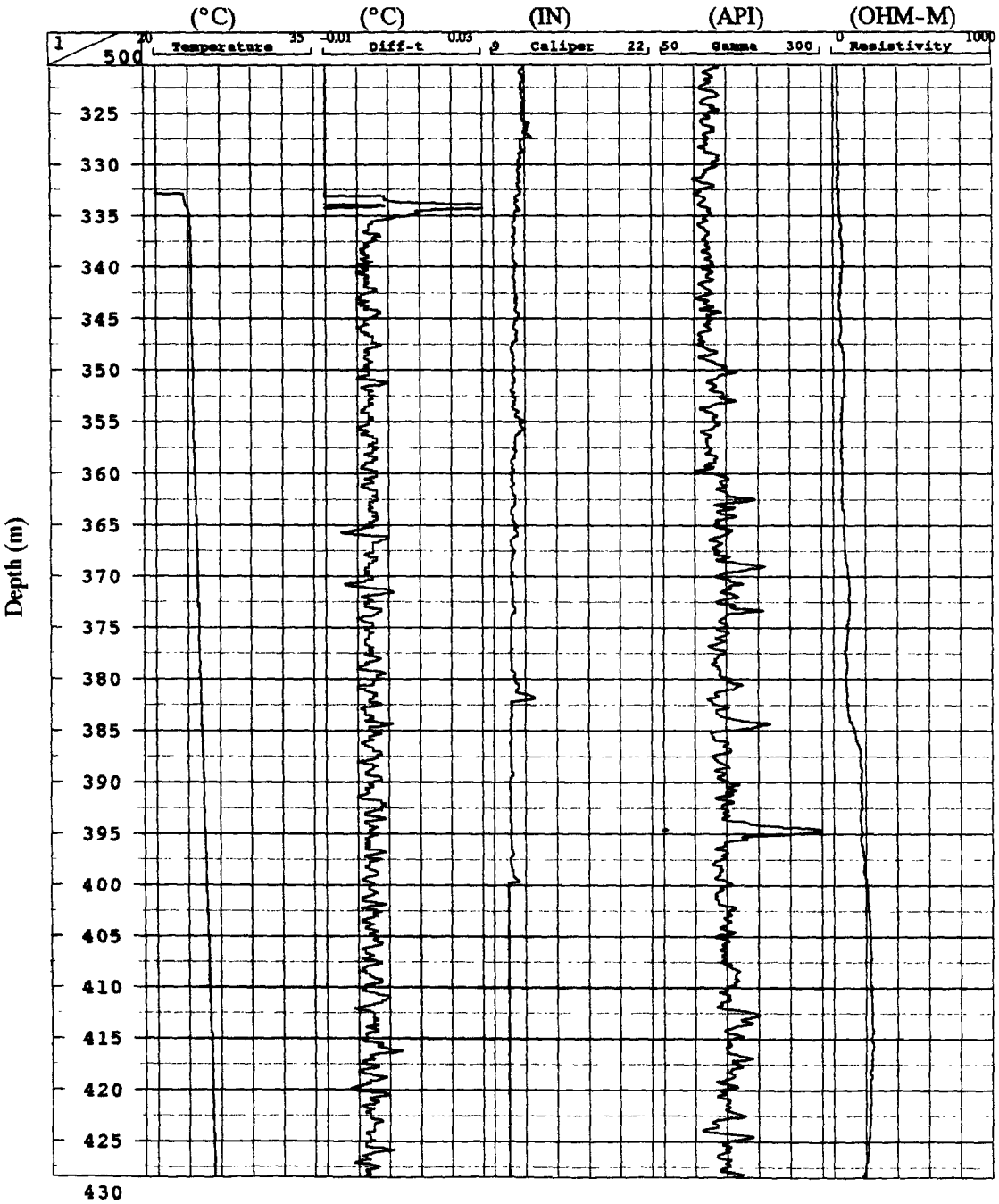

Figure HC-8.7. HC-8 temperature, differential temperature, caliper, natural gamma and guard resistivity logs (continued).

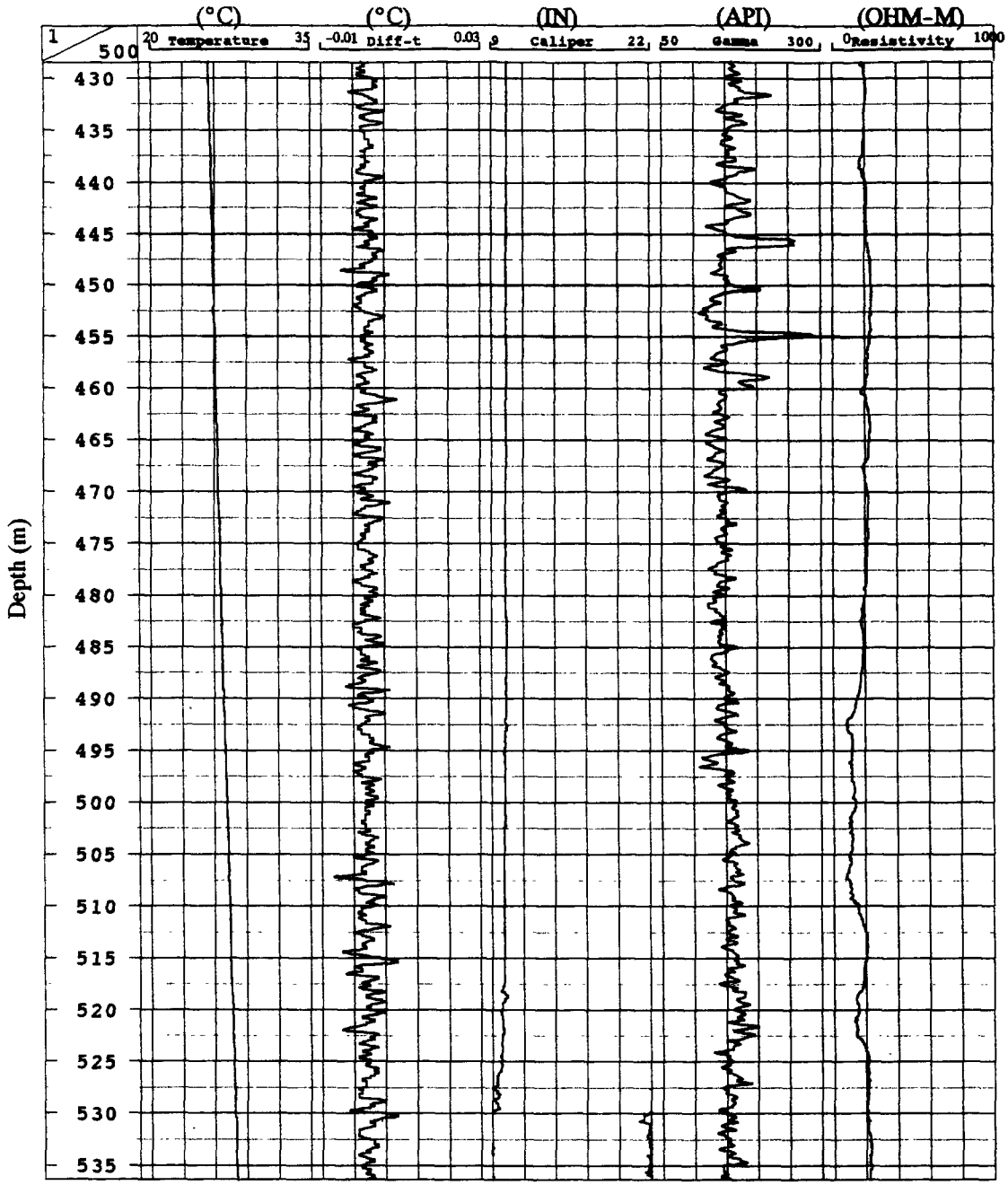

Figure HC-8.7. HC-8 temperature, differential temperature, caliper, natural gamma and guard resistivity logs (continued).

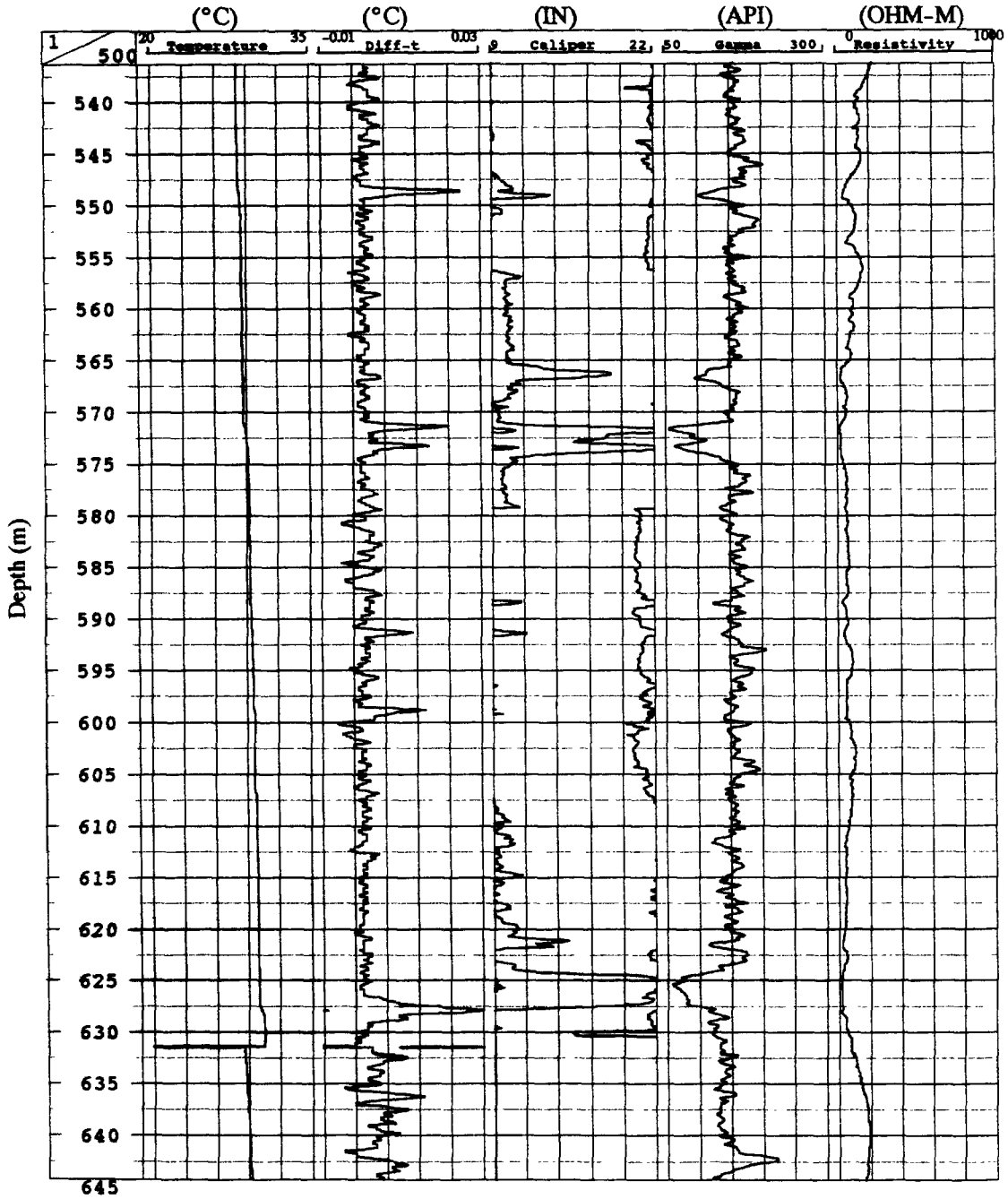

Figure HC-8.7. HC-8 temperature, differential temperature, caliper, natural gamma and guard resistivity logs (continued).

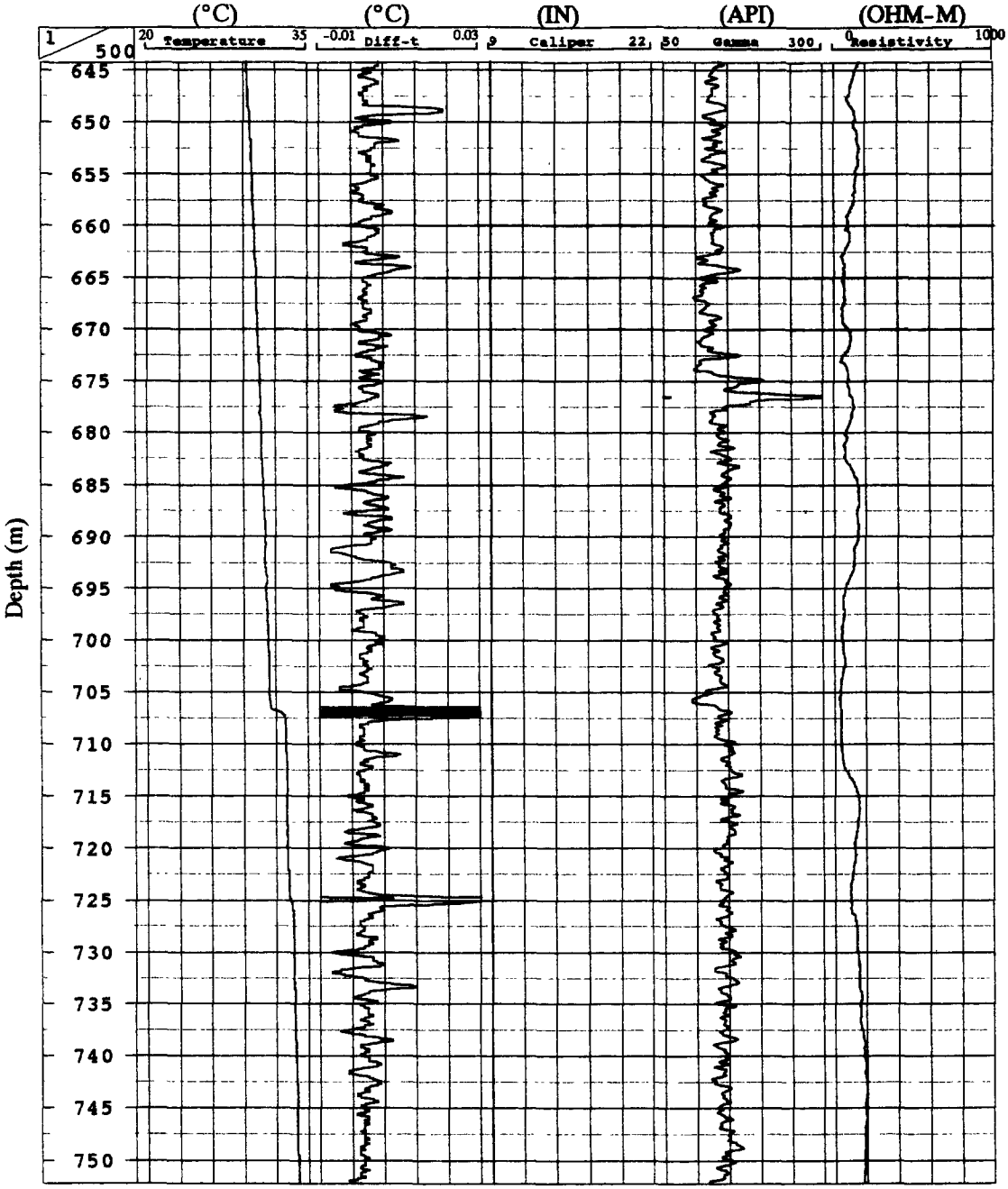

Figure HC-8.7. HC-8 temperature, differential temperature, caliper, natural gamma and guard resistivity logs (continued).

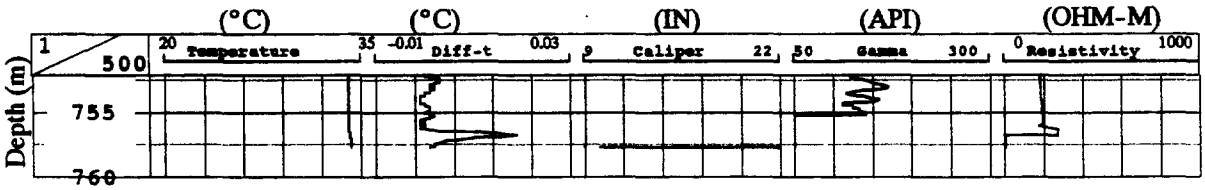

Figure HC-8.7. HC-8 temperature, differential temperature, caliper, natural gamma and guard resistivity logs (continued).

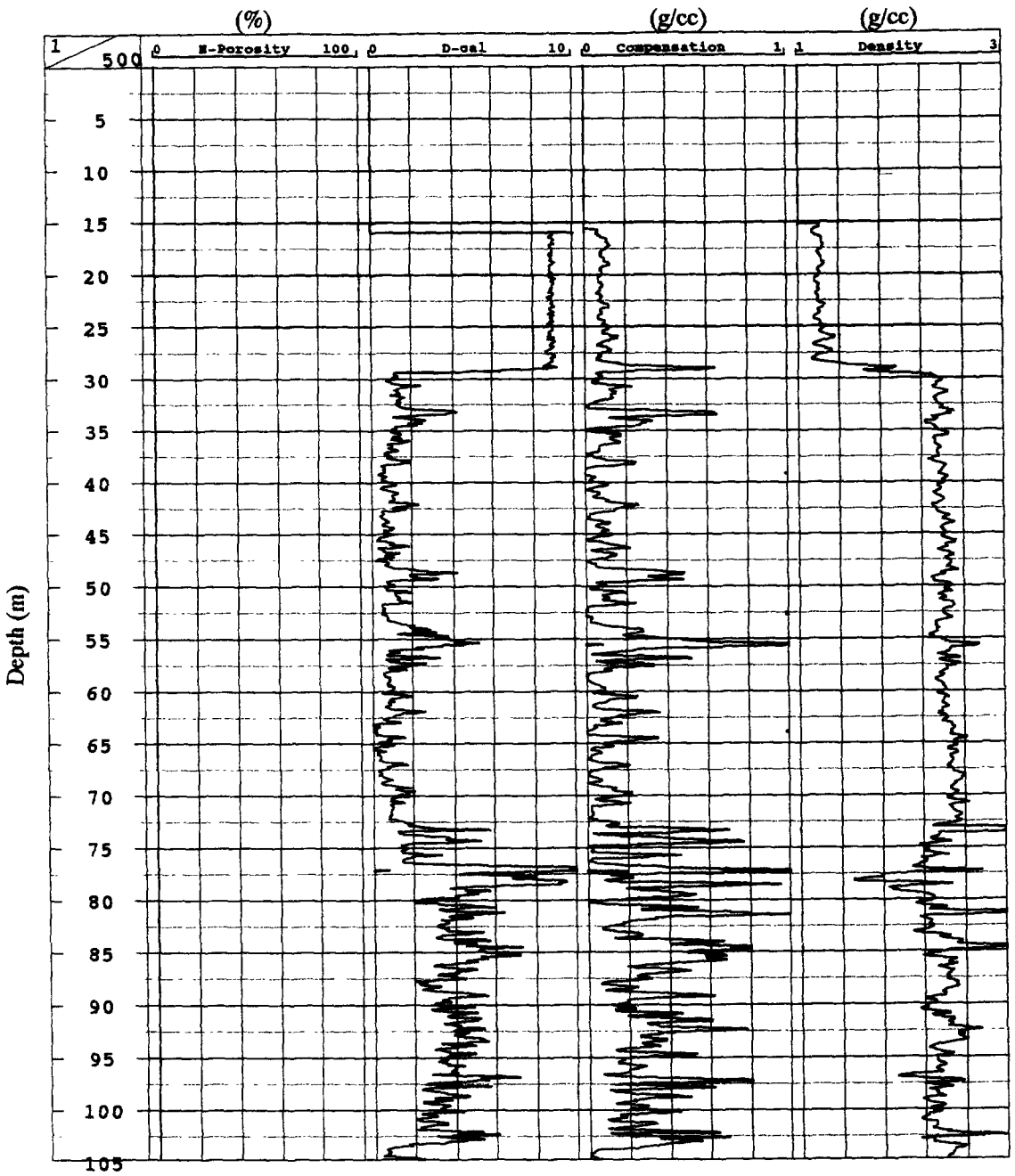

Figure HC-8.8. HC-8 neutron porosity, density calibration, density compensation and density logs.

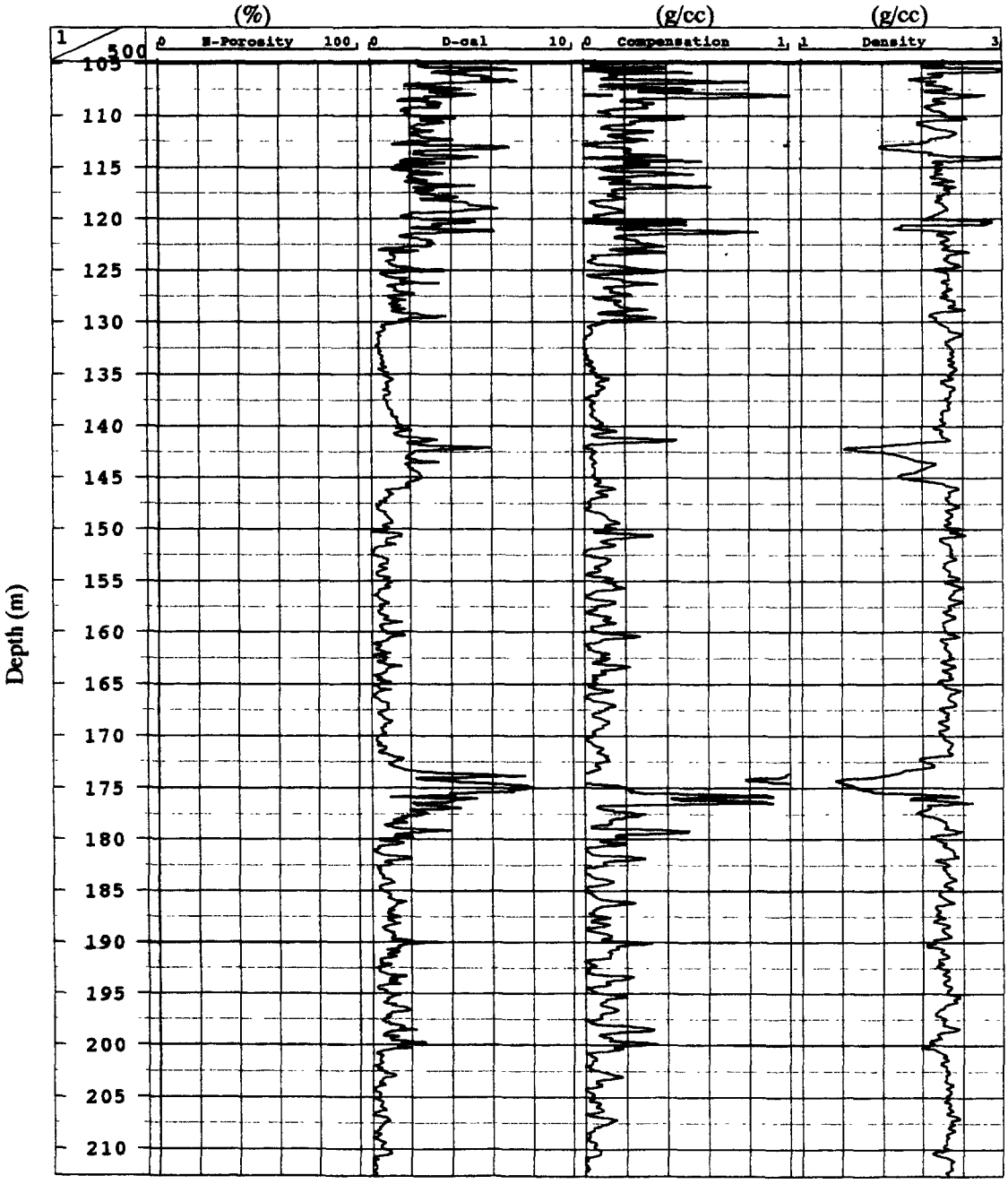

Figure HC-8.8. HC-8 neutron porosity, density calibration, density compensation and density logs (continued).

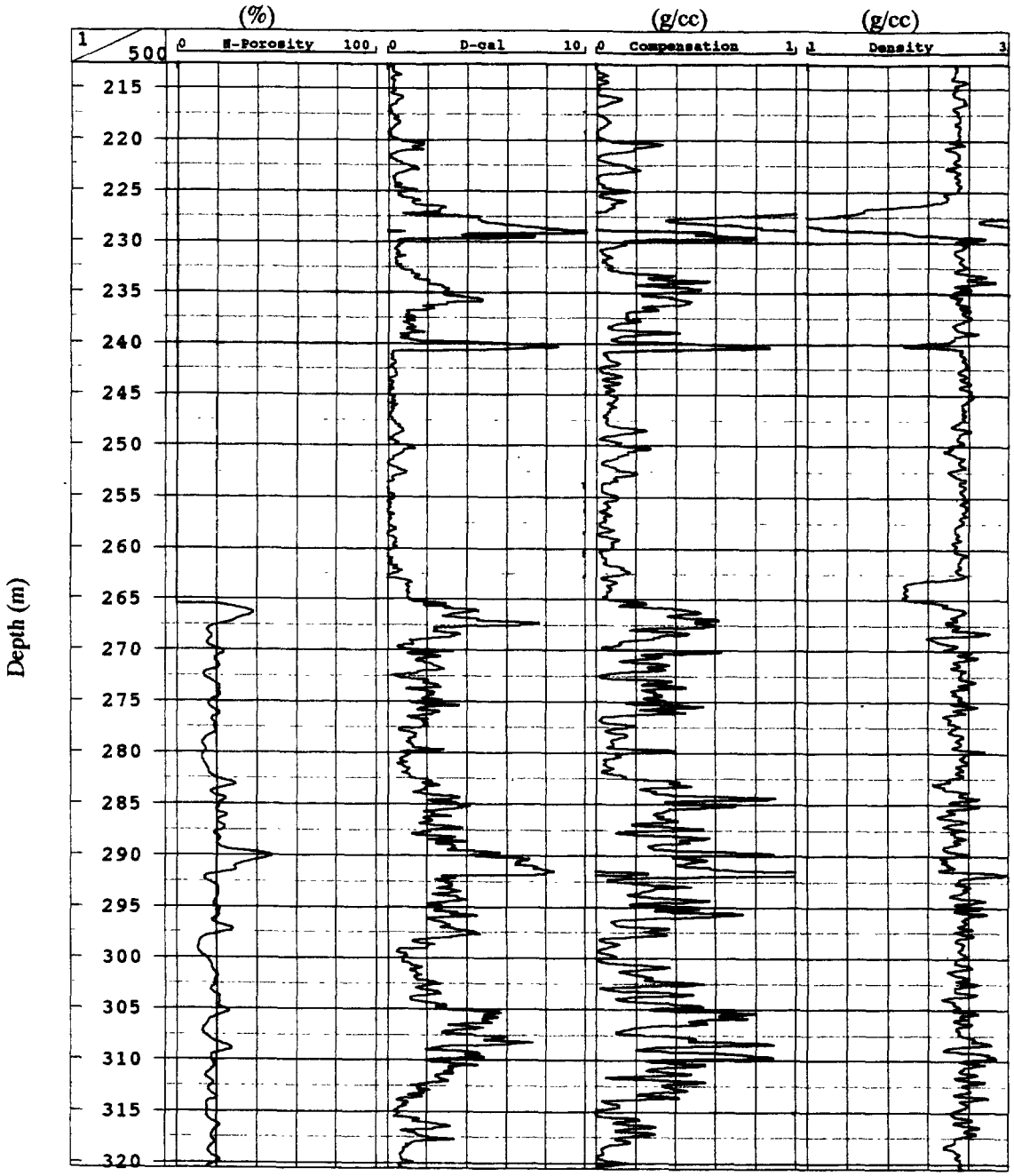

Figure HC-8.8. HC-8 neutron porosity, density calibration, density compensation and density logs (continued).

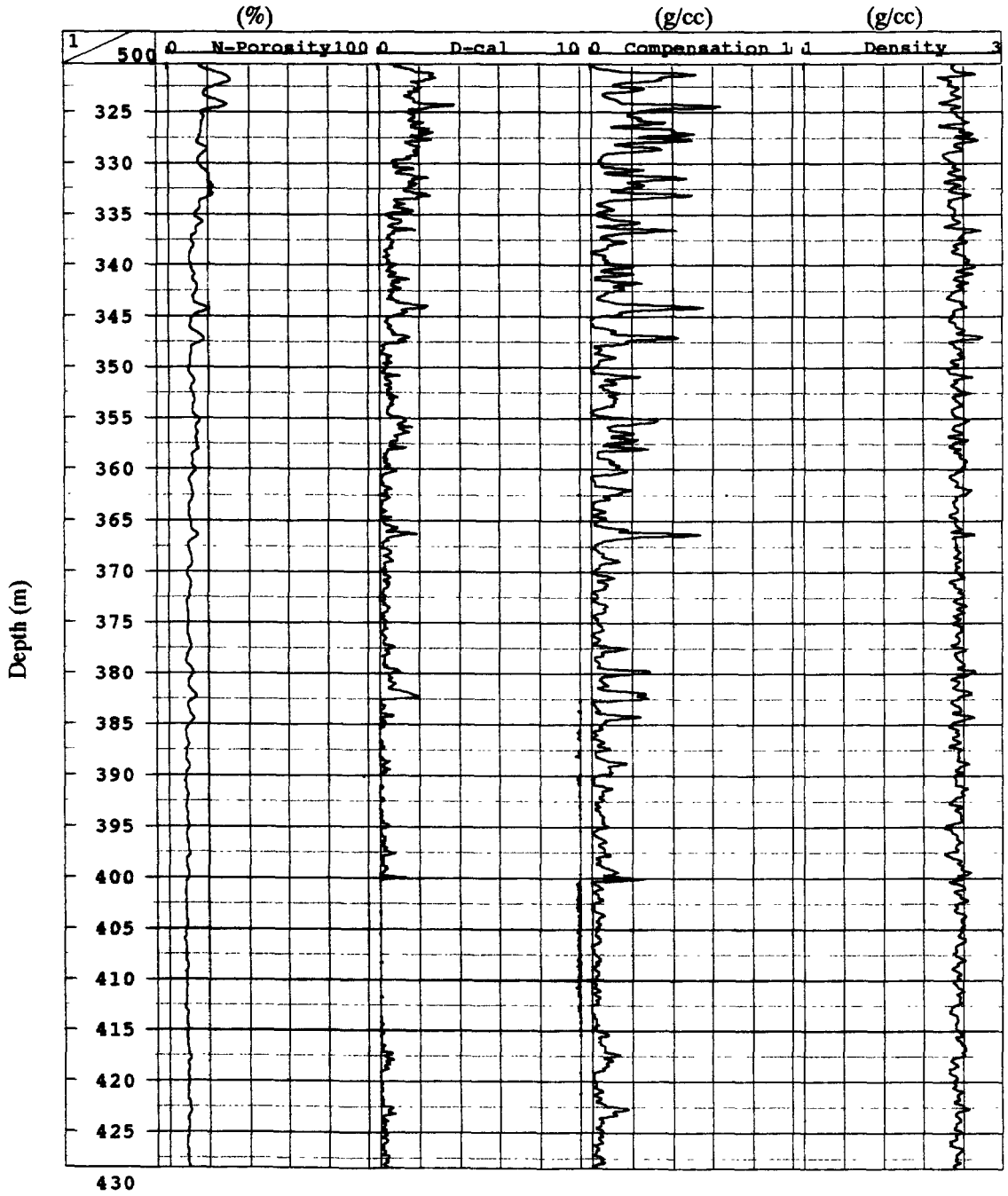

Figure HC-8.8. HC-8 neutron porosity, density calibration, density compensation and density logs (continued).

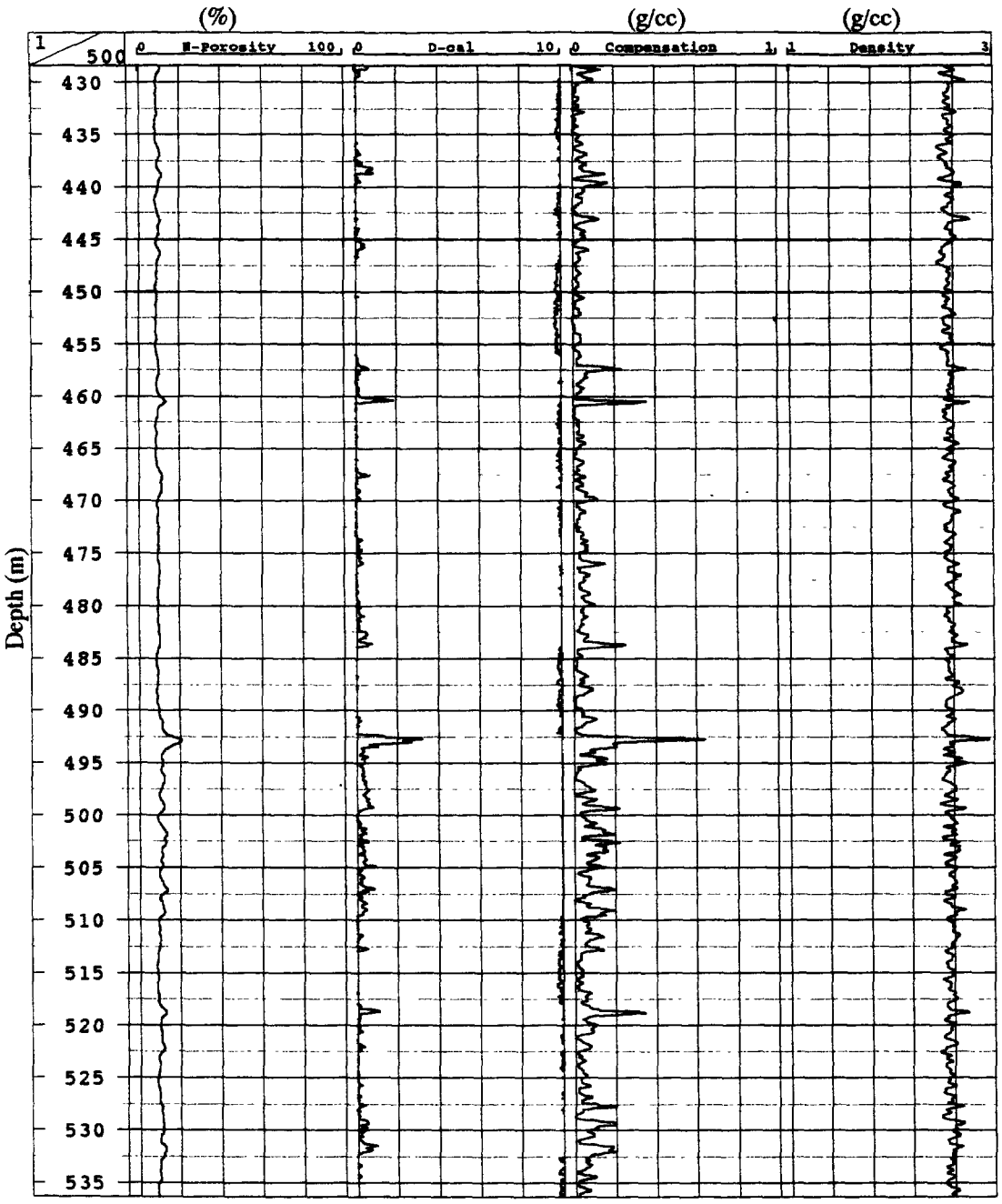

Figure HC-8.8. HC-8 neutron porosity, density calibration, density compensation and density logs (continued).

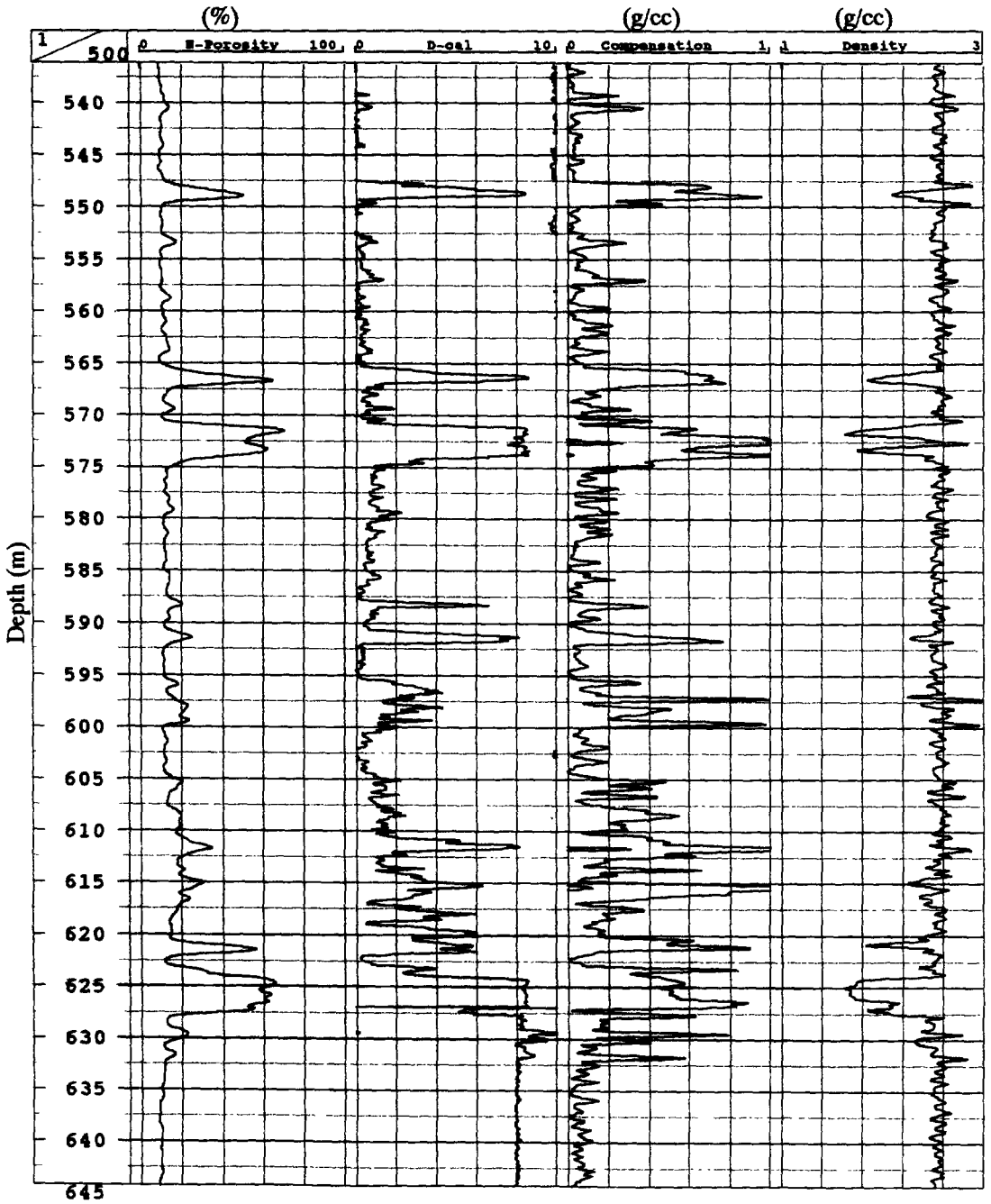

Figure HC-8.8. HC-8 neutron porosity, density calibration, density compensation and density logs (continued).

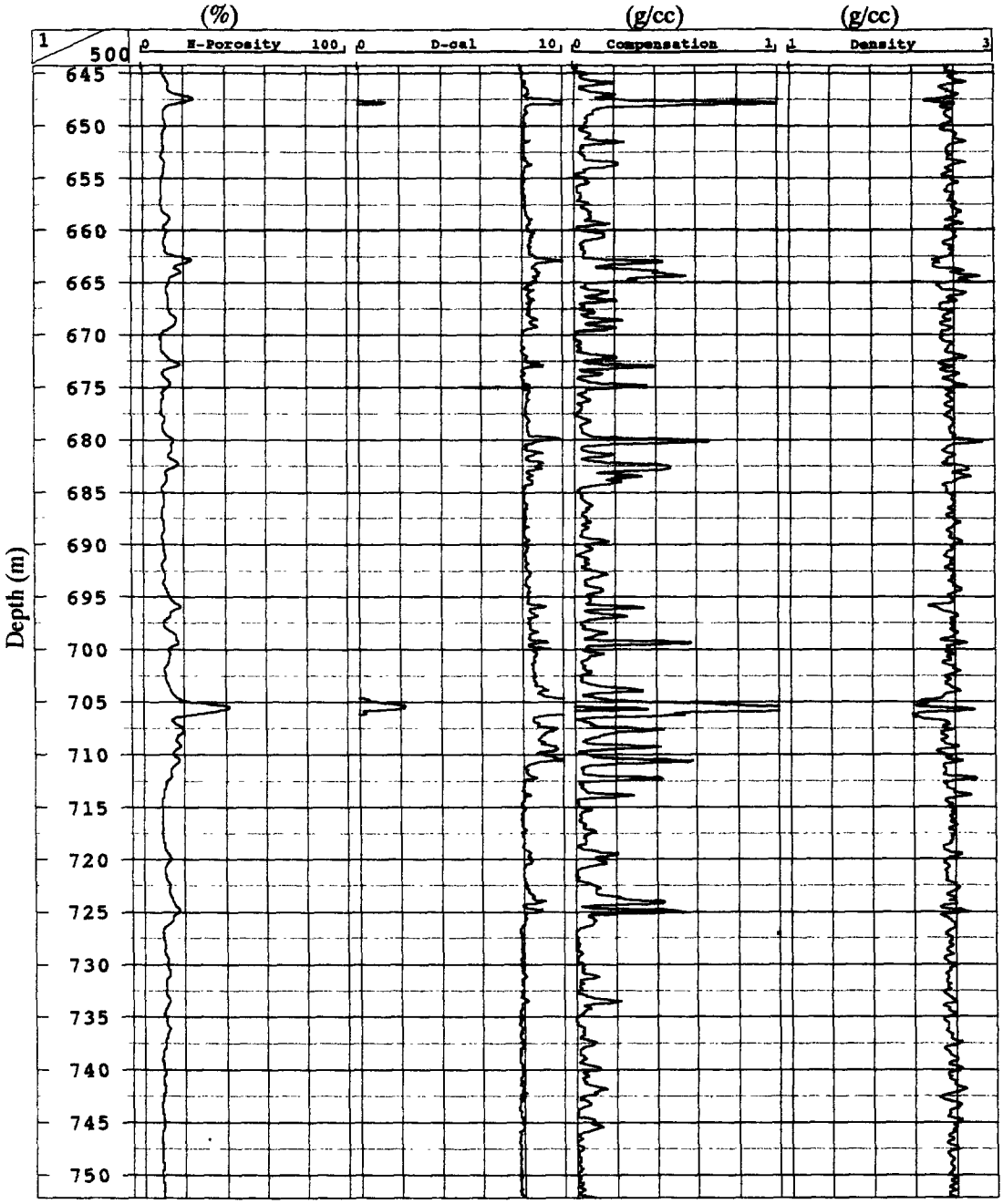

Figure HC-8.8. HC-8 neutron porosity, density calibration, density compensation and density logs (continued).

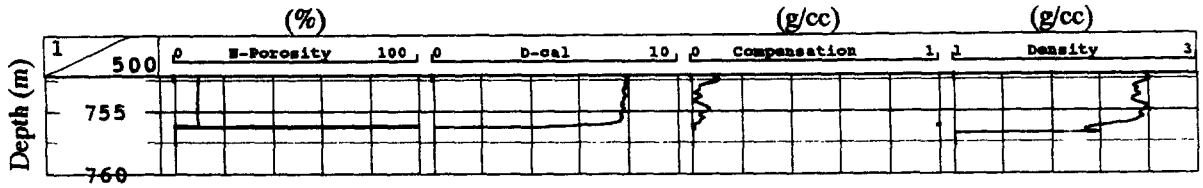

Figure HC-8.8. HC-8 neutron porosity, density calibration, density compensation and density logs (continued).

PM-1

Available Data

- Slug Test
- Historic Water Level
- Fracture Interpretation
- Caliper Log
- Spontaneous Potential Log
- Resistivity Log
- Temperature Log
- Gamma-Gamma Log
- Natural Gamma Log
- Neutron Log

Analysis	
Date:	3/24/1963
Method: Bouwer & Rice, 1976	
H (m):	77.7
R_c (m):	0.15
R_w (m):	0.15
L_w (m):	77.7
D (m):	1,000
A:	8.88
B:	2.60
L_N (R_c/R_w):	4.46
L_N ($D-H/R_w$):	6.0
Hydraulic Conductivity (cm/sec):	1.87E-05

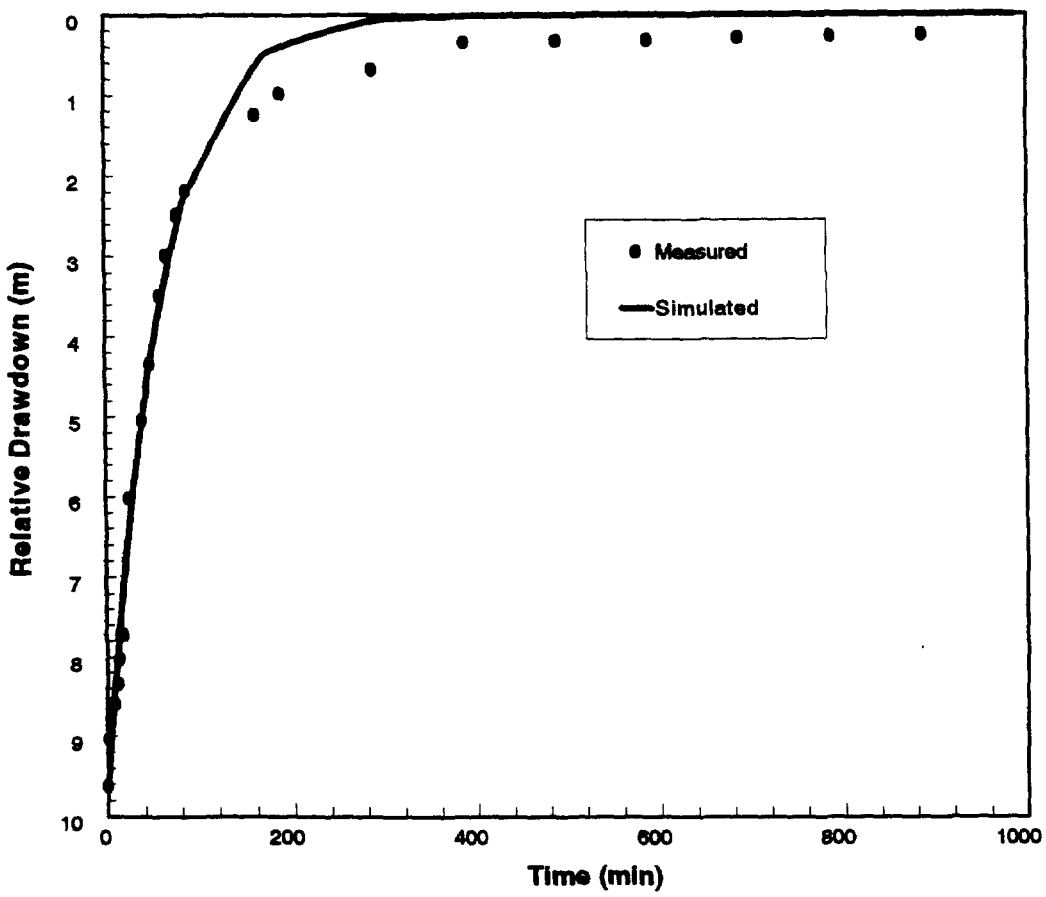

Figure PM-1.1. PM-1 slug test analysis (1963).

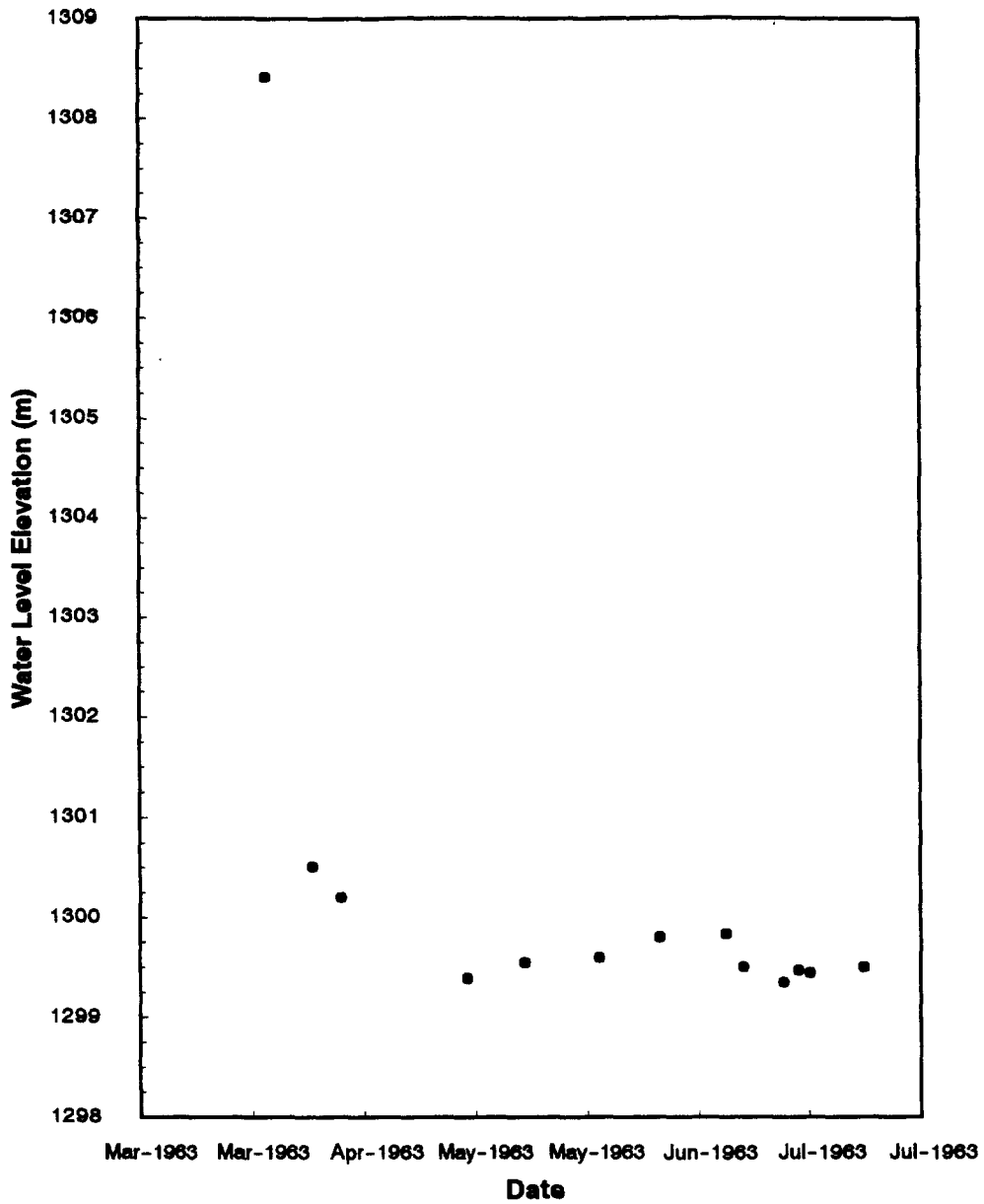

Figure PM-1.2. PM-1 water level vs. time.

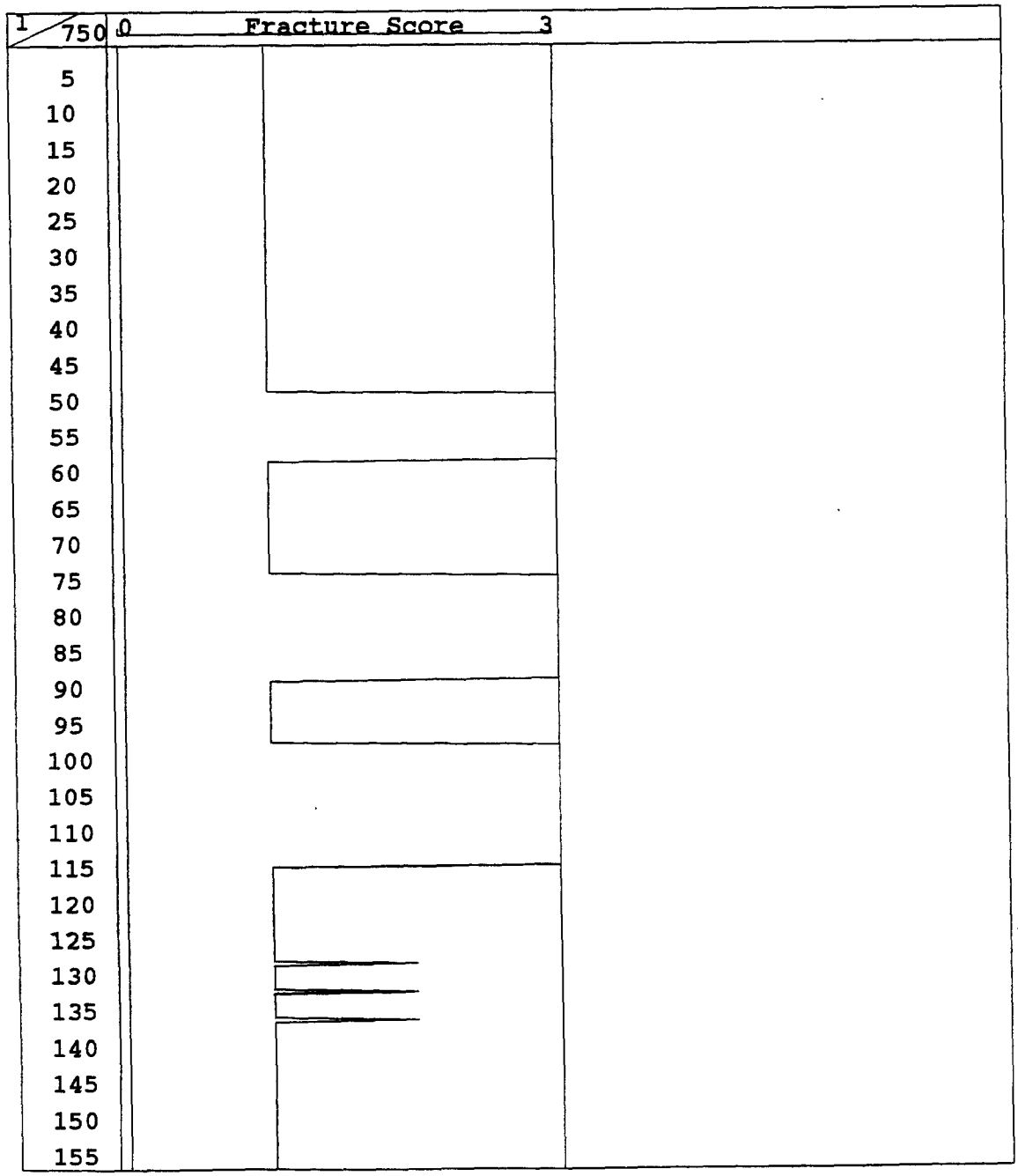

Figure PM-1.3. PM-1 fracture interpretation scores (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault).

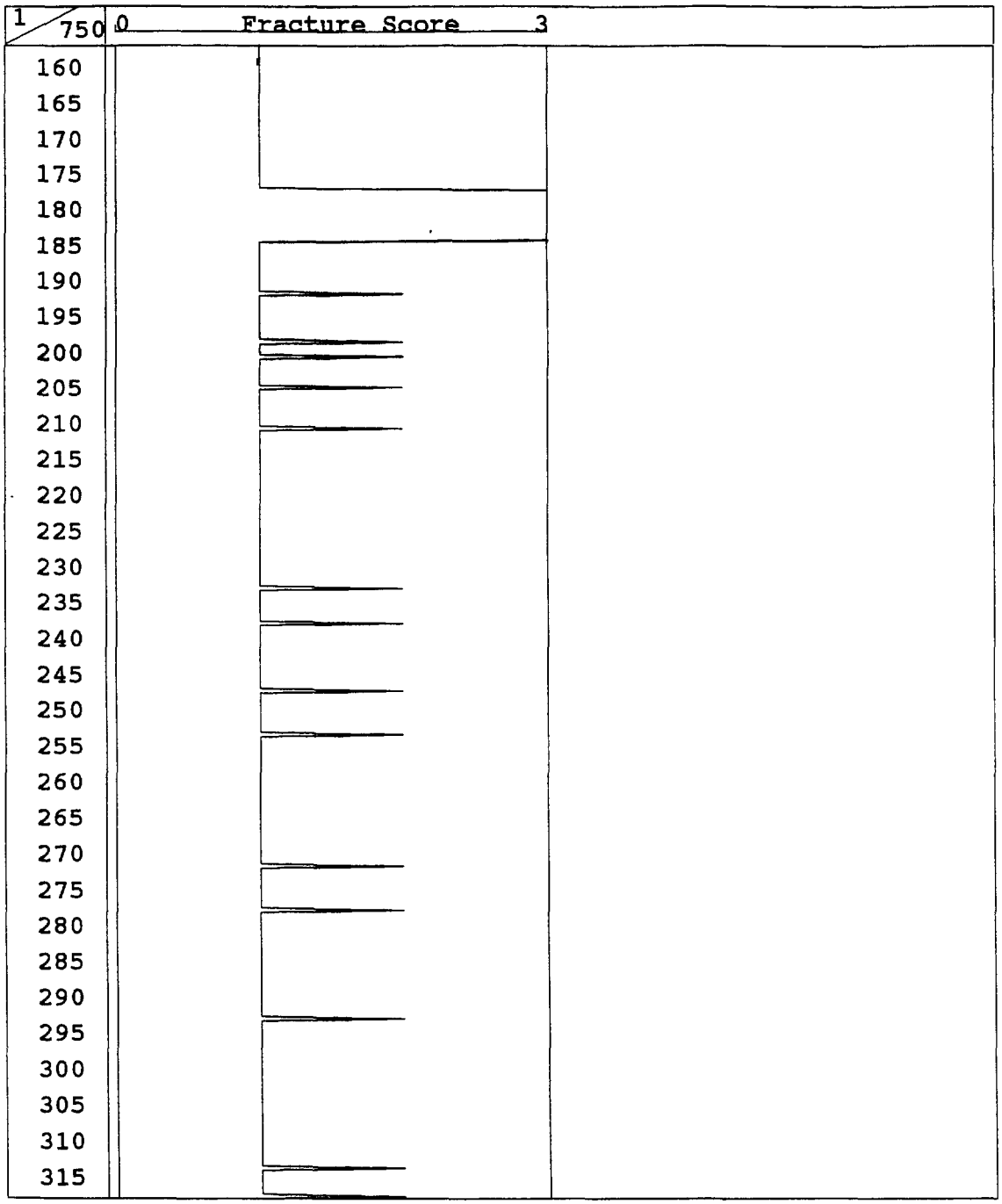

Figure PM-1.3. PM-1 fracture interpretation scores (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) (continued).

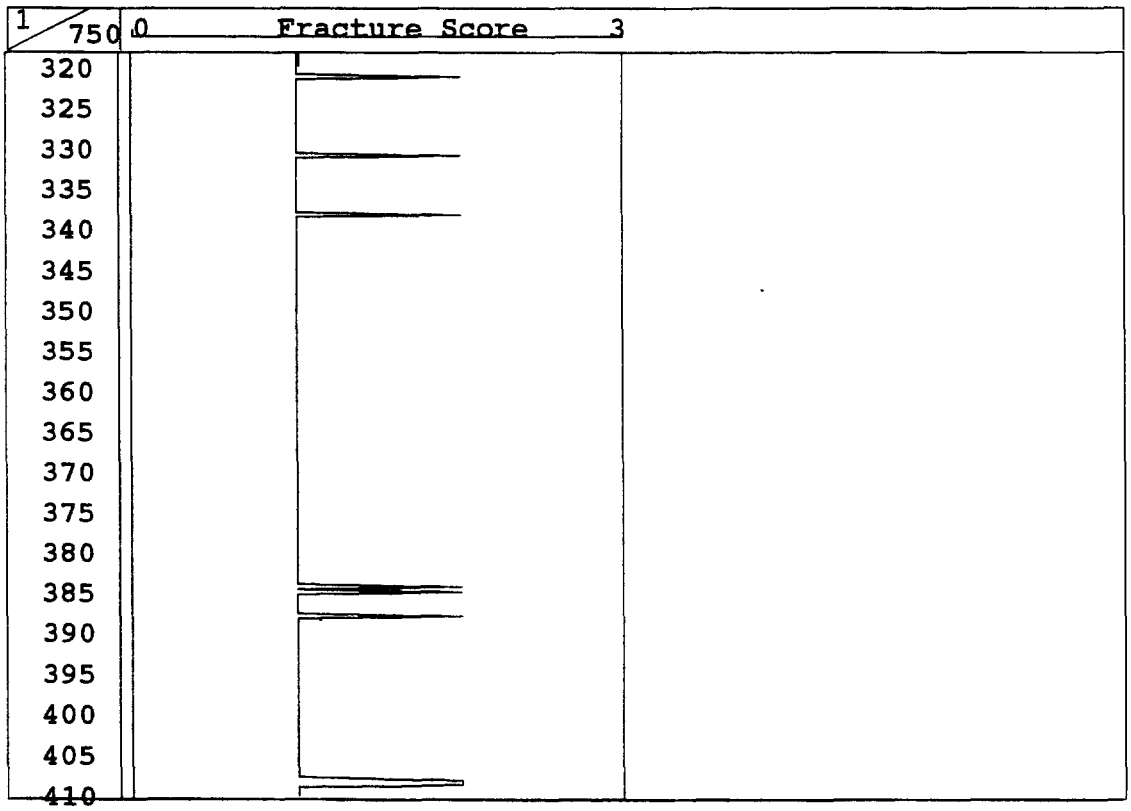

Figure PM-1.3. PM-1 fracture interpretation scores (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) (continued).

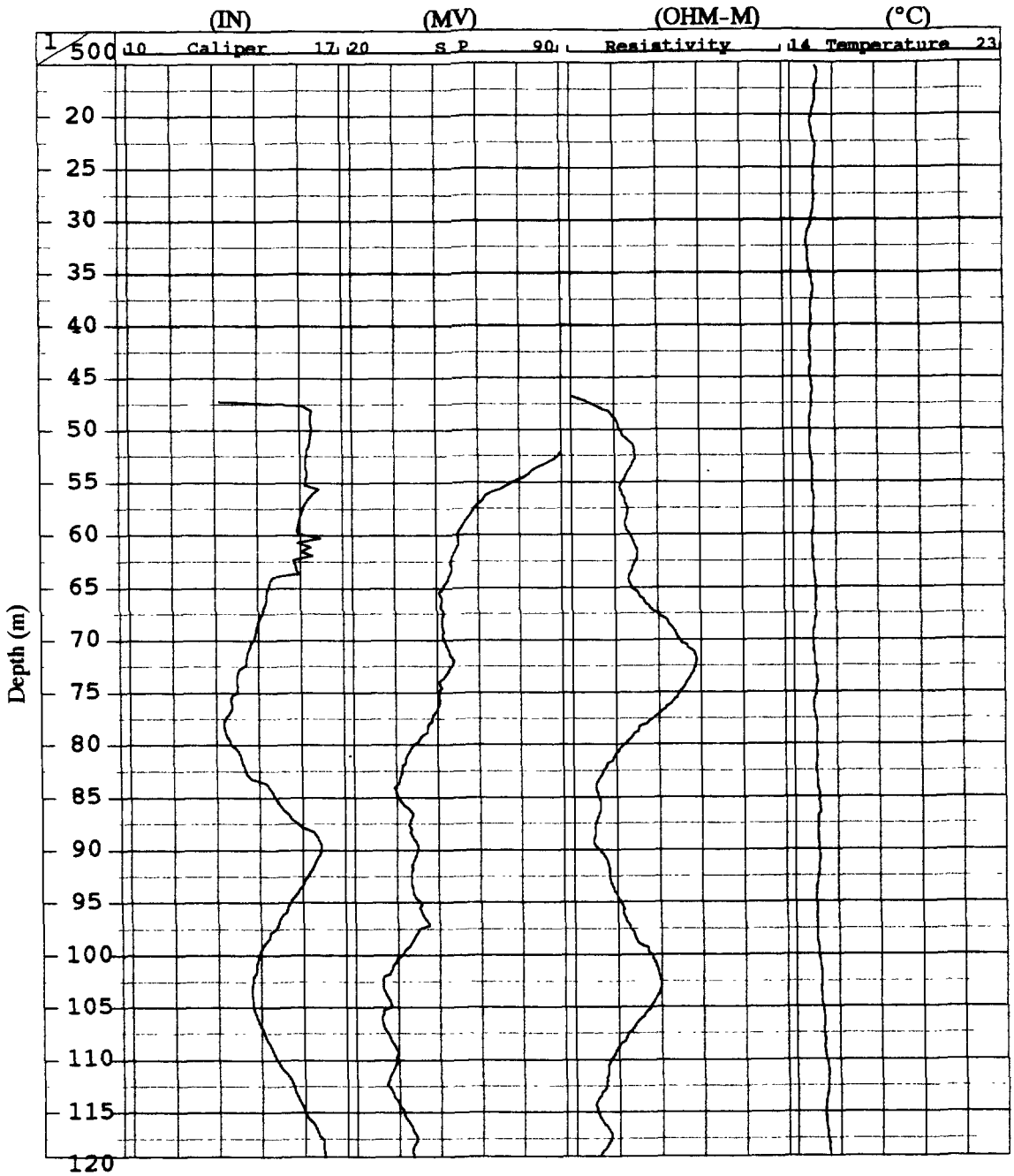

Figure PM-1.4. PM-1 spontaneous potential, resistivity and temperature logs.

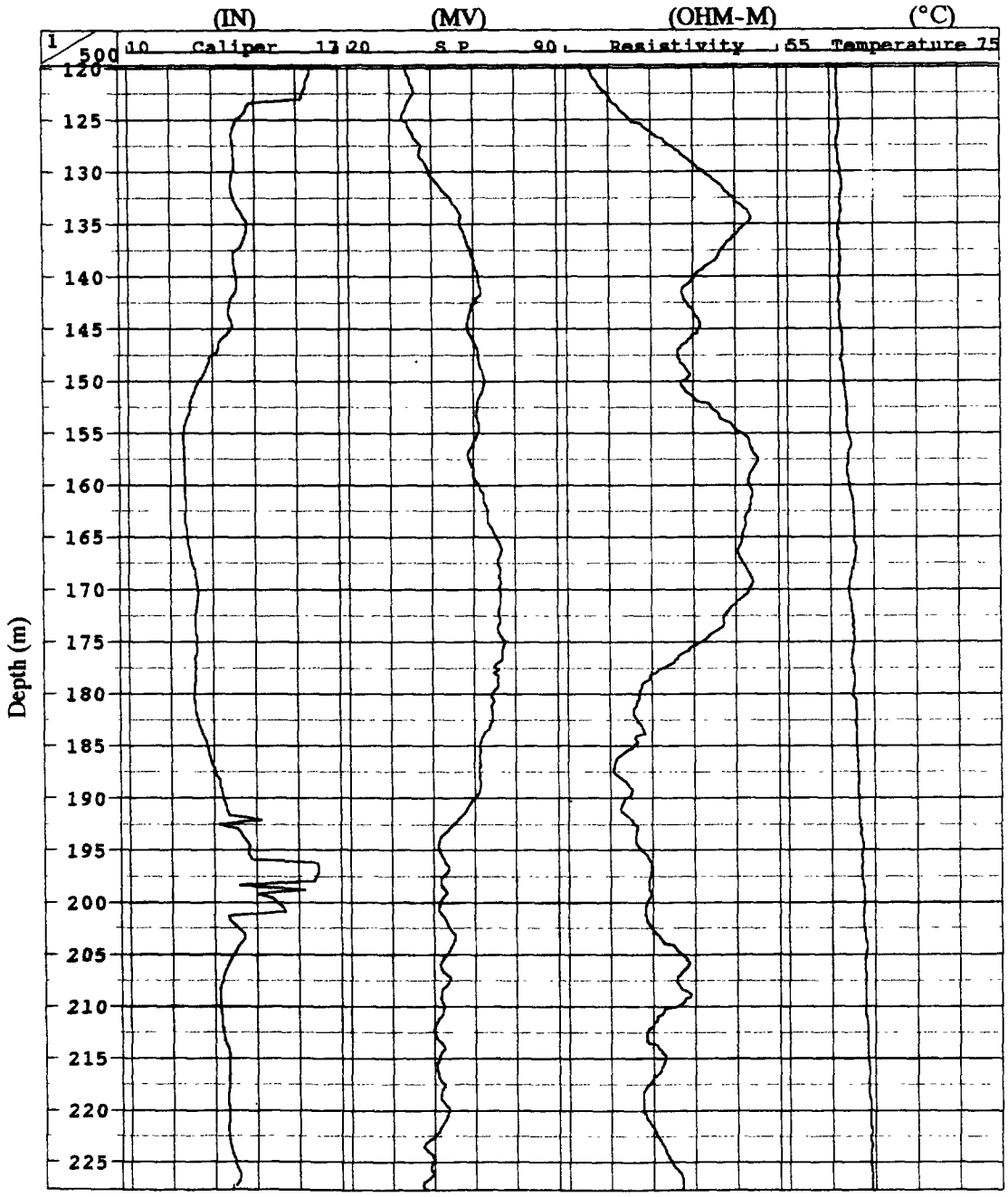

Figure PM-1.4. PM-1 spontaneous potential, resistivity and temperature logs (continued).

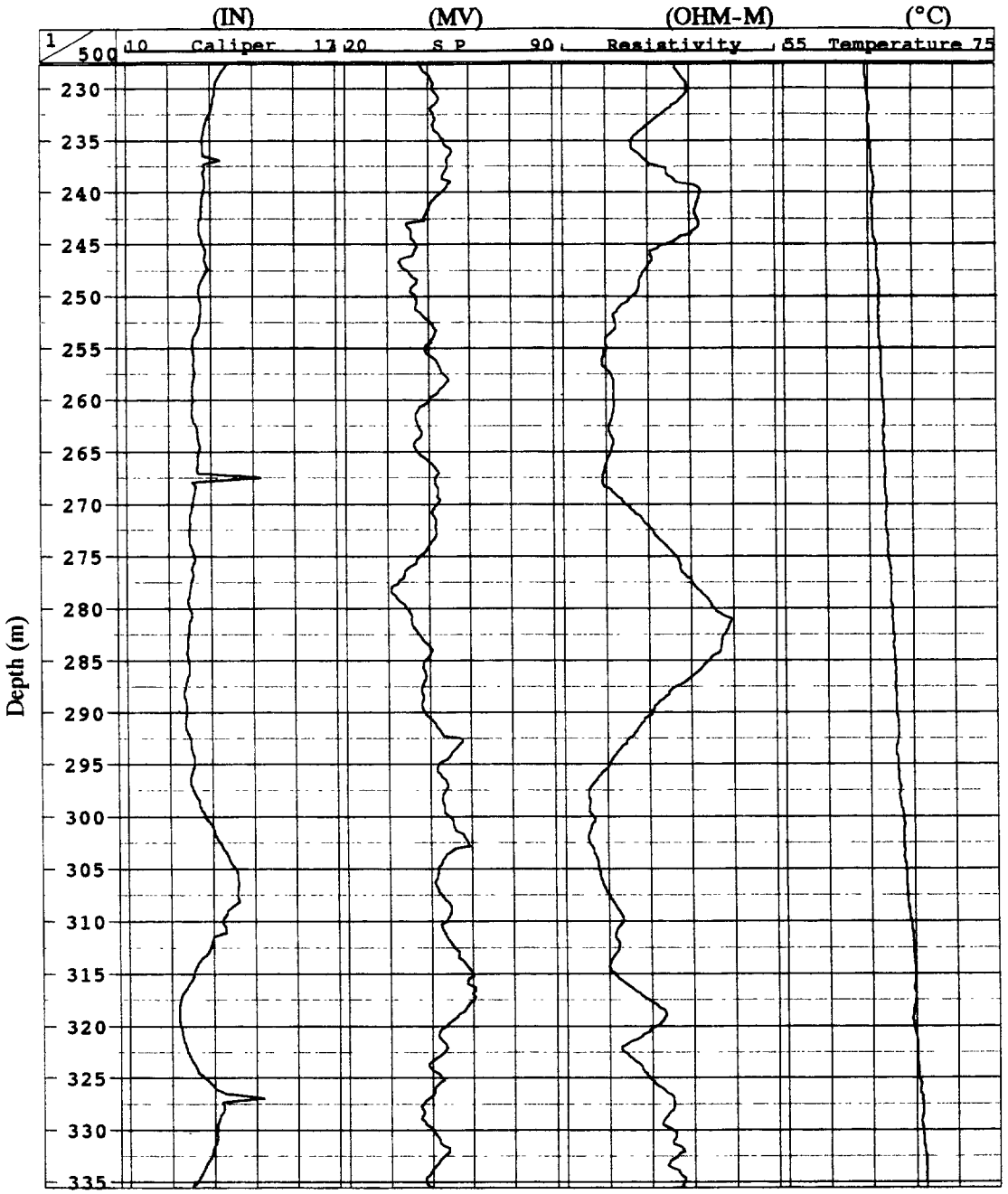

Figure PM-1.4. PM-1 spontaneous potential, resistivity and temperature logs (continued).

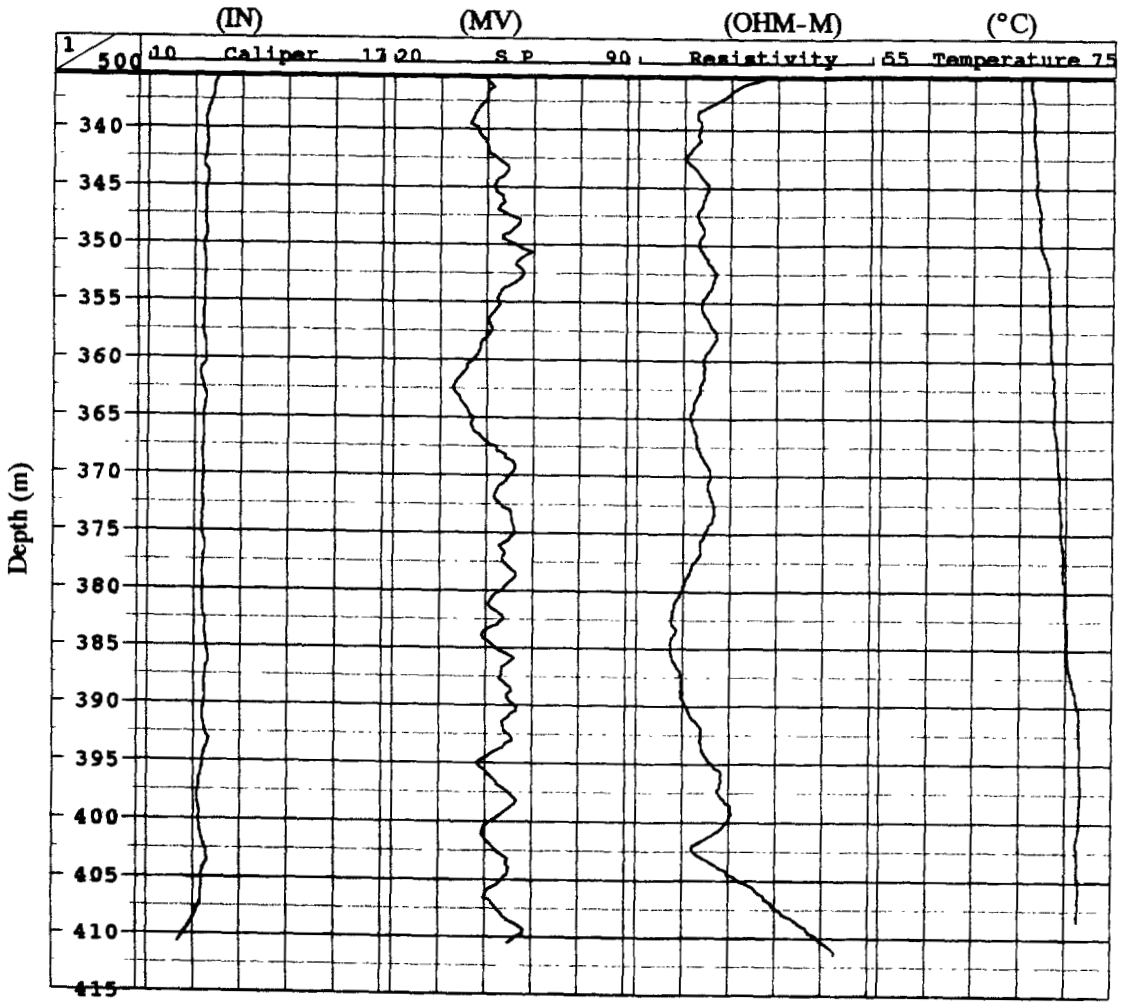

Figure PM-1.4. PM-1 spontaneous potential, resistivity and temperature logs (continued).

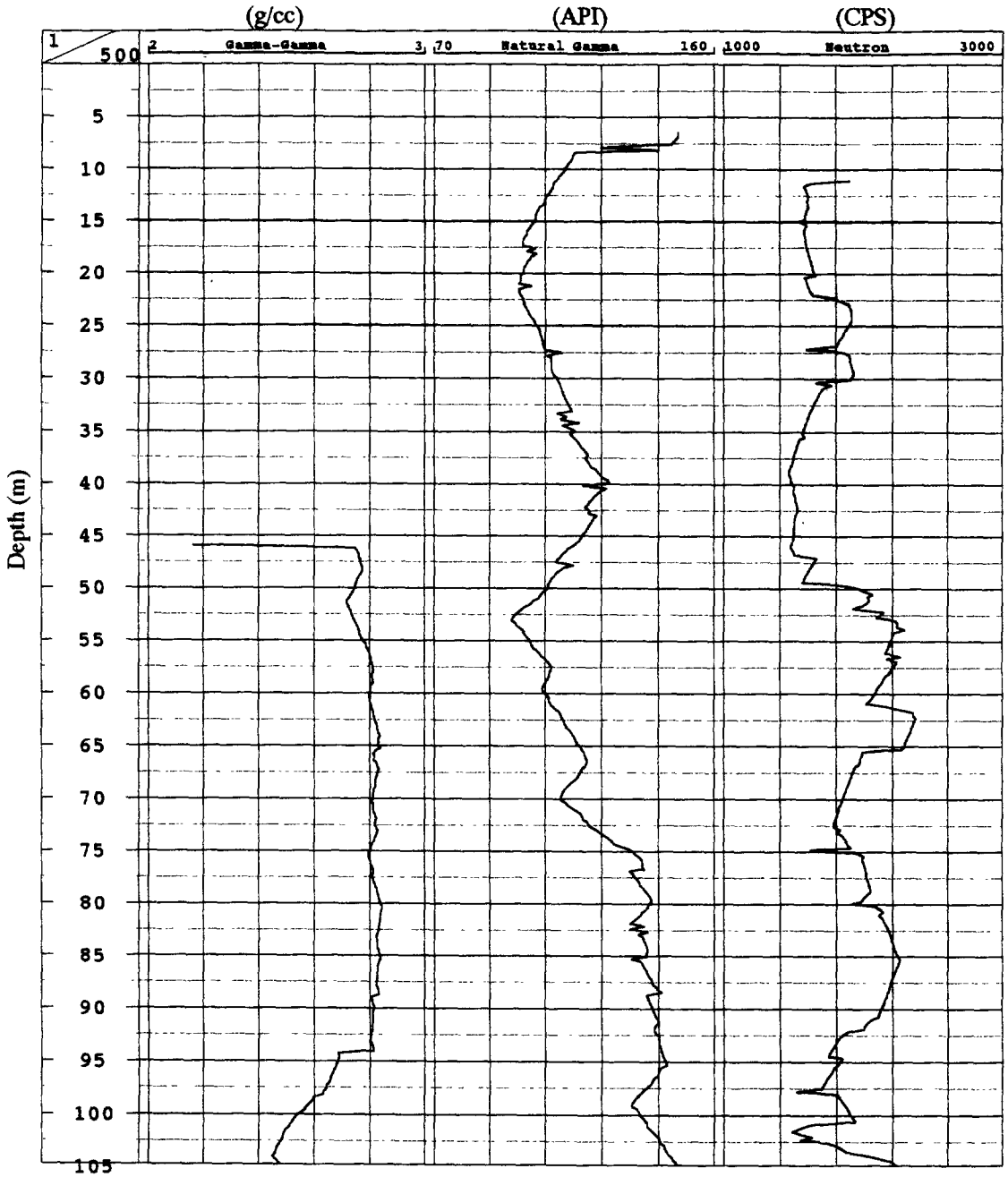

Figure PM-1.5. PM-1 gamma-gamma density, natural gamma and neutron logs.

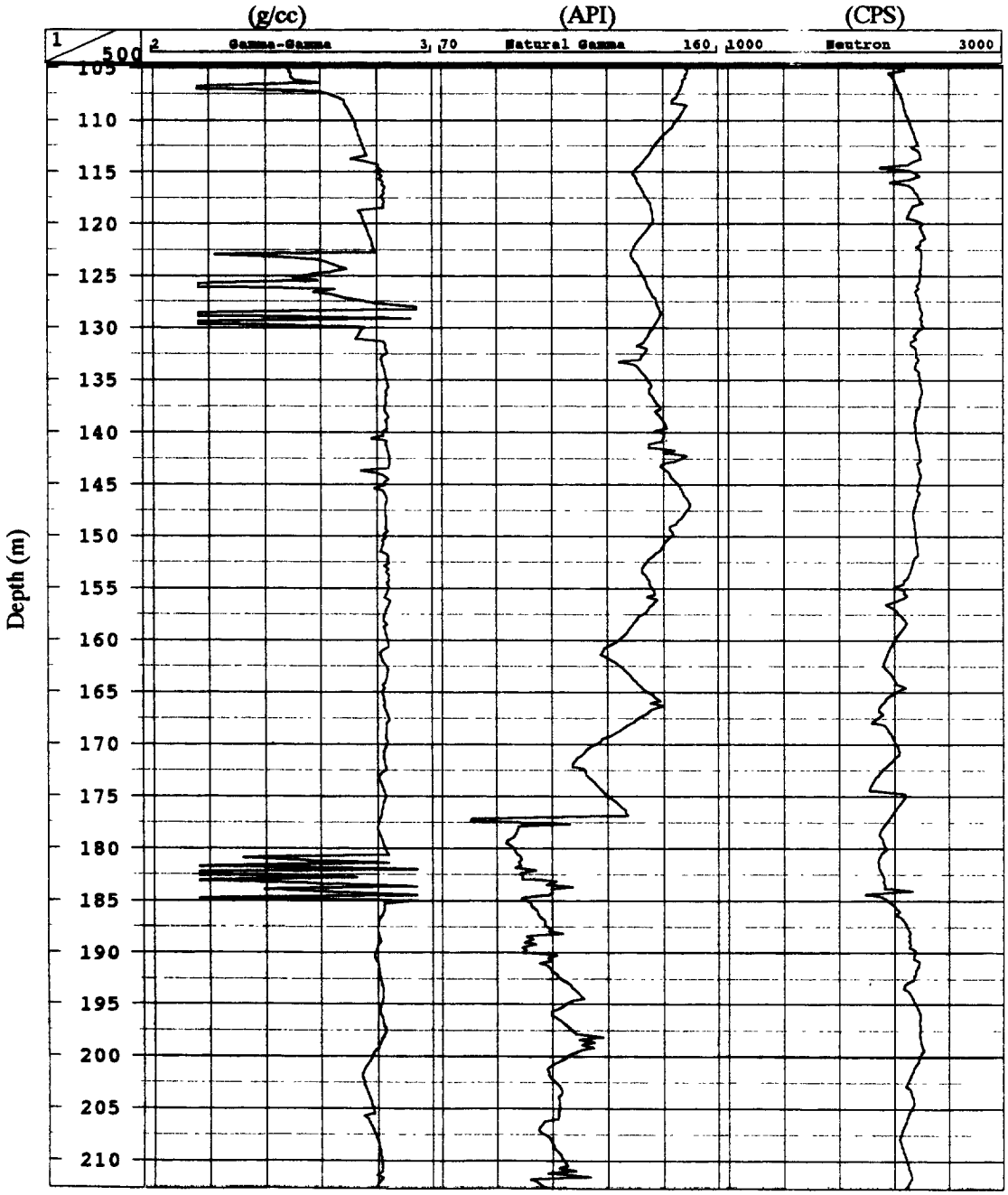

Figure PM-1.5. PM-1 gamma-gamma density, natural gamma and neutron logs (continued).

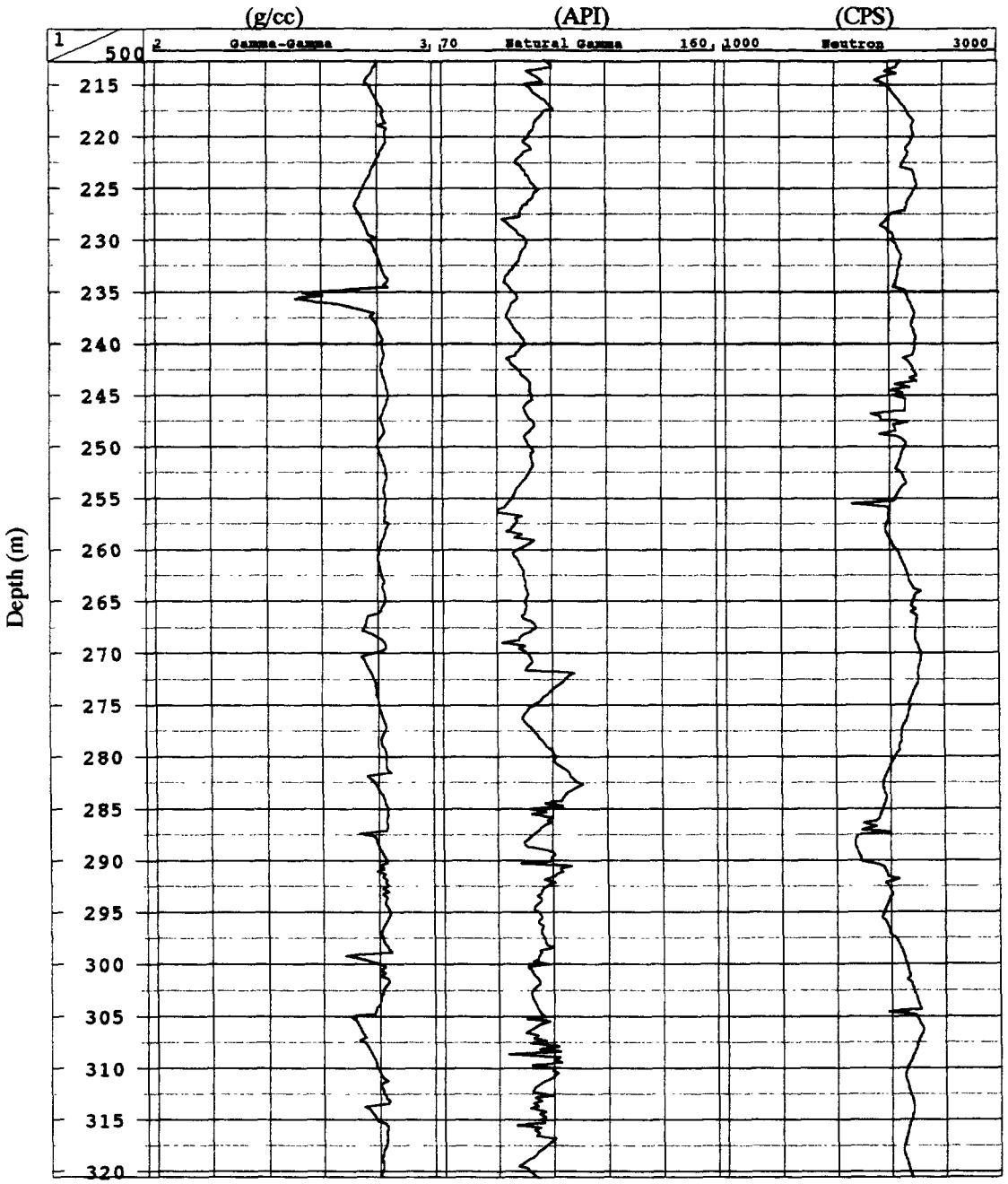

Figure PM-1.5. PM-1 gamma-gamma density, natural gamma and neutron logs (continued).

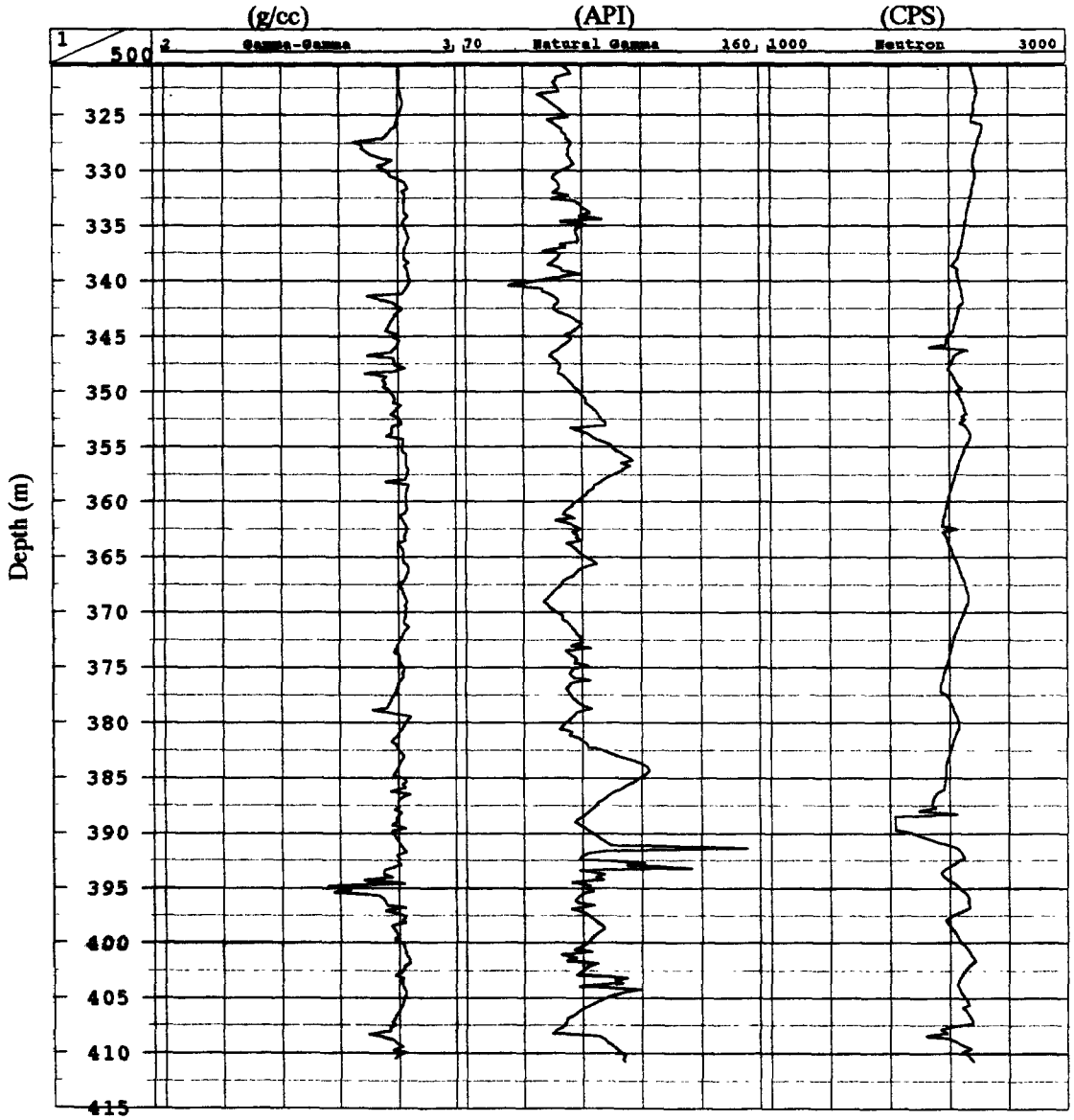

Figure PM-1.5. PM-1 gamma-gamma density, natural gamma and neutron logs (continued).

PM-2

Available Data

- Water Level
- Fracture Interpretation
- Caliper Log
- Spontaneous Potential Log
- Resistivity Log
- Gamma-Gamma Log
- Natural Gamma Log
- Neutron Log

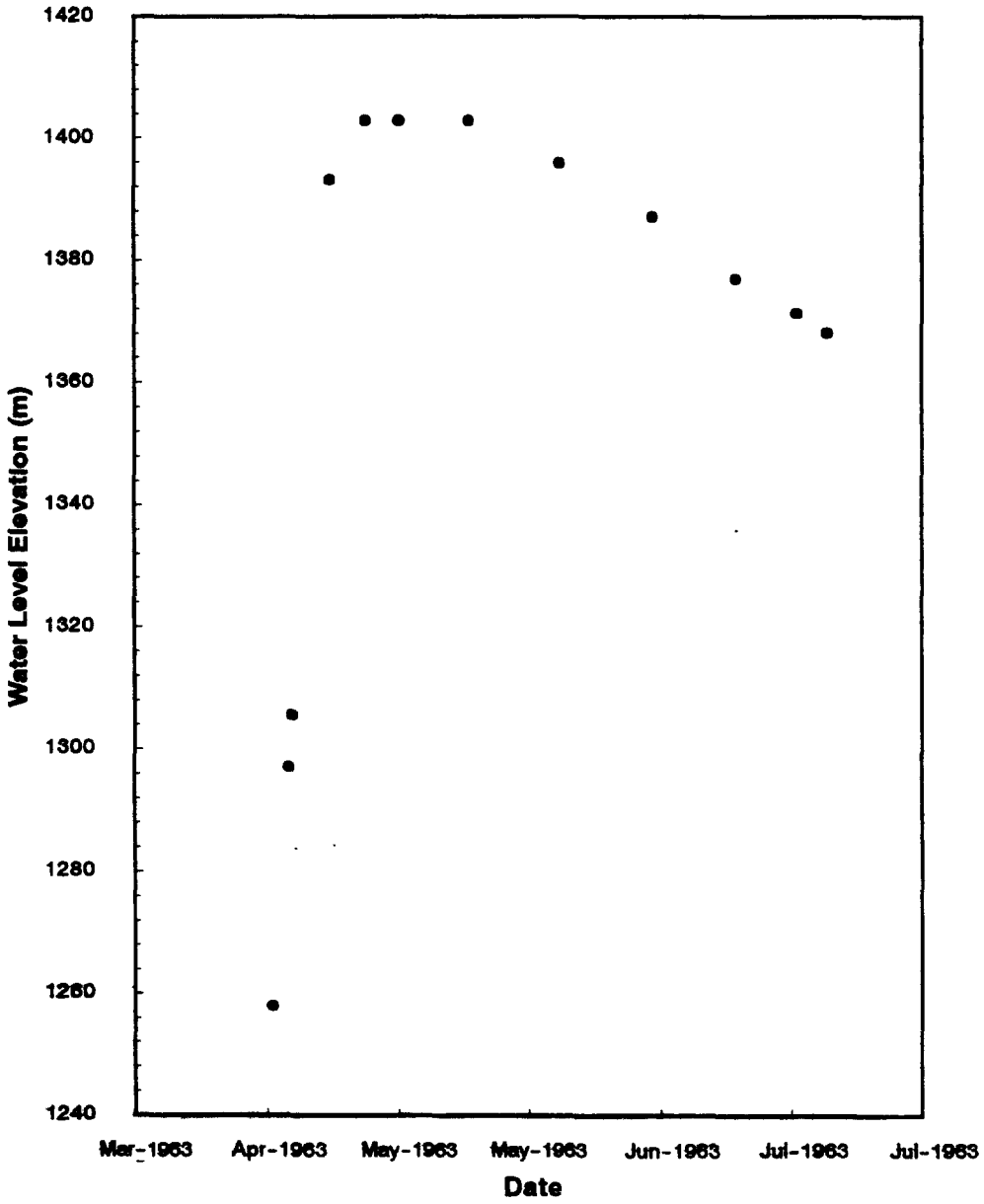

Figure PM-2.1. PM-2 water level vs. time.

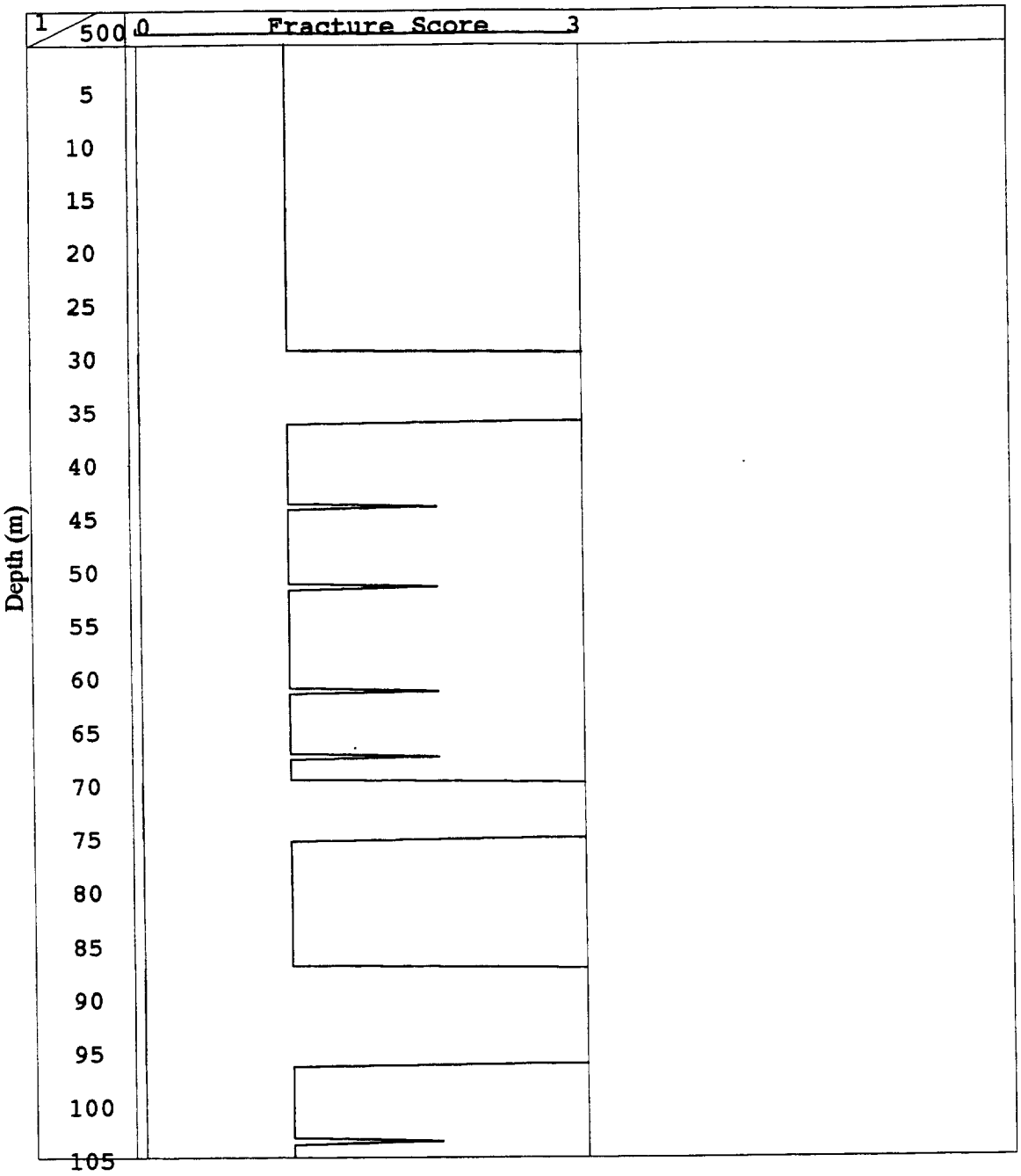

Figure PM-2.2. PM-2 fracture interpretation (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault).

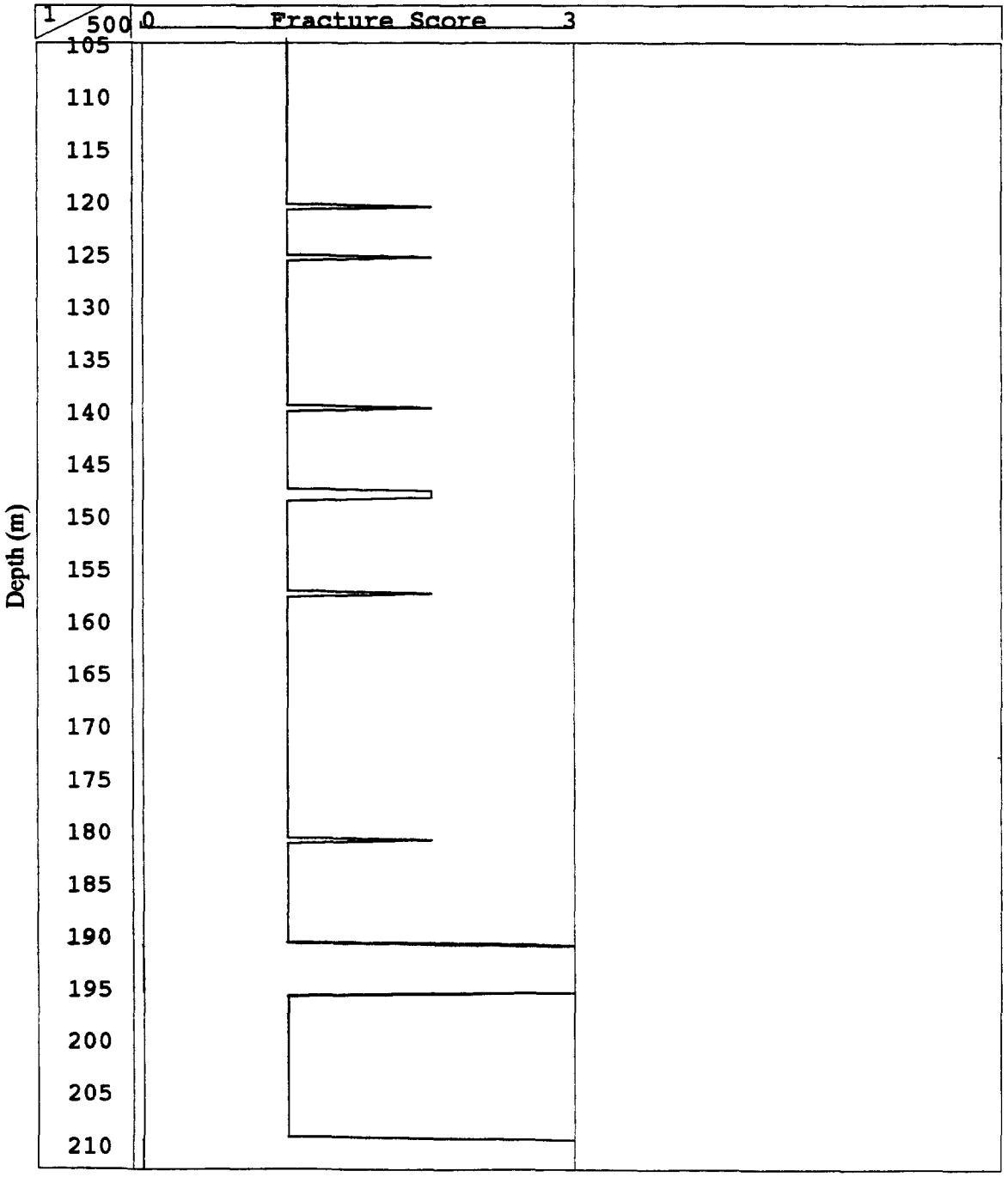

Figure PM-2.2. PM-2 fracture interpretation (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) (continued).

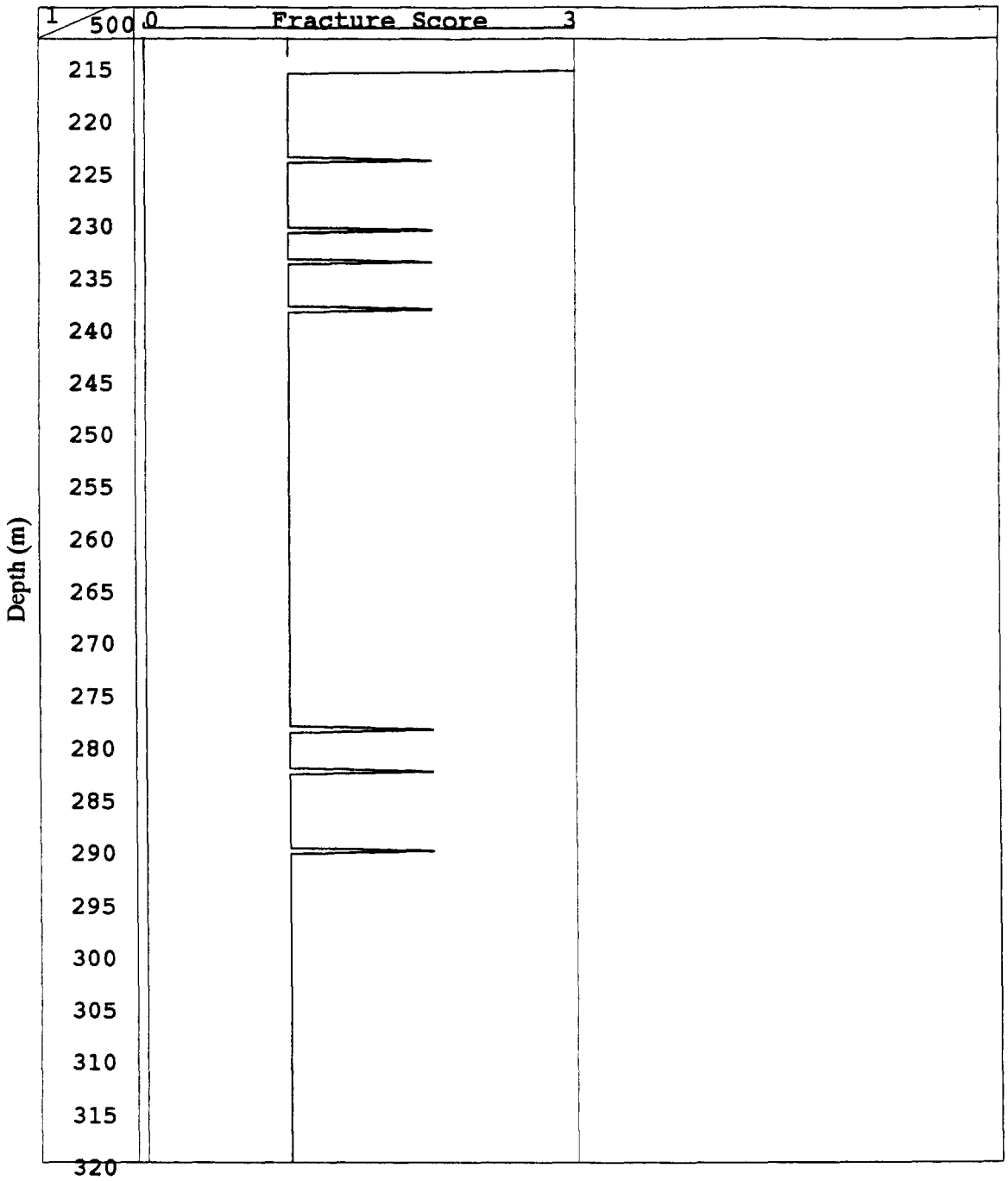

Figure PM-2.2. PM-2 fracture interpretation (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) (continued).

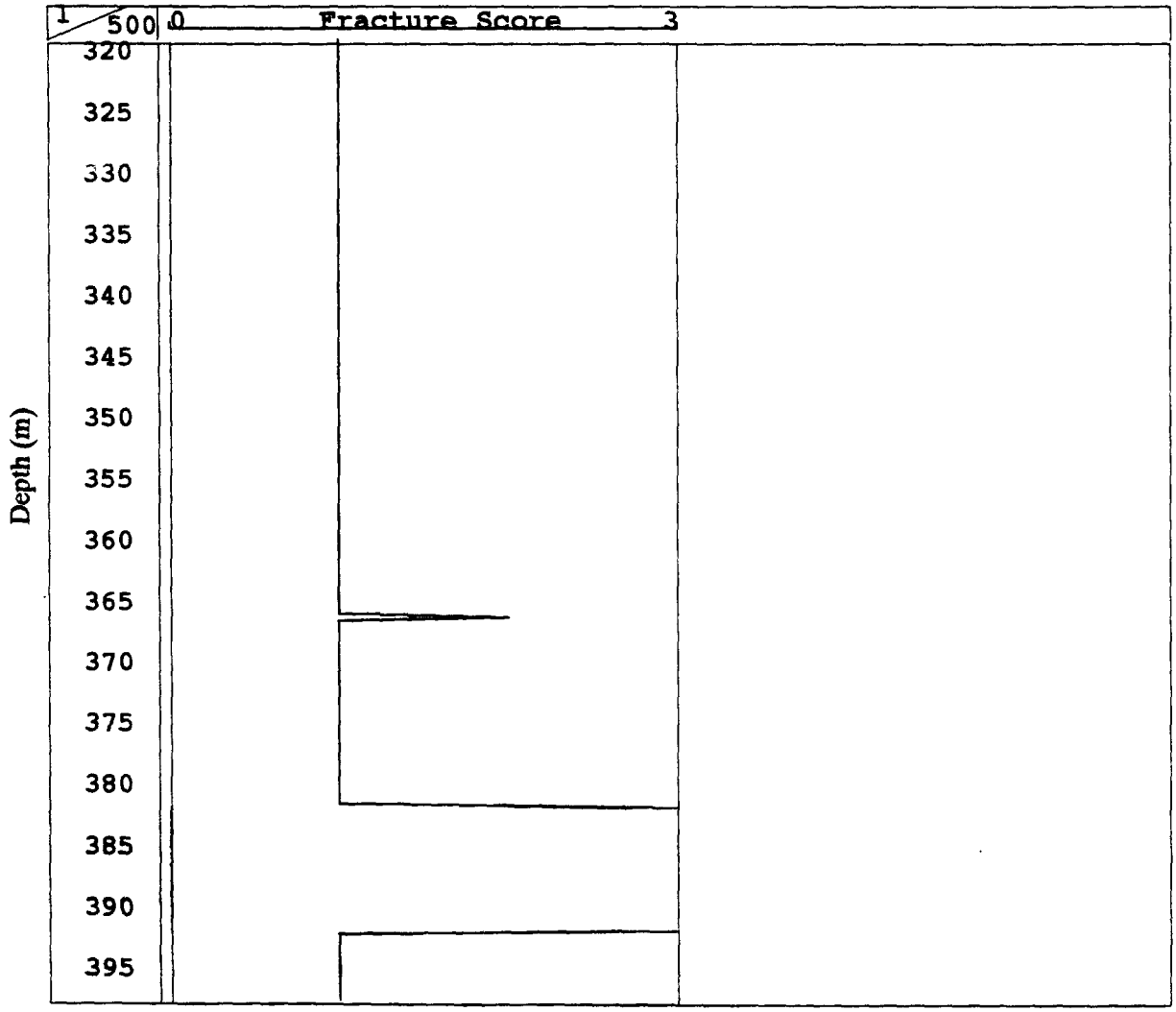

Figure PM-2.2. PM-2 fracture interpretation (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) (continued).

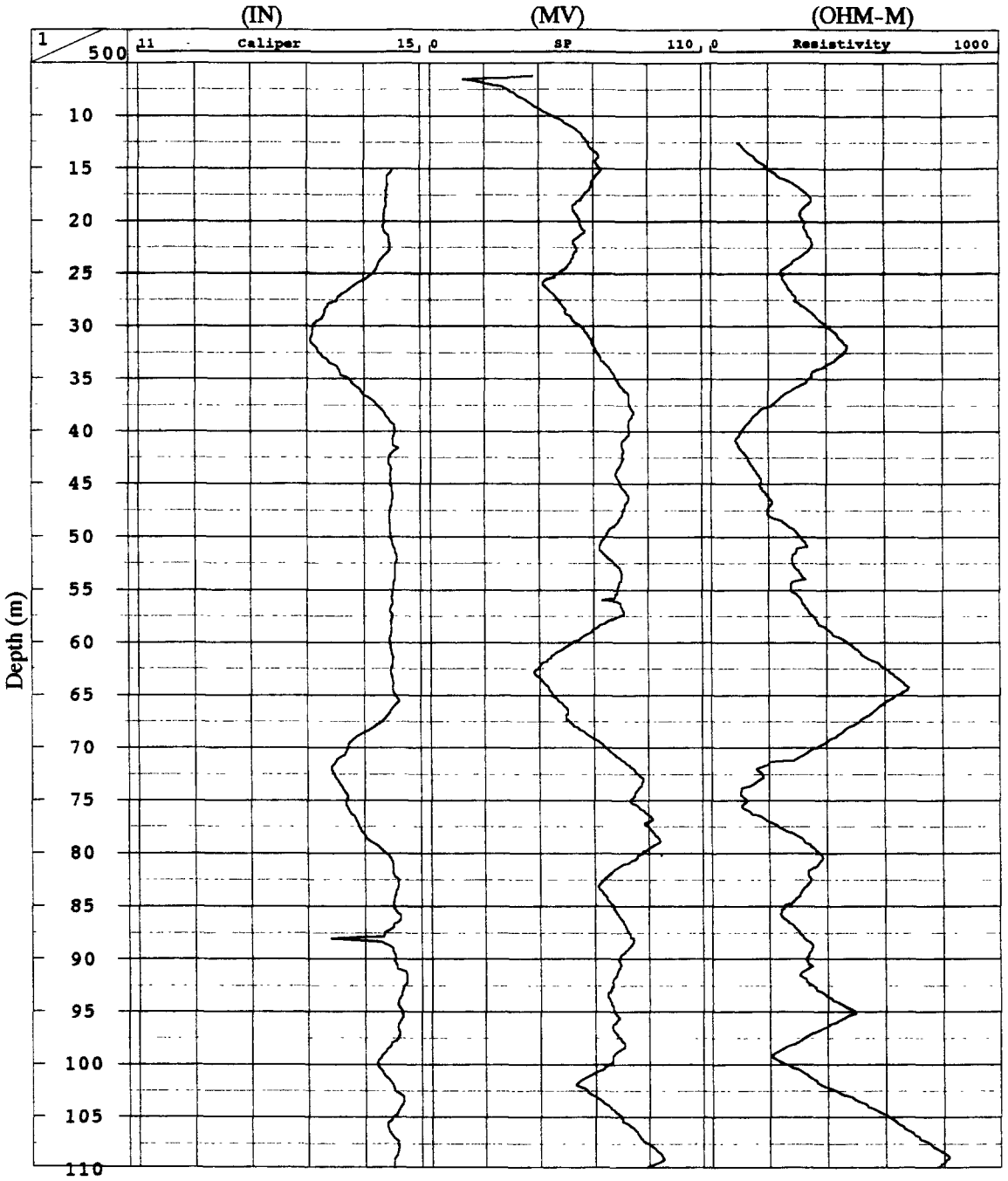

Figure PM-2.3. PM-2 caliper, spontaneous potential and resistivity logs.

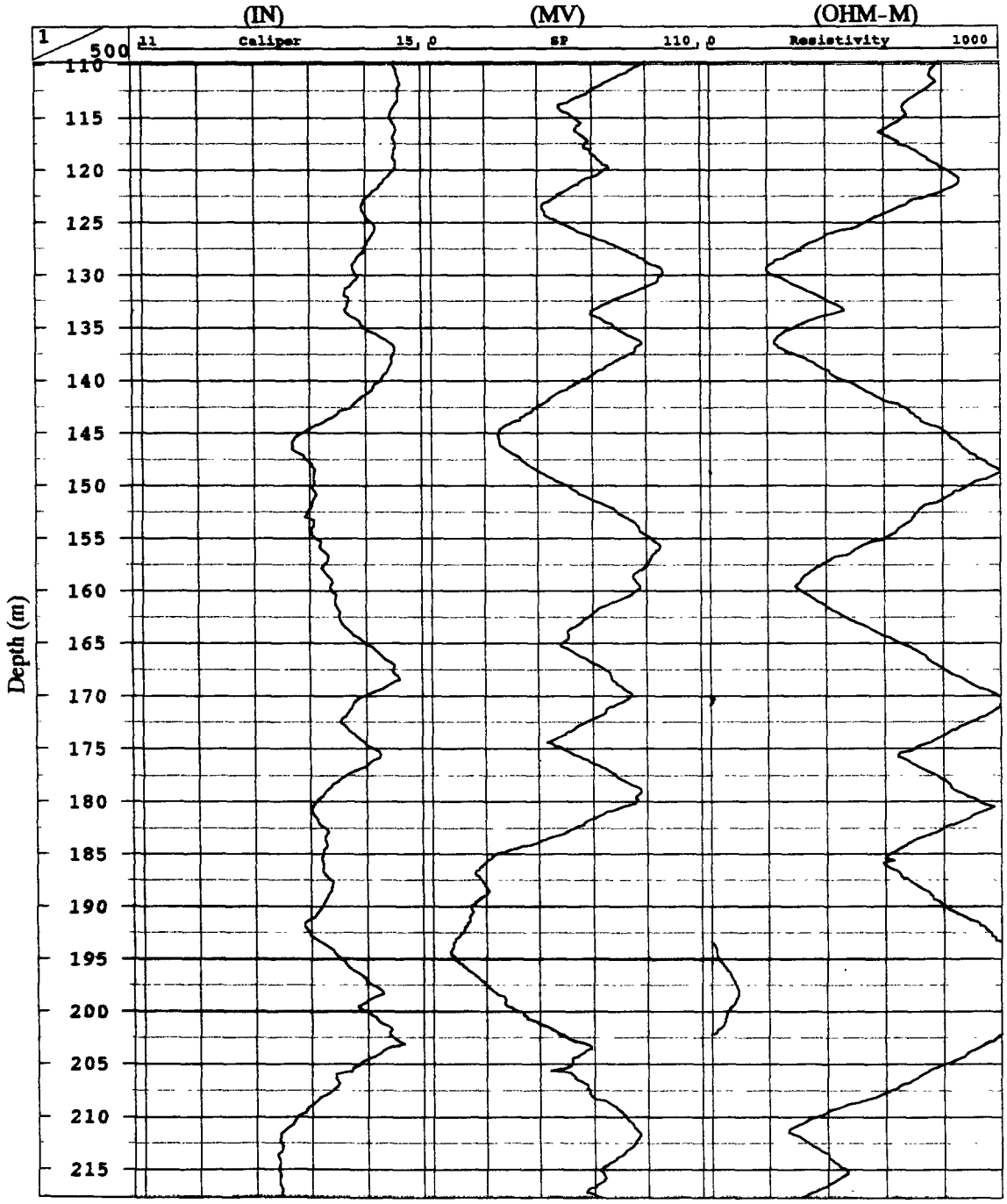

Figure PM-2.3. PM-2 caliper, spontaneous potential and resistivity logs (continued).

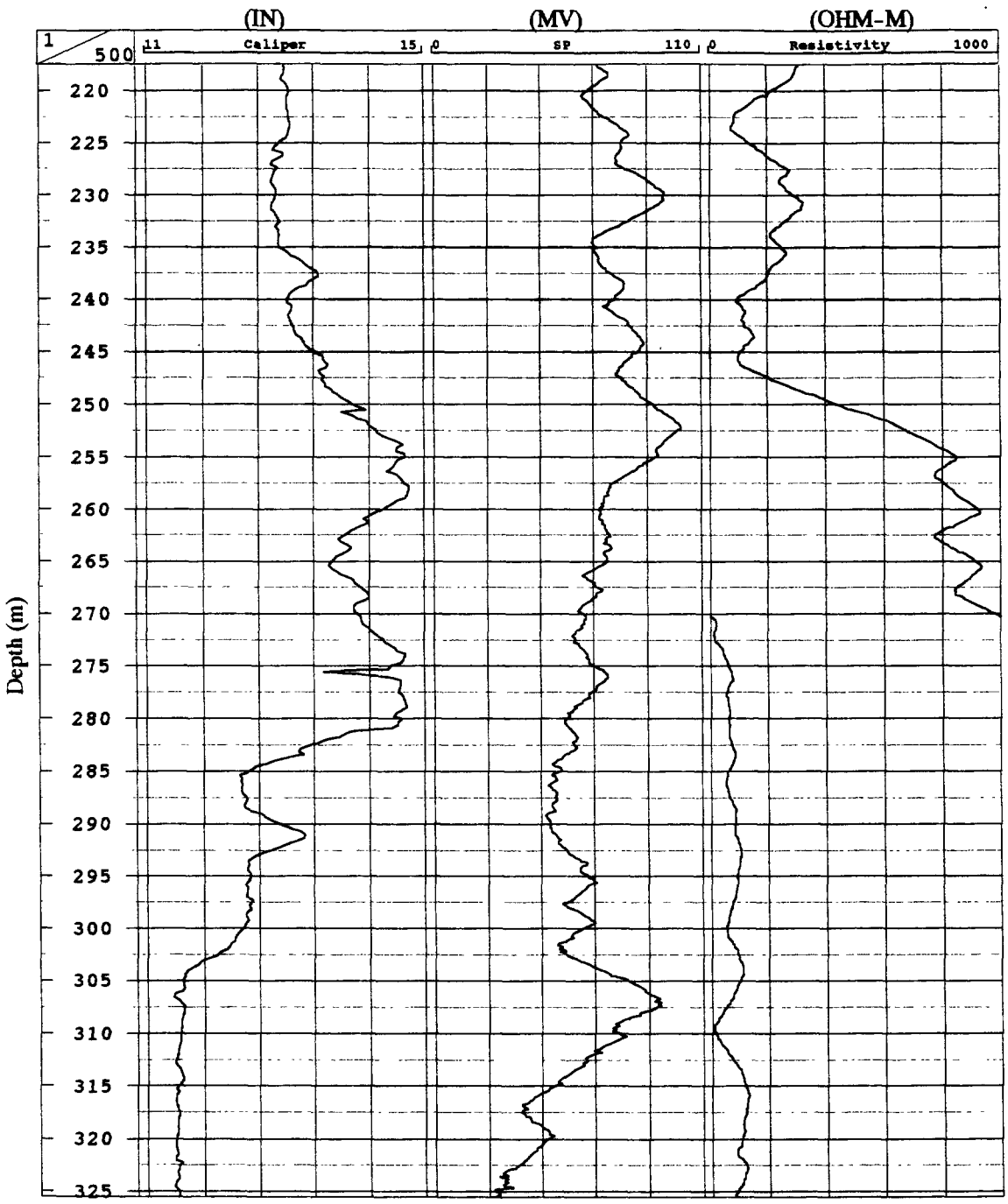

Figure PM-2.3. PM-2 caliper, spontaneous potential and resistivity logs (continued).

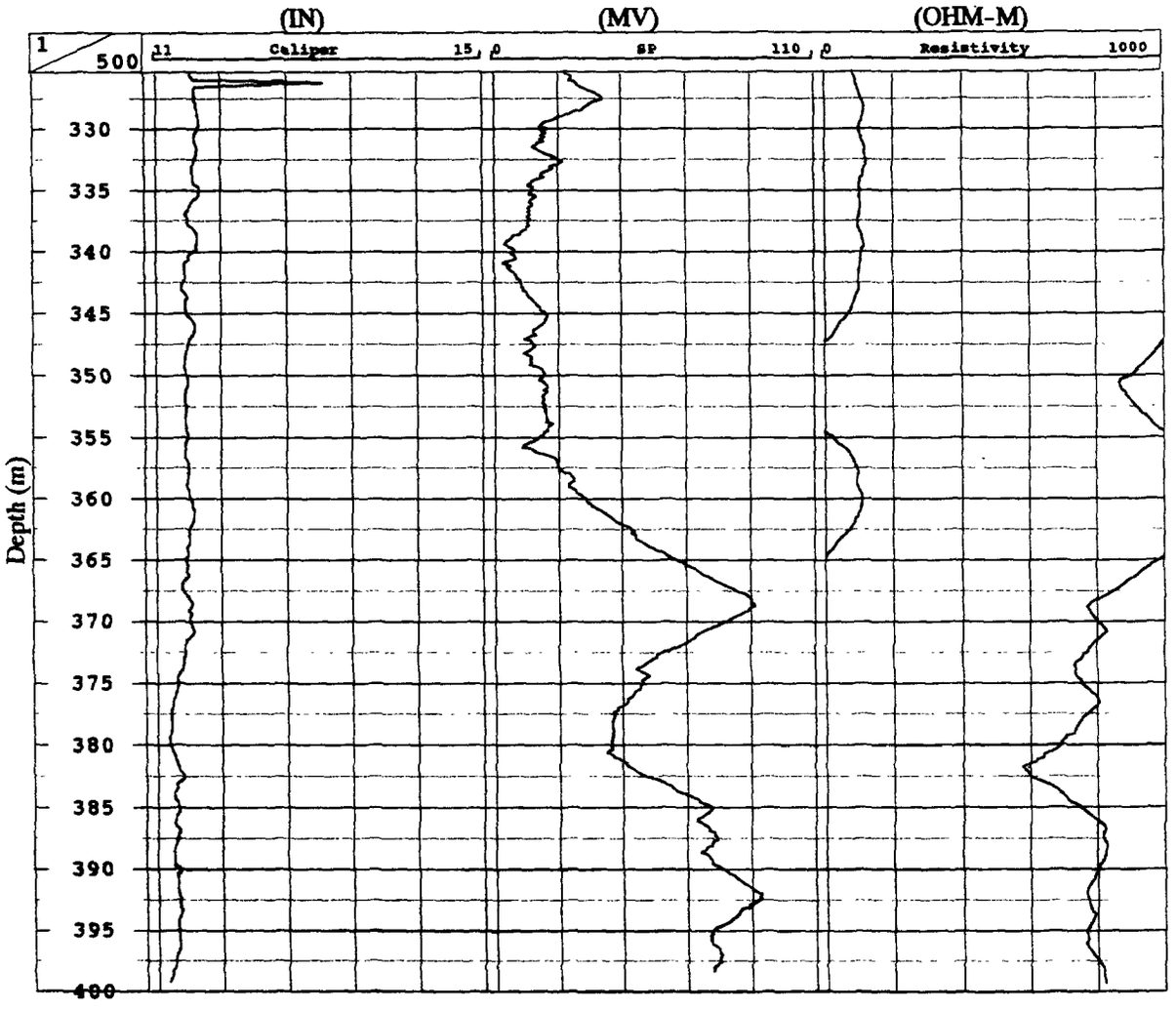

Figure PM-2.3. PM-2 caliper, spontaneous potential and resistivity logs (continued).

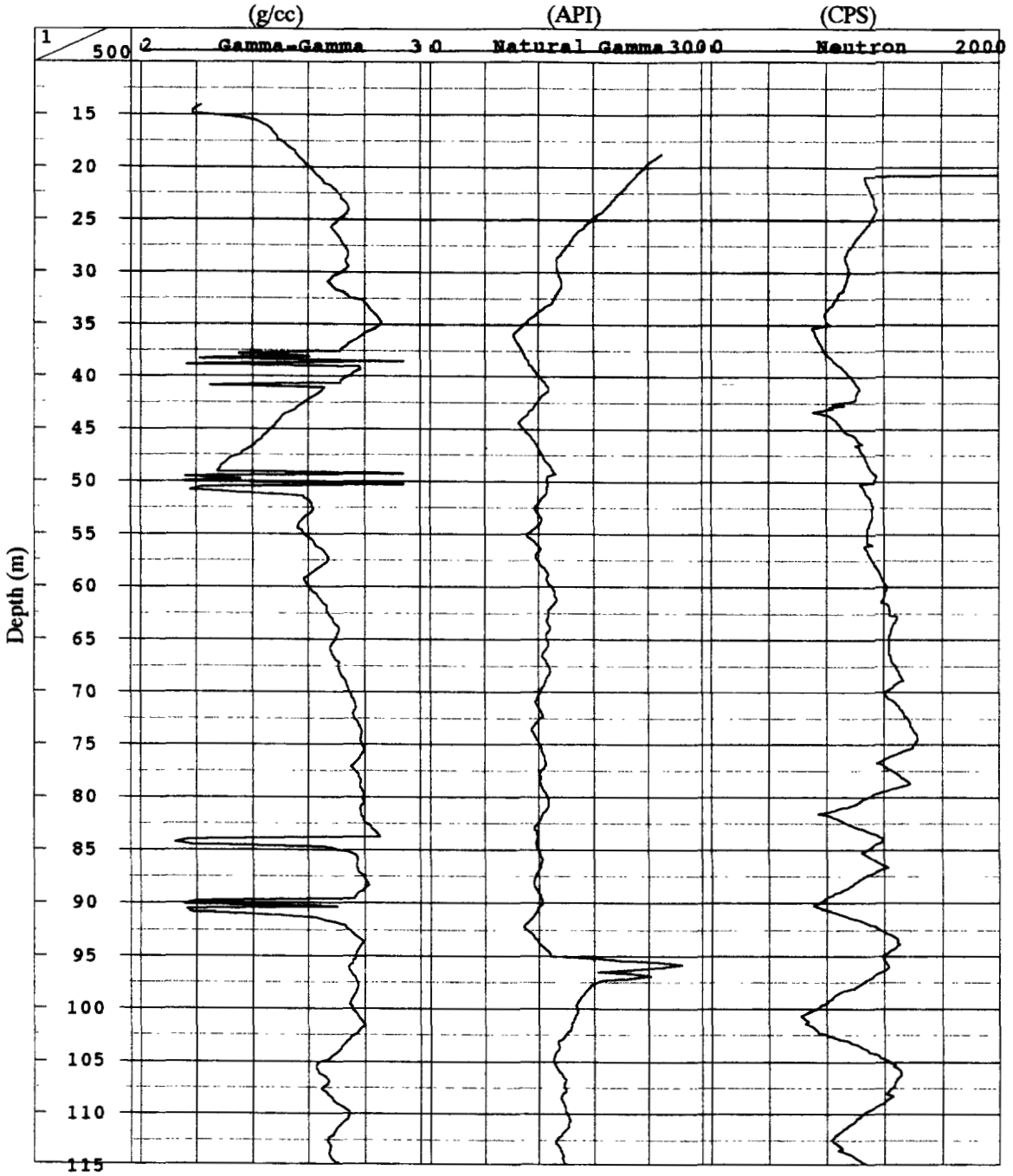

Figure PM-2.4. PM-2 gamma-gamma density, natural gamma and neutron logs.

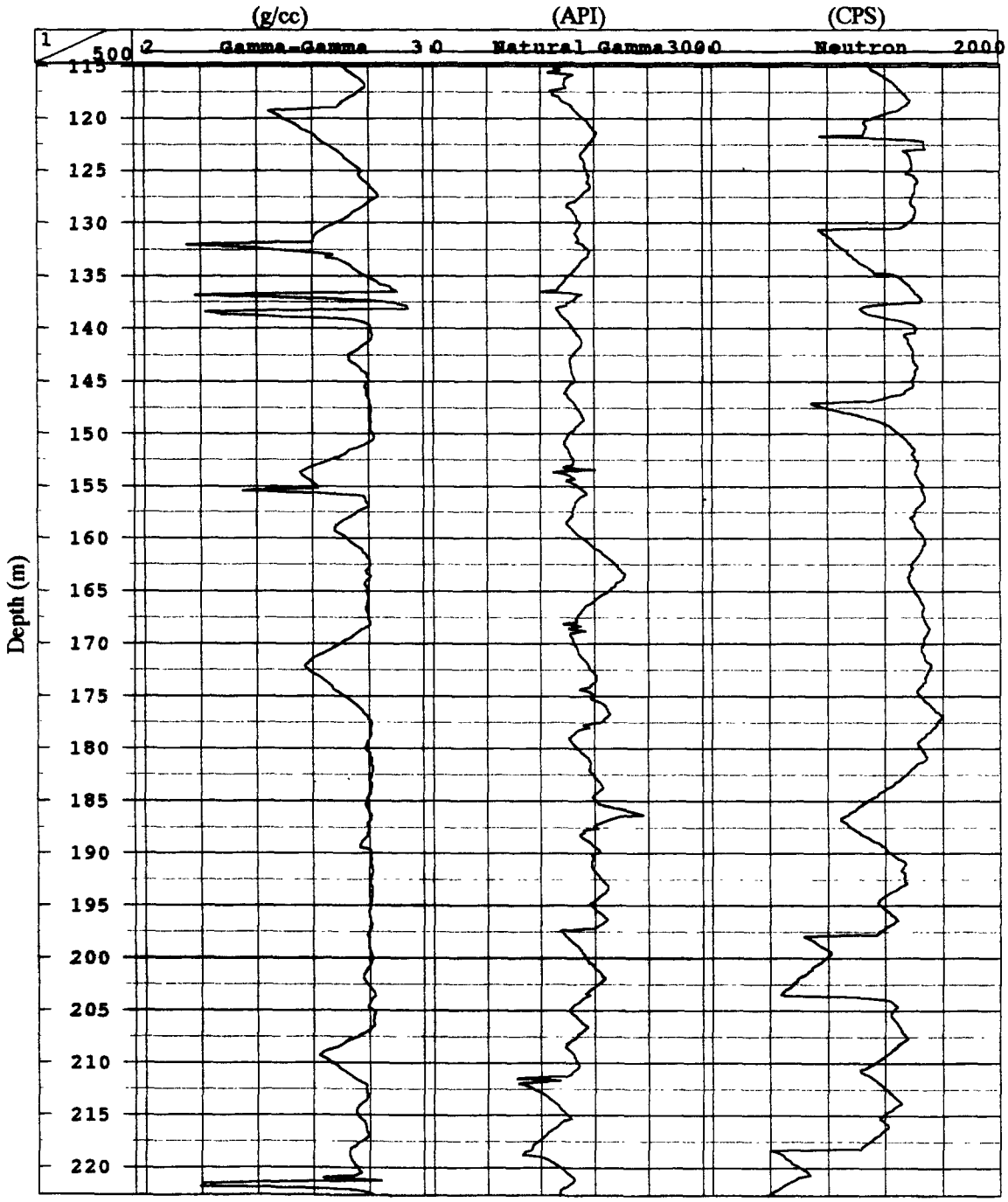

Figure PM-2.4. PM-2 gamma-gamma density, natural gamma and neutron logs (continued).

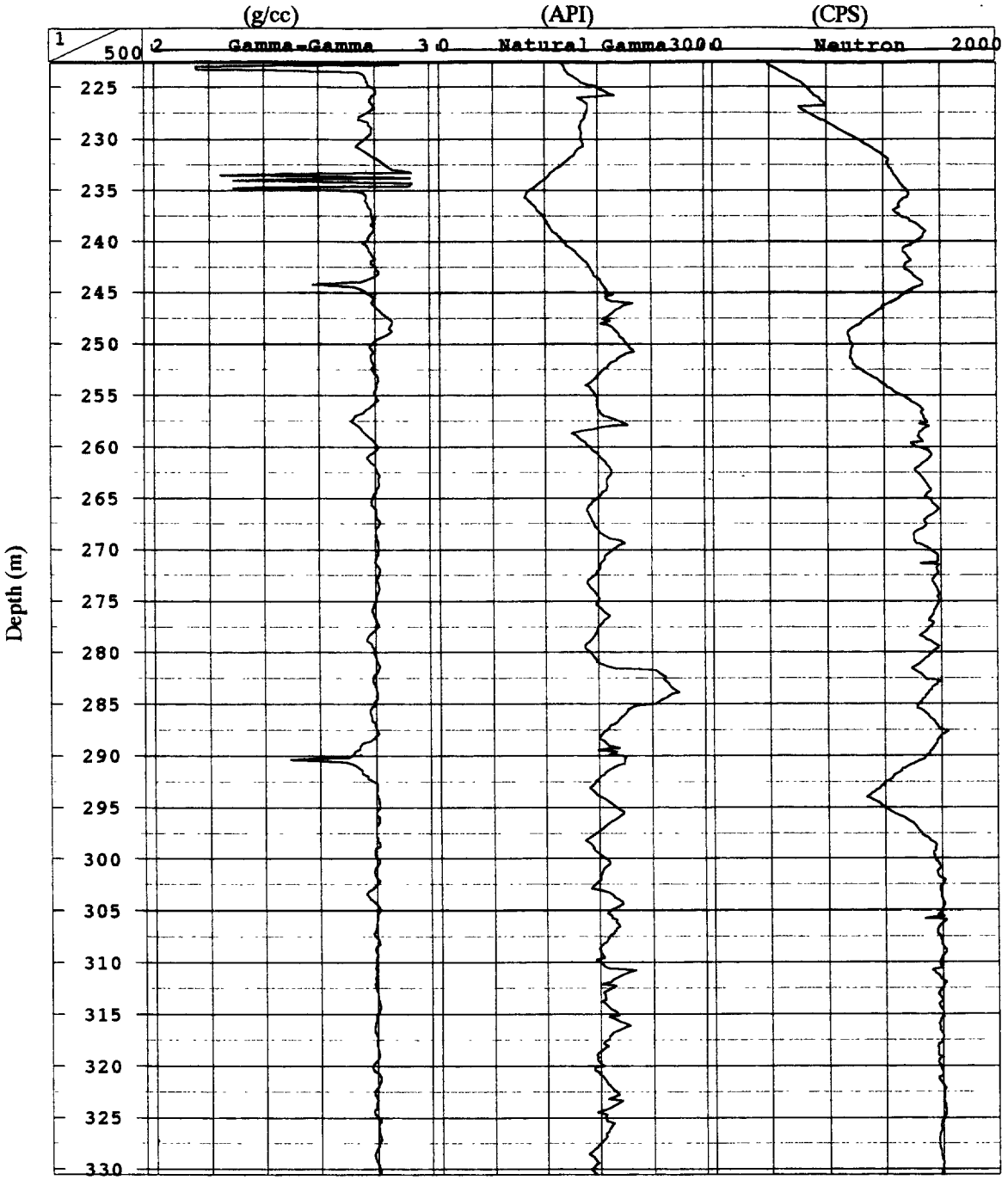

Figure PM-2.4. PM-2 gamma-gamma density, natural gamma and neutron logs (continued).

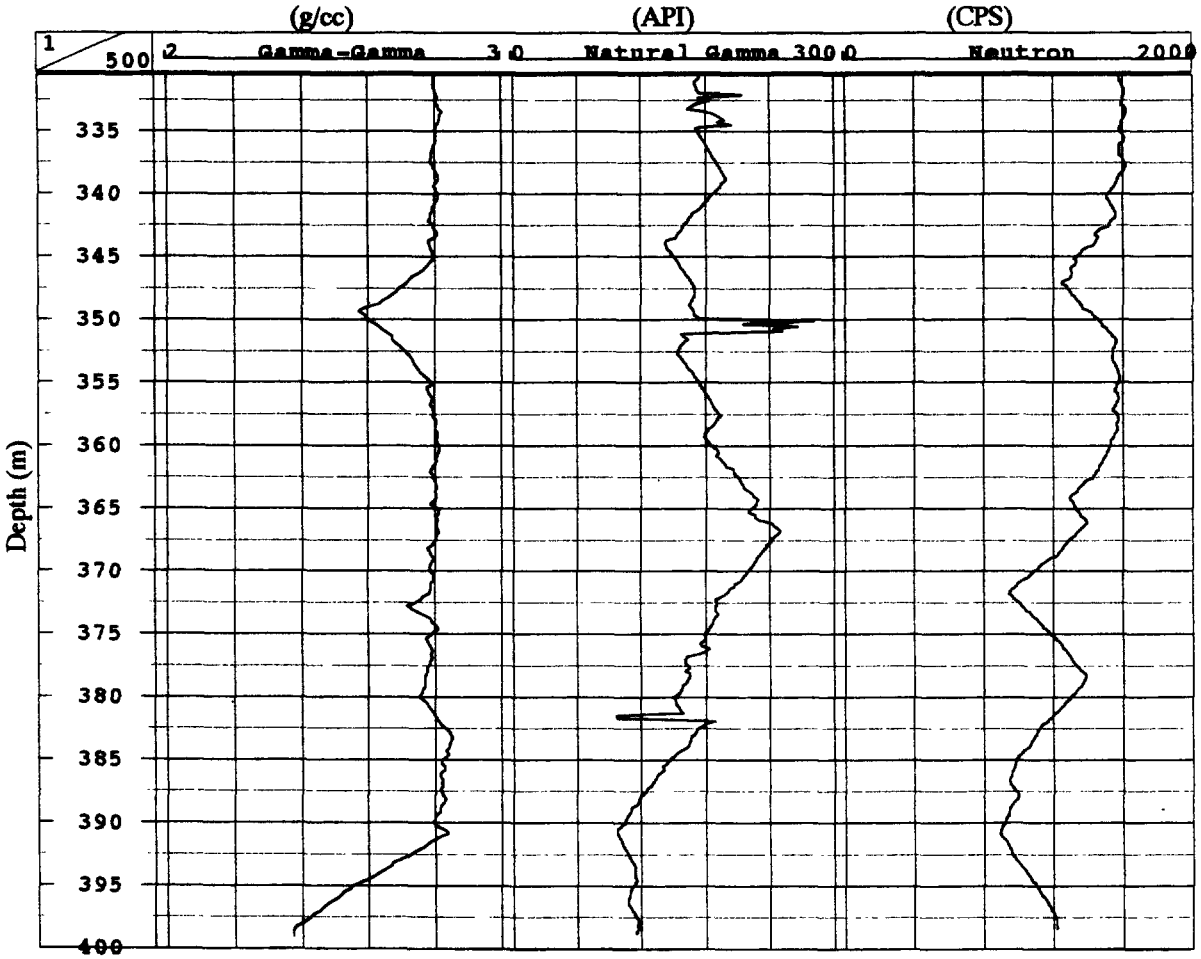

Figure PM-2.4. PM-2 gamma-gamma density, natural gamma and neutron logs (continued).

PM-3

Available Data

- Slug Test
- Historic Water Level
- Fracture Interpretation
- Caliper Log
- Spontaneous Potential Log
- Resistivity Log
- Gamma-Gamma Log
- Natural Gamma Log
- Neutron Log

Analysis	
Date:	4/22/1963
Method: Bouwer & Rice, 1976	
H (m):	99.4
R_c (m):	0.15
R_w (m):	0.15
L_w (m):	99.4
D (m):	1,000
A:	9.38
B:	2.89
L_N (R_c/R_w):	4.75
L_N ($D-H/R_w$):	6.0
Hydraulic Conductivity (cm/sec):	2.31E-06

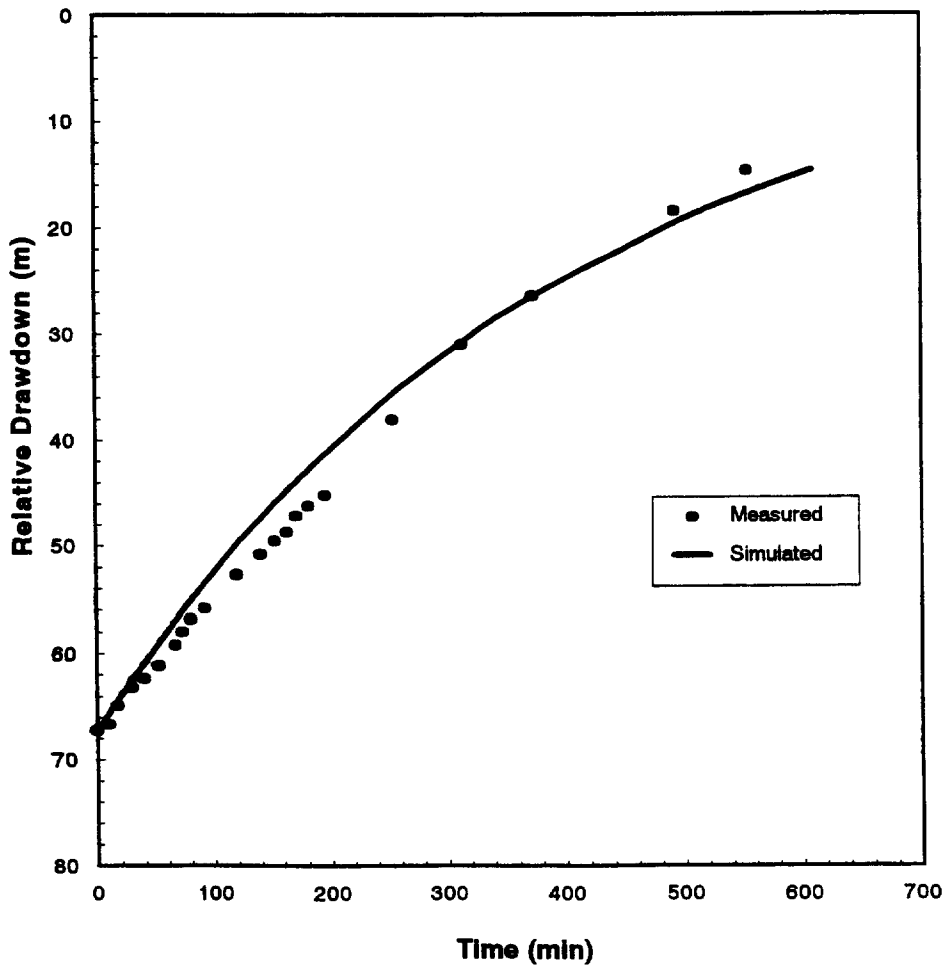

Figure PM-3.1.. PM-3 slug test analysis (1963).

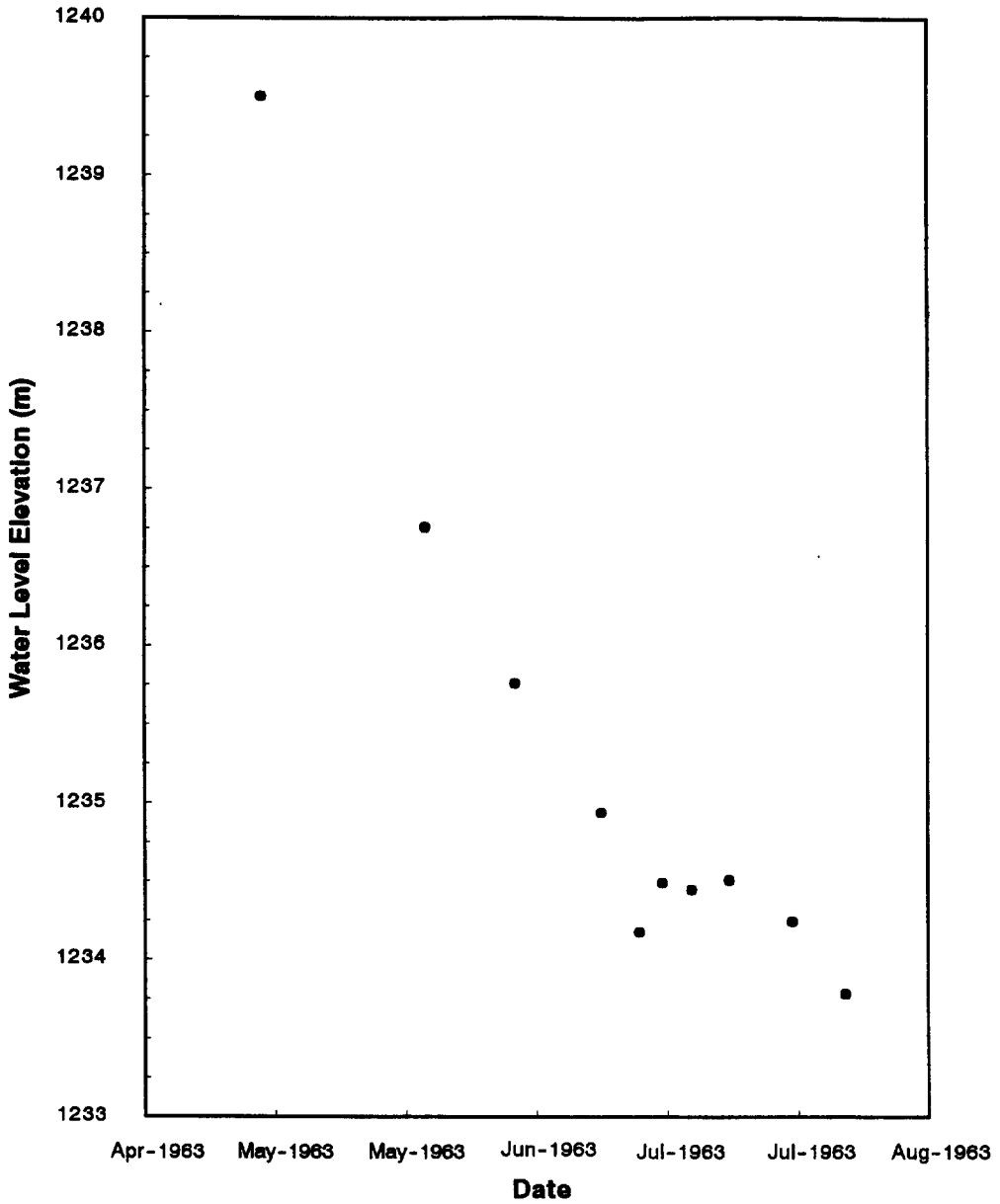

Figure PM-3.2. PM-3 water level vs. time.

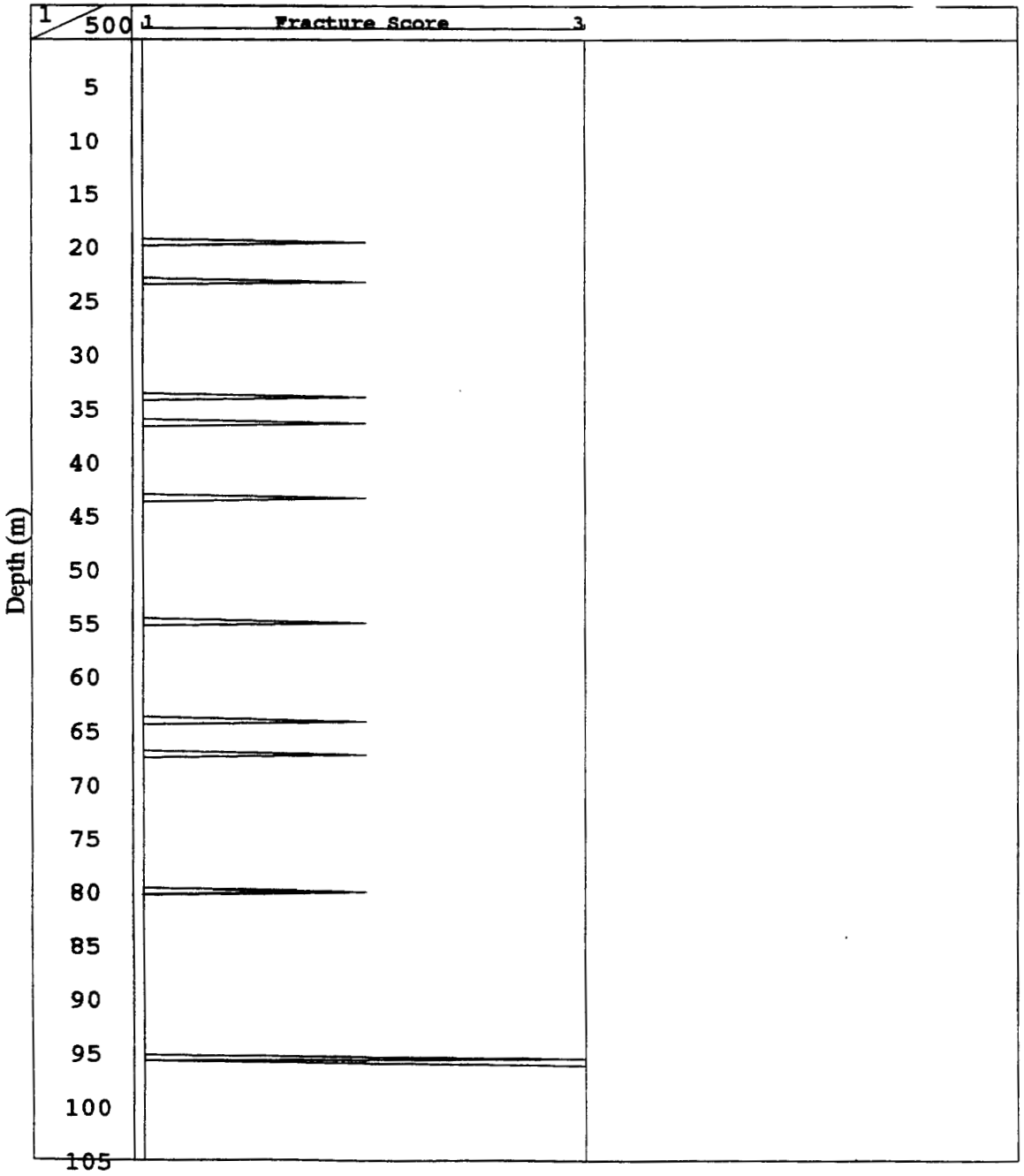

Figure PM-3.3. PM-3 fracture interpretation (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault).

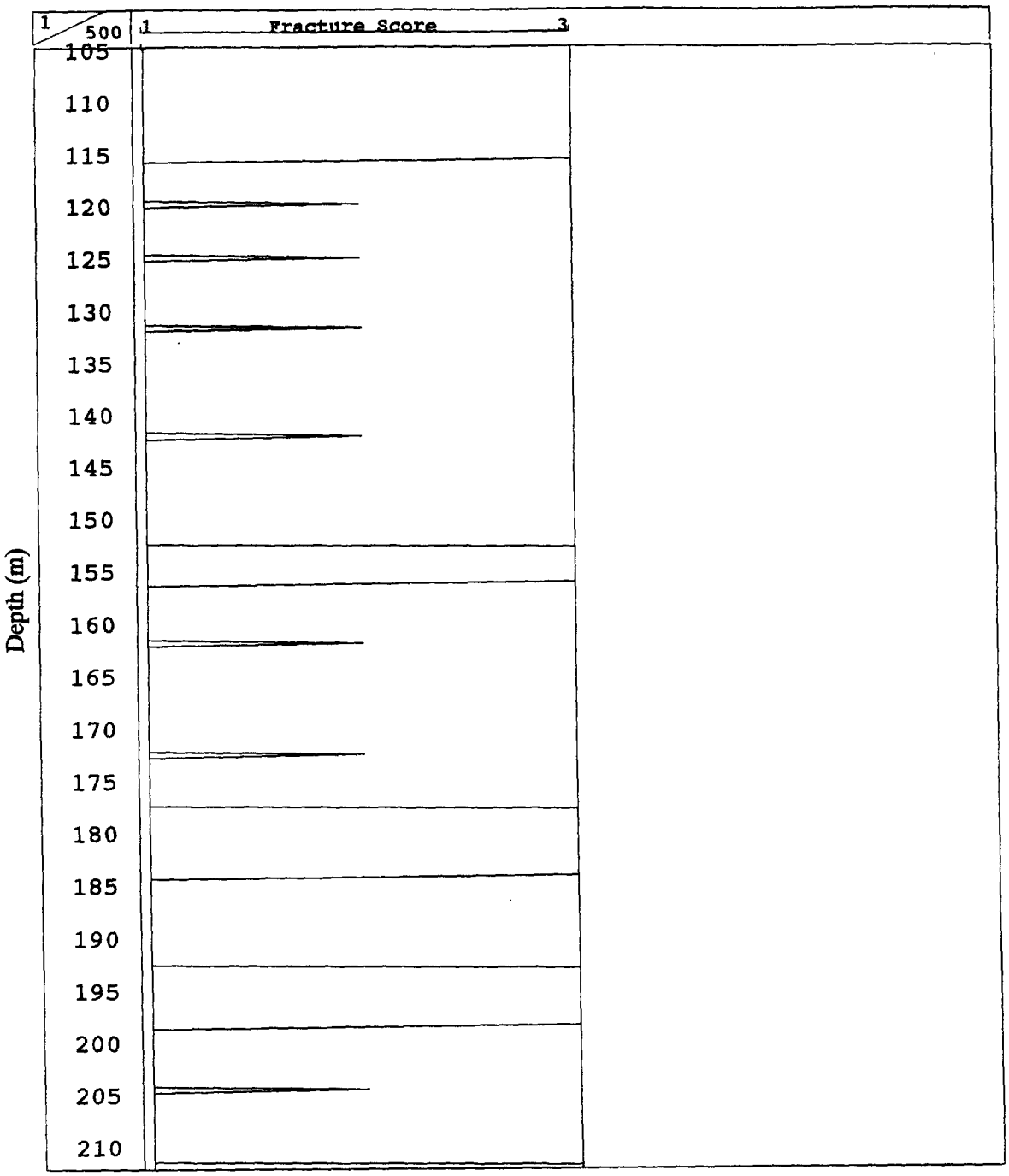

Figure PM-3.3. PM-3 fracture interpretation (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) (continued).

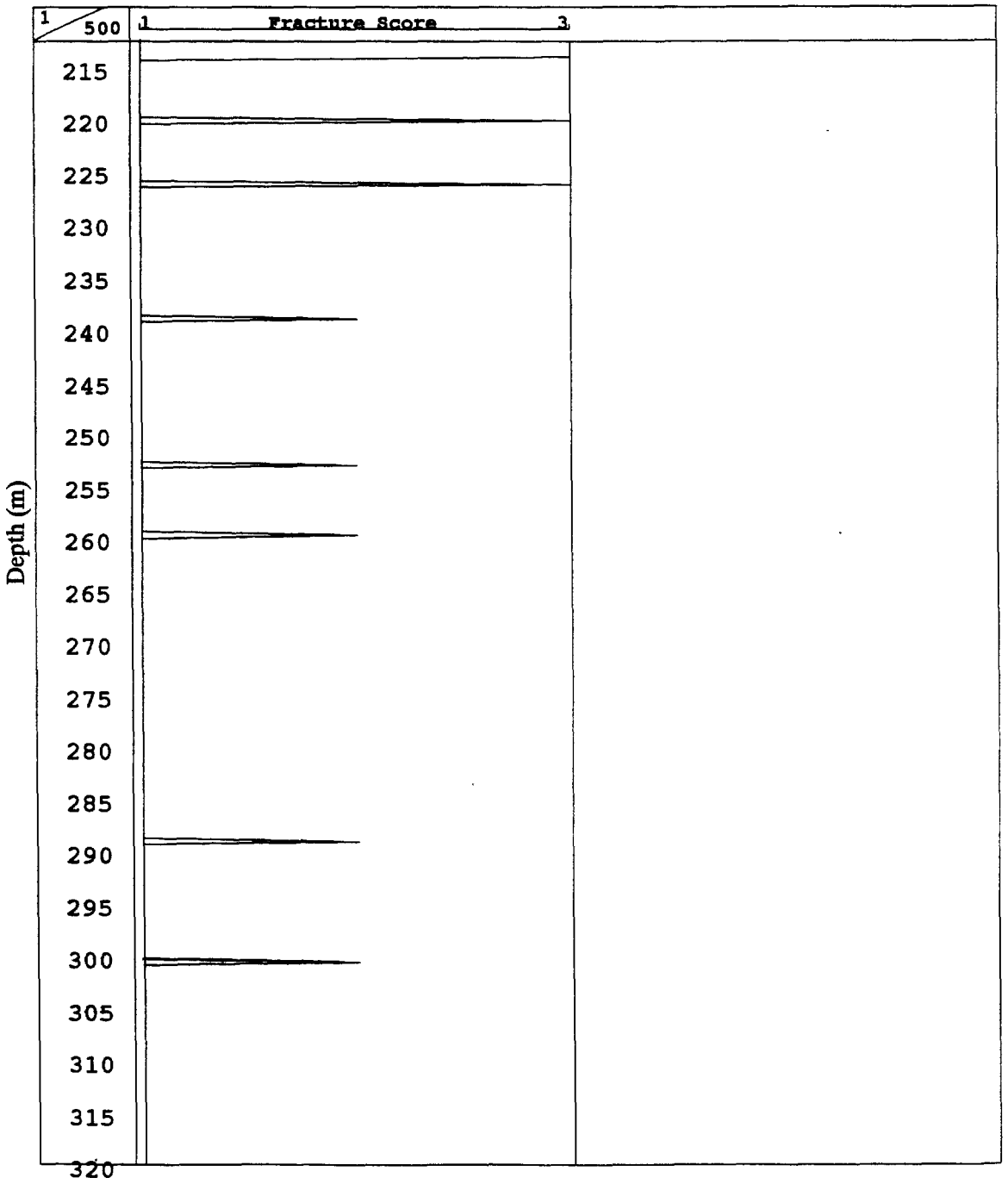

Figure PM-3.3. PM-3 fracture interpretation (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) continued).

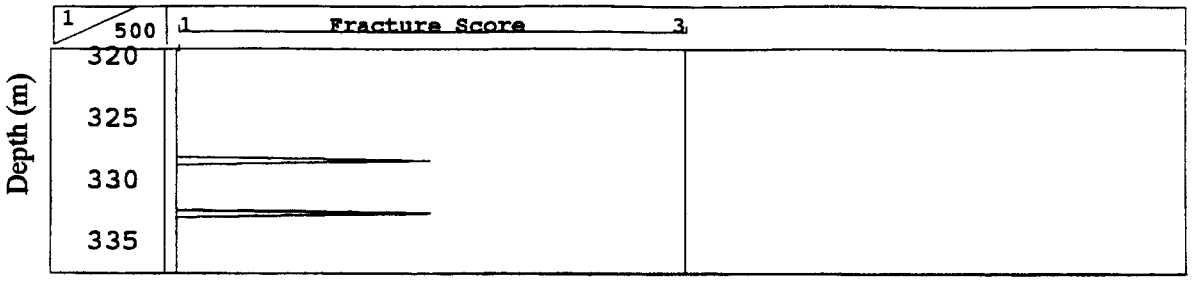

Figure PM-3.3. PM-3 fracture interpretation (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) (continued).

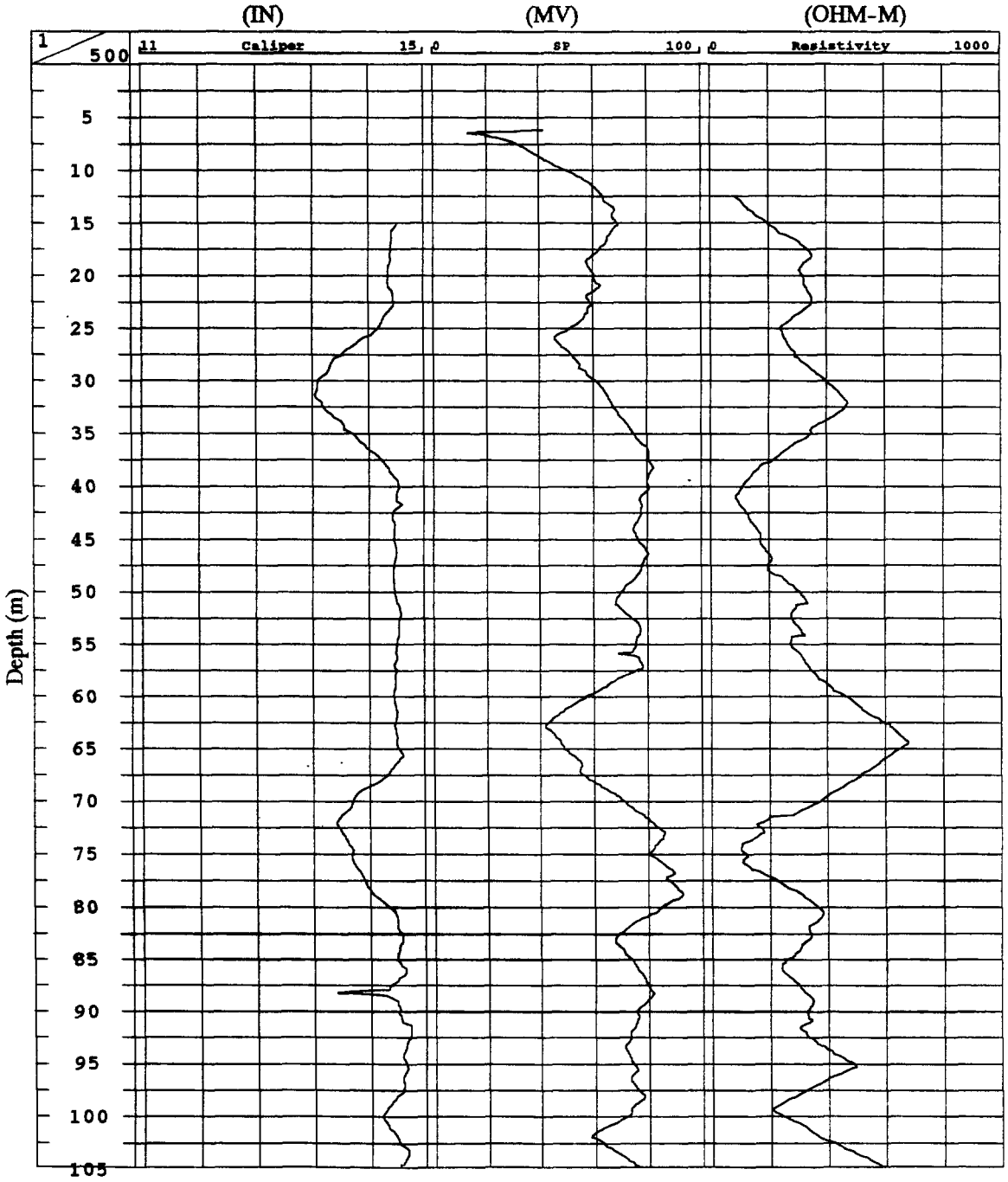

Figure PM-3.4. PM-3 caliper, spontaneous potential and resistivity logs.

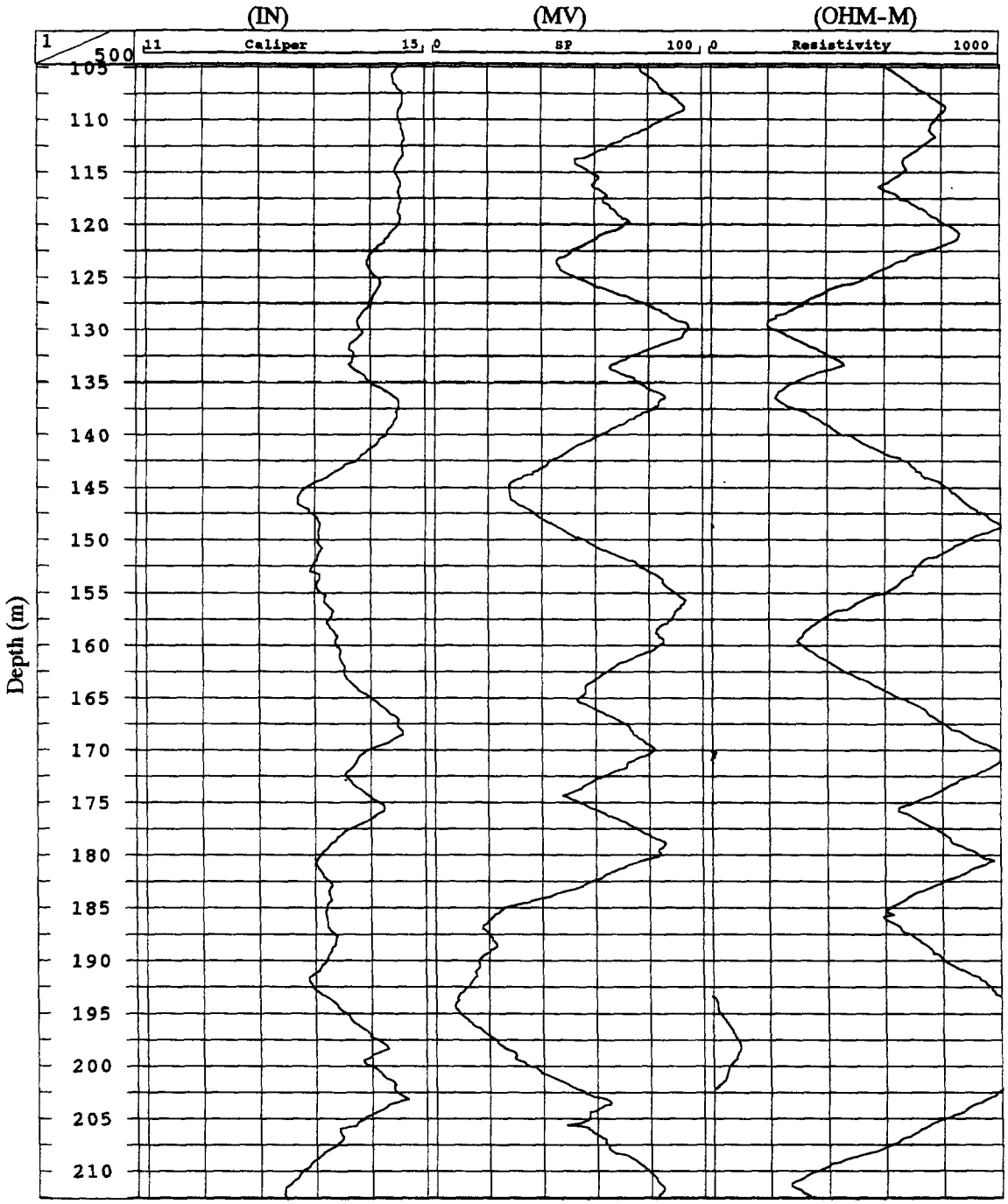

Figure PM-3.4. PM-3 caliper, spontaneous potential and resistivity logs (continued).

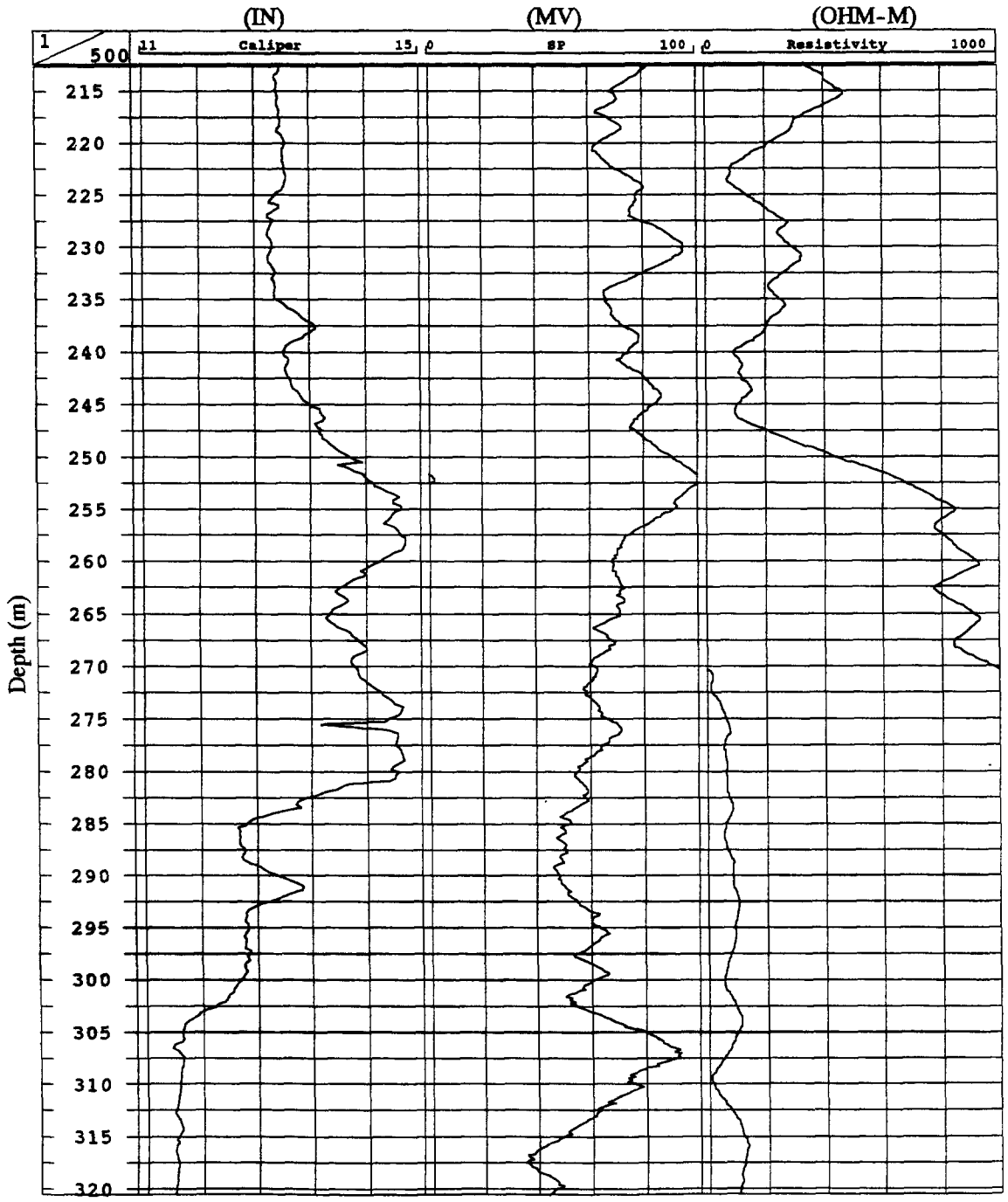

Figure PM-3.4. PM-3 caliper, spontaneous potential and resistivity logs (continued).

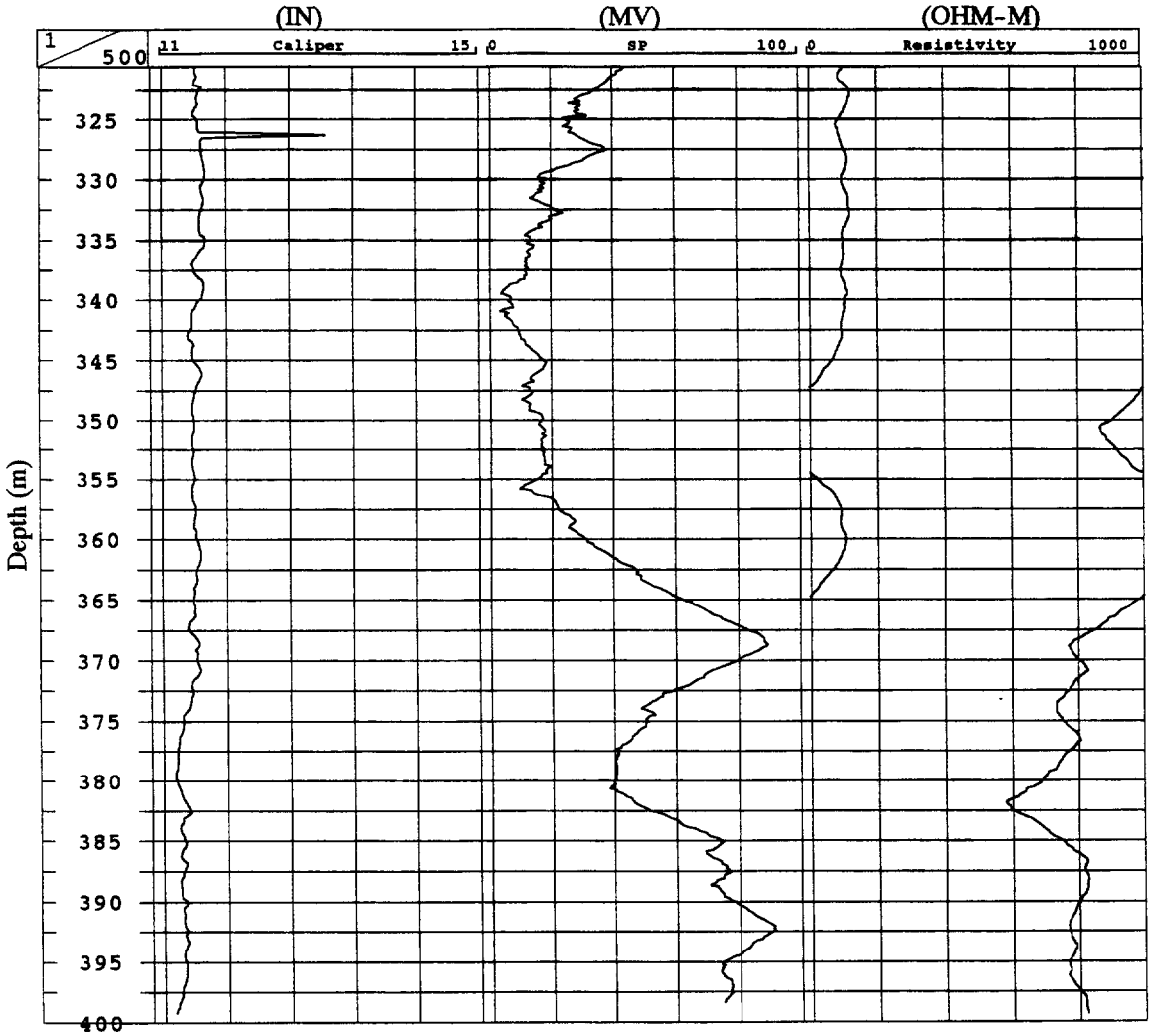

Figure PM-3.4. PM-3 caliper, spontaneous potential and resistivity logs (continued).

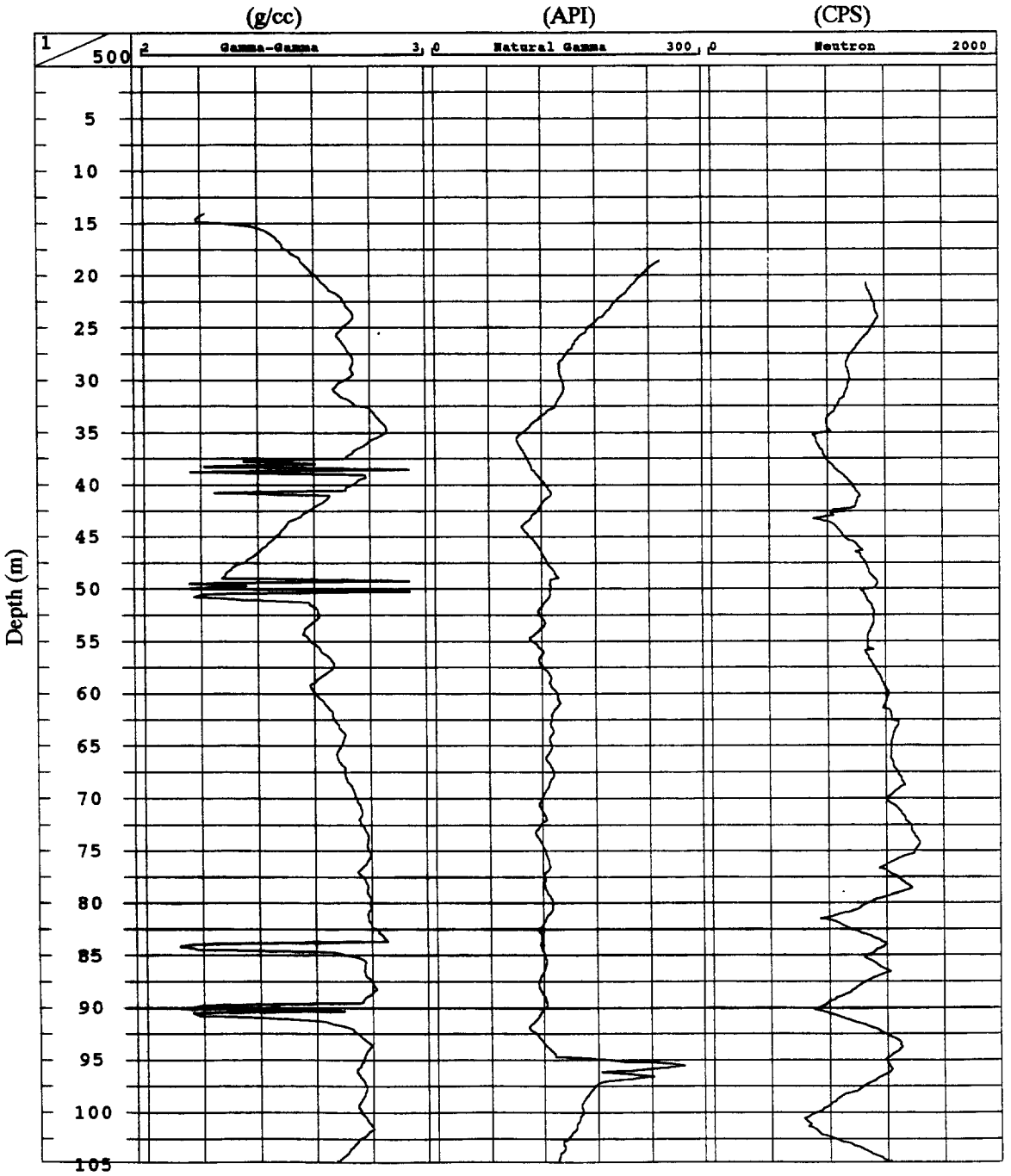

Figure PM-3.5. PM-3 gamma-gamma density, natural gamma and neutron logs.

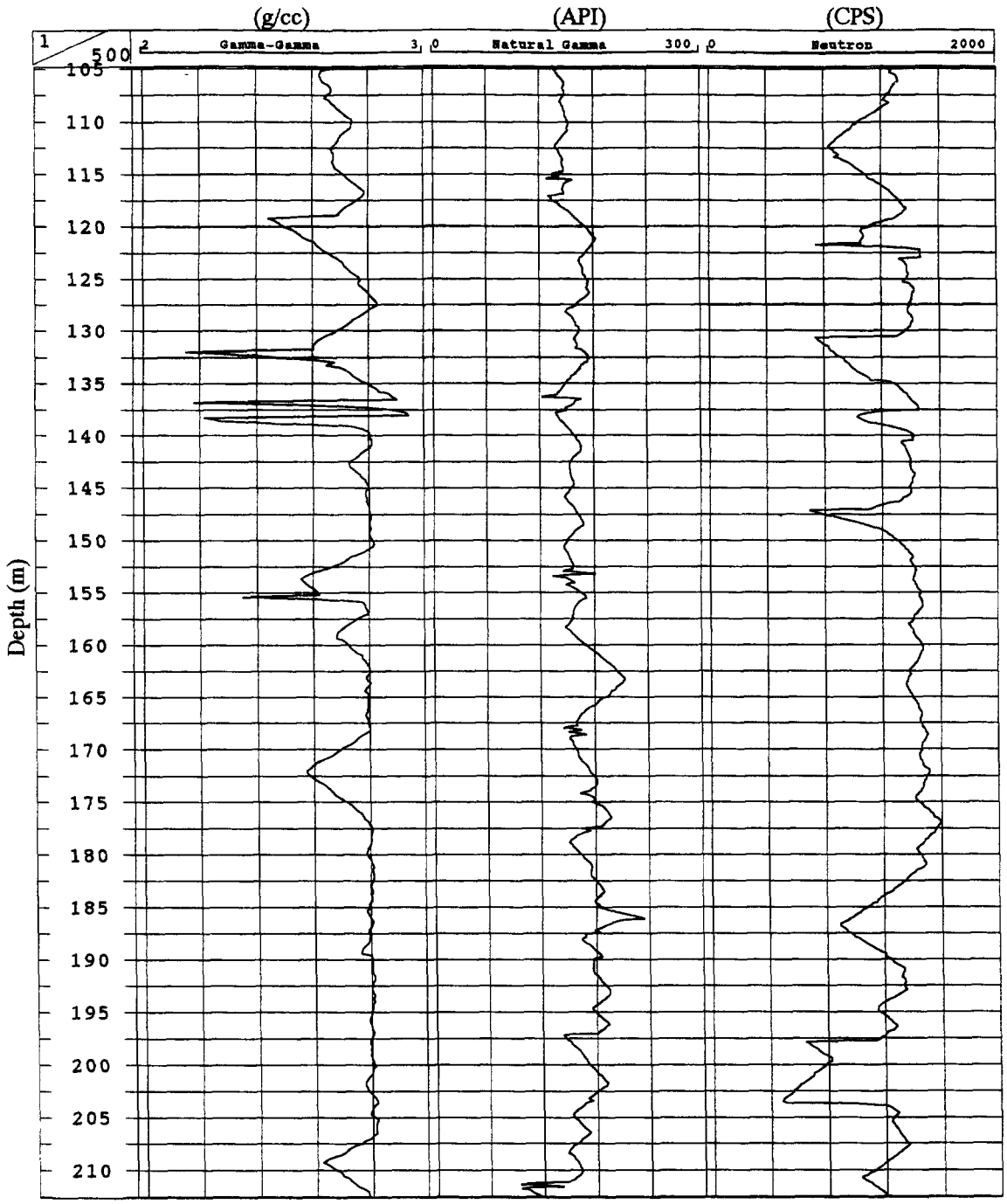

Figure PM-3.5. PM-3 gamma-gamma density, natural gamma and neutron logs (continued).

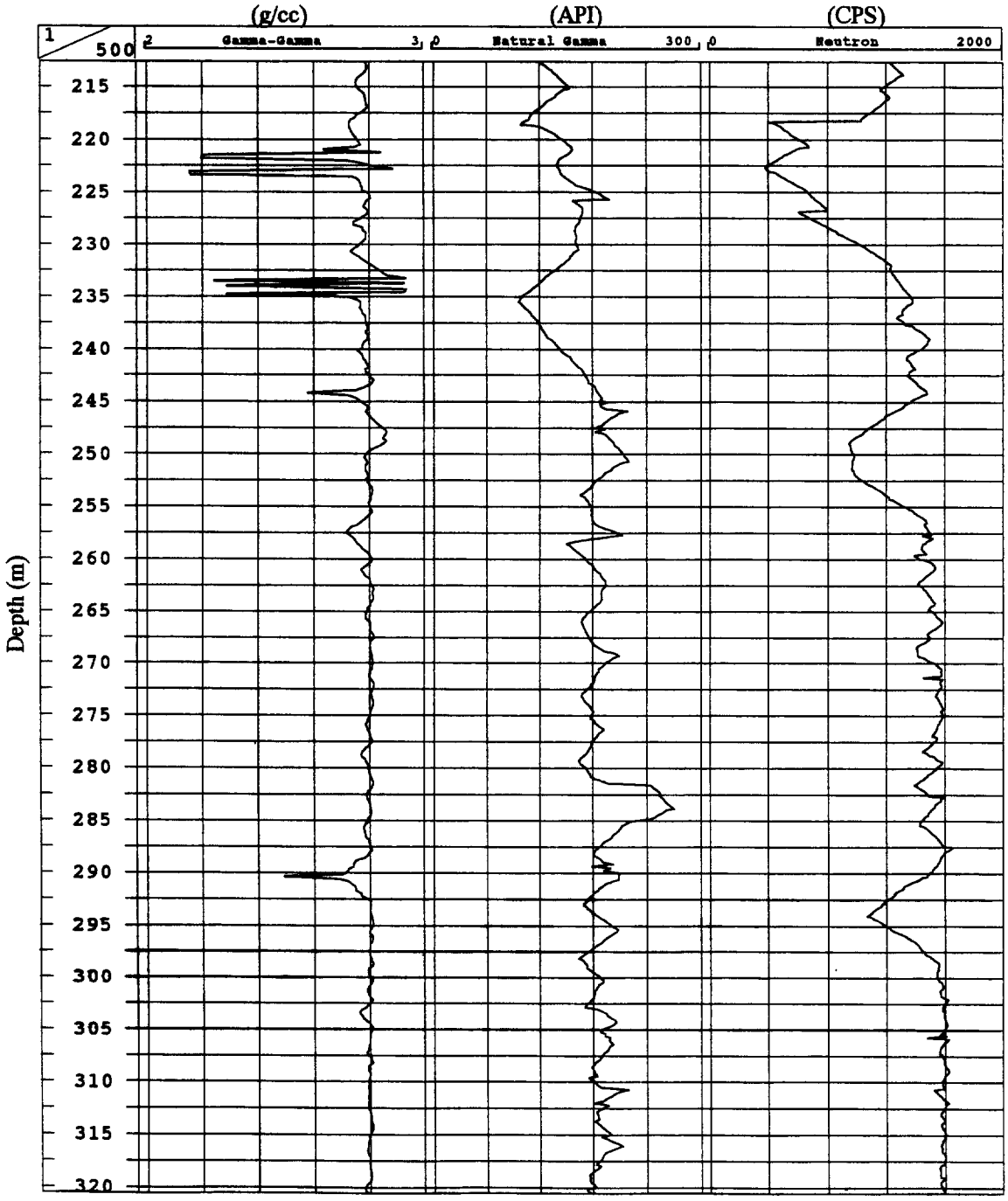

Figure PM-3.5. PM-3 gamma-gamma density, natural gamma and neutron logs (continued).

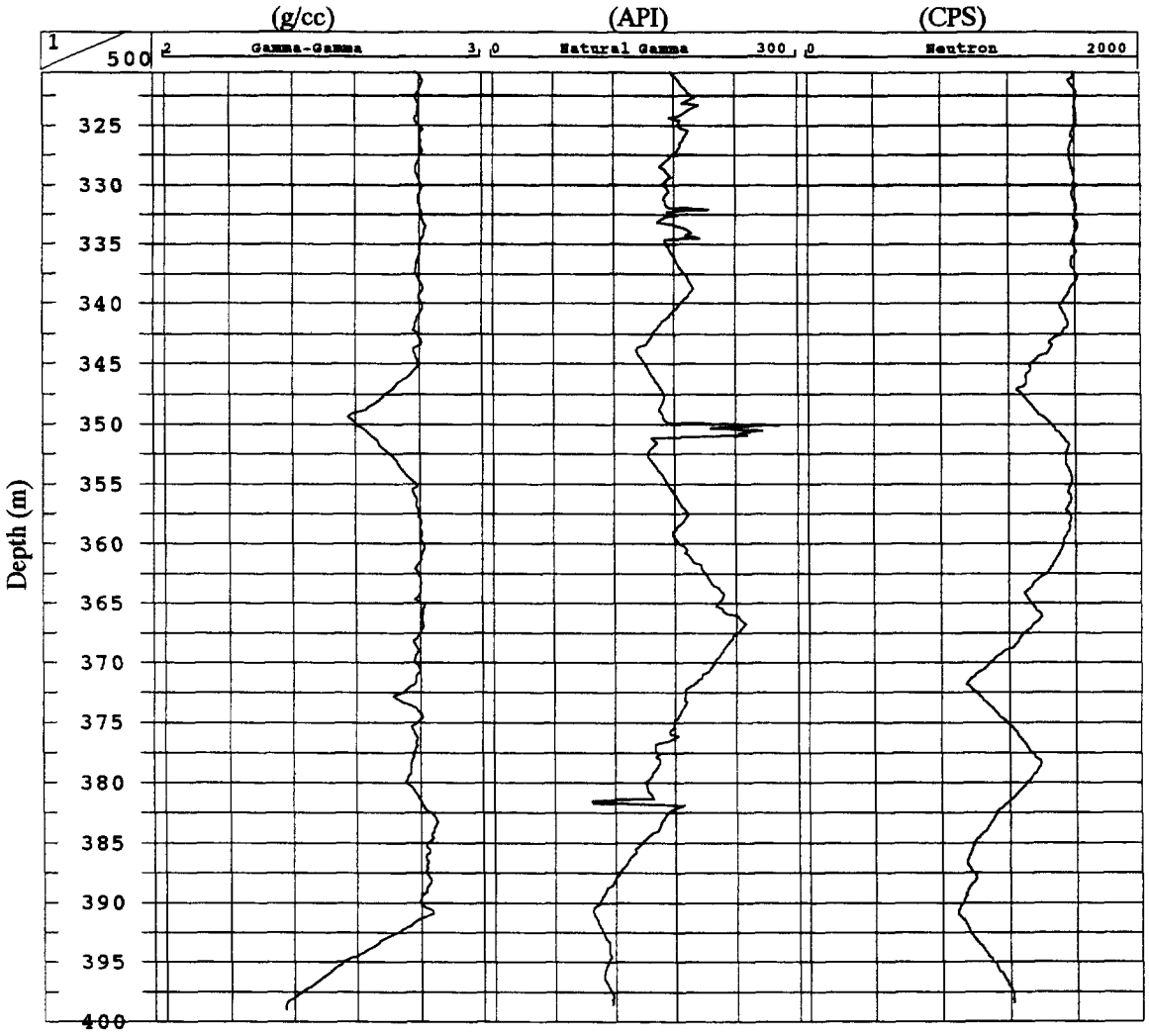

Figure PM-3.5. PM-3 gamma-gamma density, natural gamma and neutron logs (continued).

PM-8

Available Data

- Historic Water Level

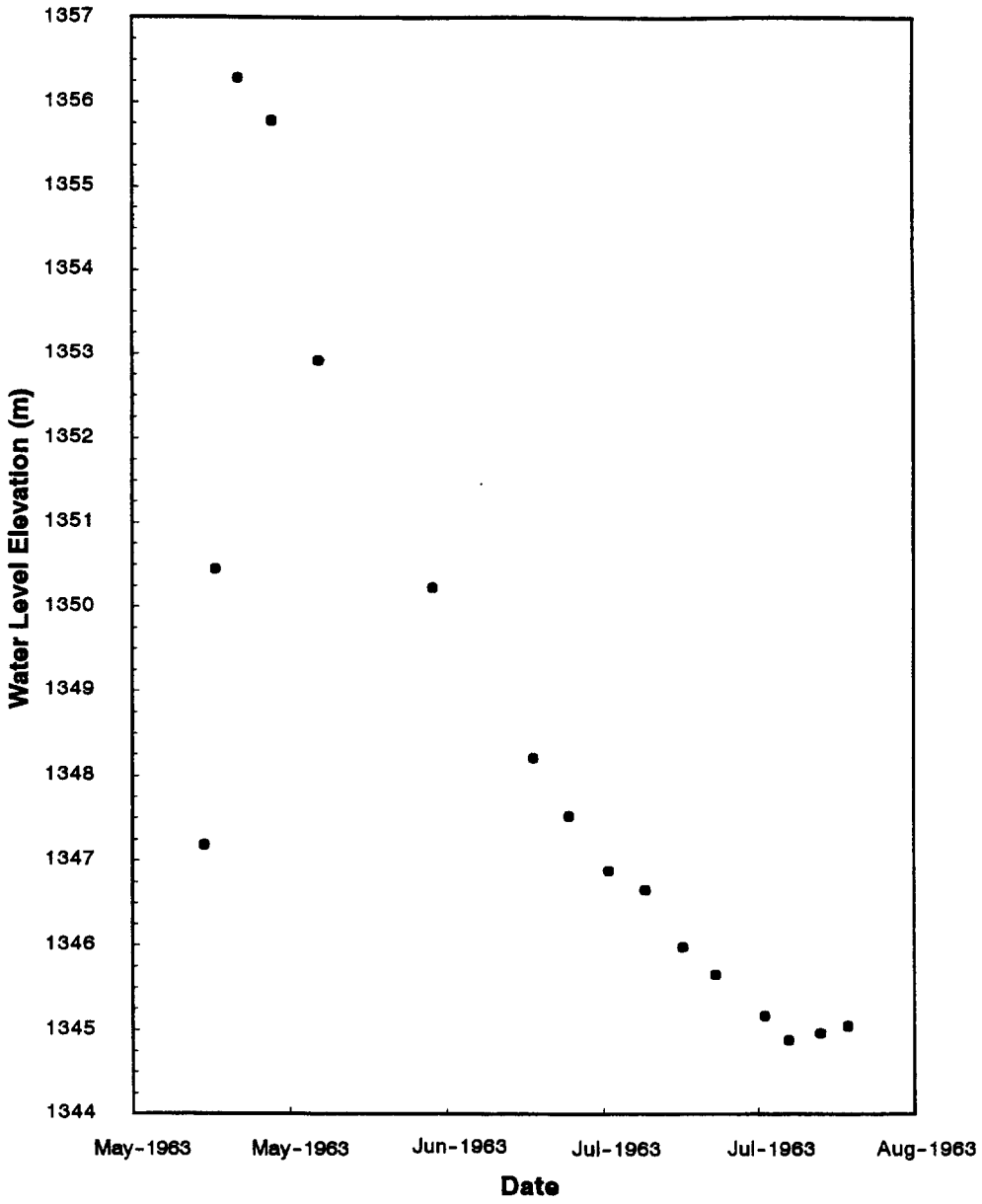

Figure PM-8.1. PM-8 water level vs. time.

USBM-1

Available Data

- Historic Water Level
- Slug Test
- Fracture Interpretation Log
- Caliper Log
- Natural Gamma Log
- Neutron Log

Analysis	
Date:	7/30/1963
Method: Bouwer & Rice, 1976	
H (m):	82.3
R_c (m):	0.15
R_w (m):	0.15
L_w (m):	82.3
D (m):	1,000
A	9.00
B	2.67
L_N (R_c/R_w):	4.52
L_N ($D-H/R_w$):	6.0
Hydraulic Conductivity (cm/sec):	1.23E-05

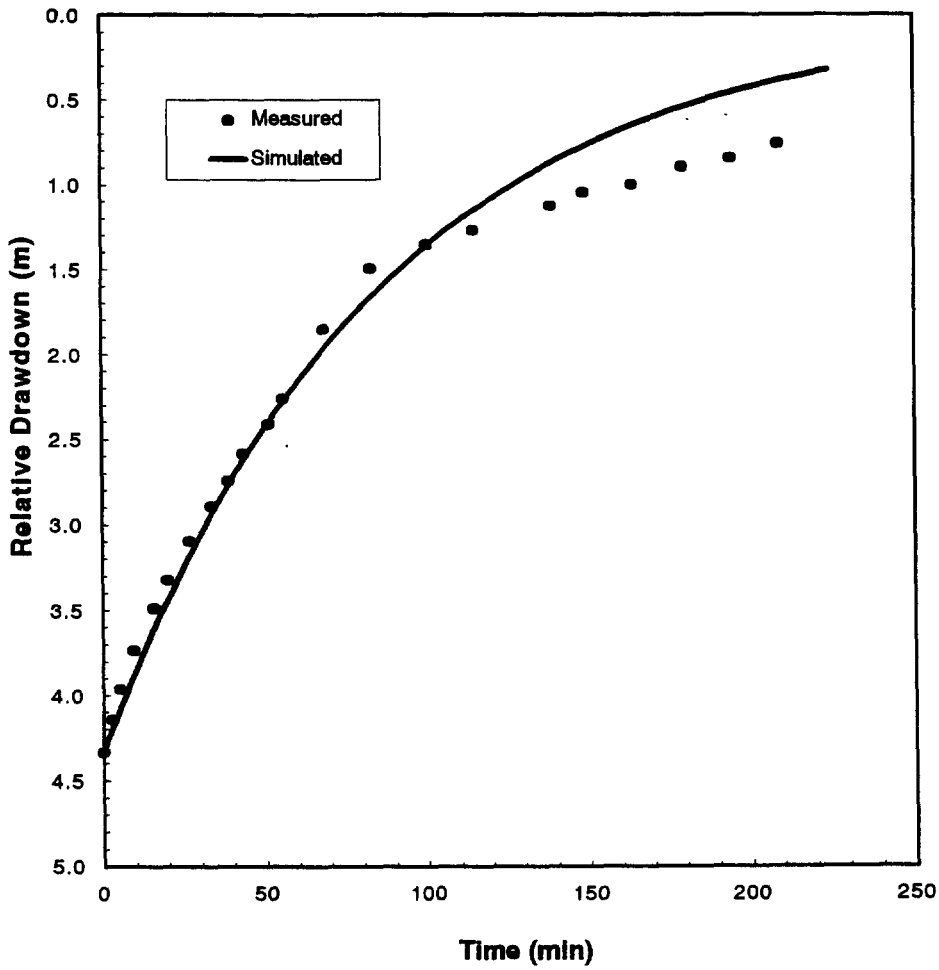

Figure USGM-1.1.USBM-1 slug test analysis (1963).

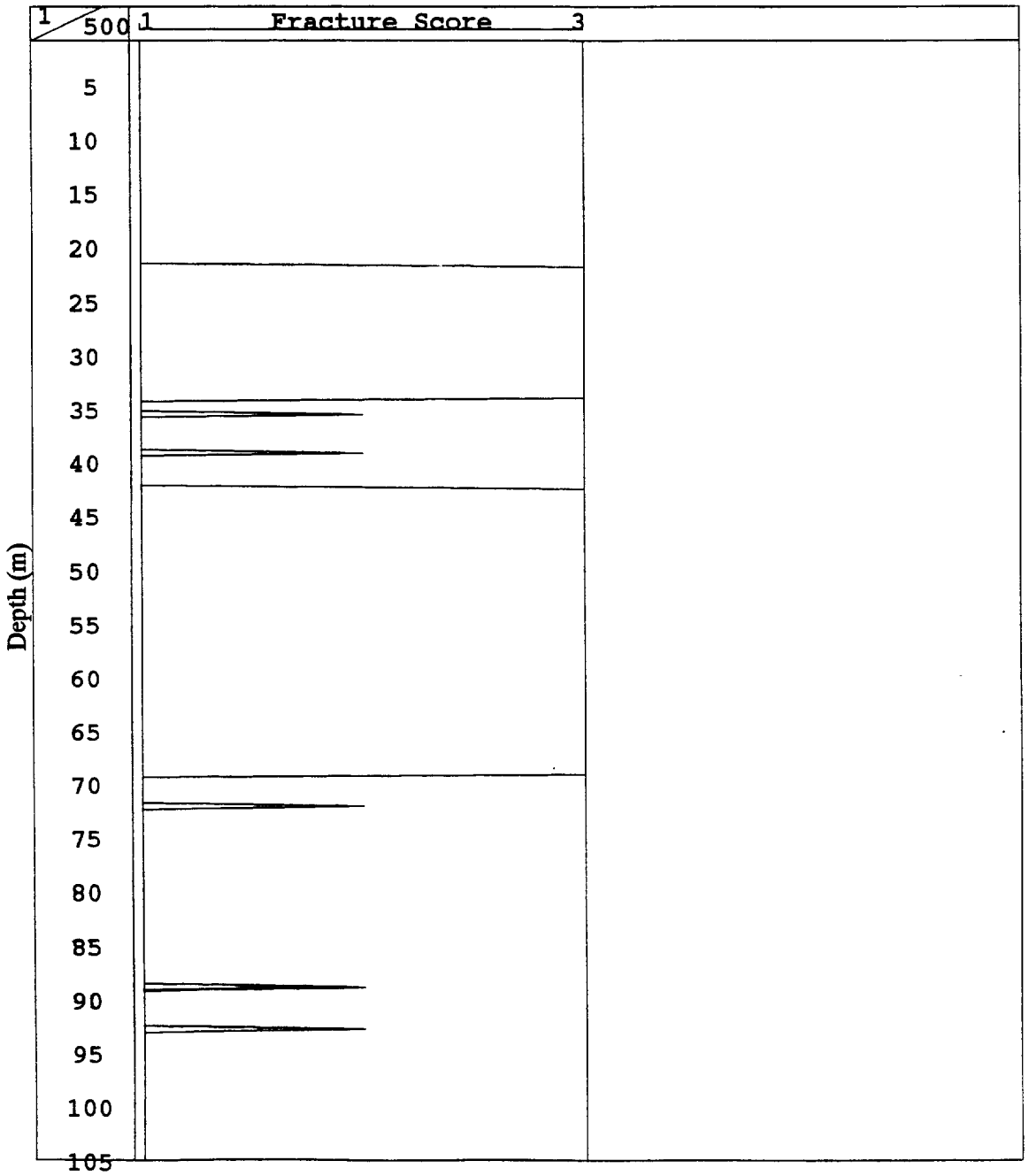

Figure USBM-1.3. USBM-1 fracture interpretation (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault).

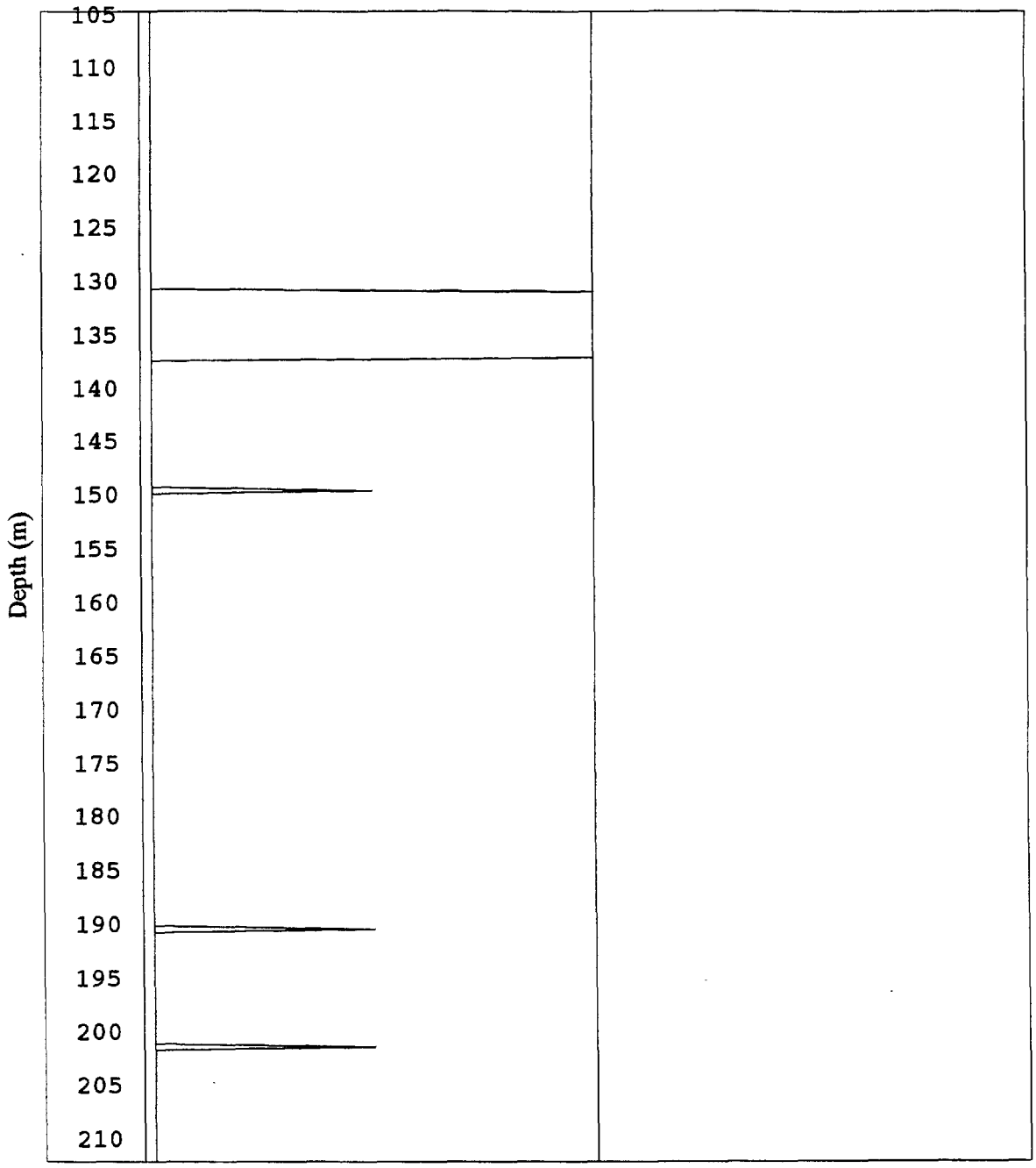

Figure USBM-1.3. USBM-1 fracture interpretation (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) (continued).

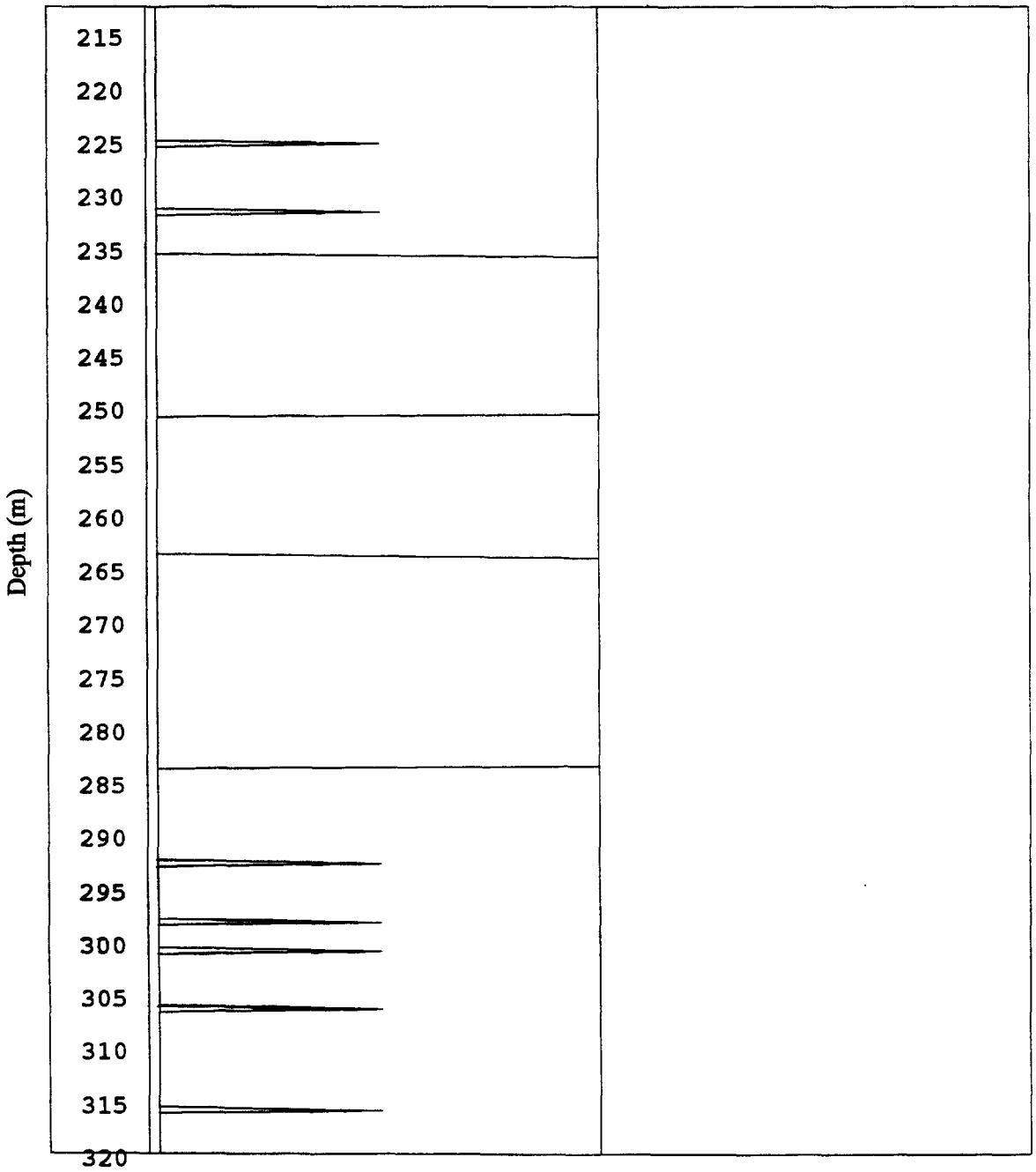

Figure USBM-1.3. USBM-1 fracture interpretation (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) (continued).

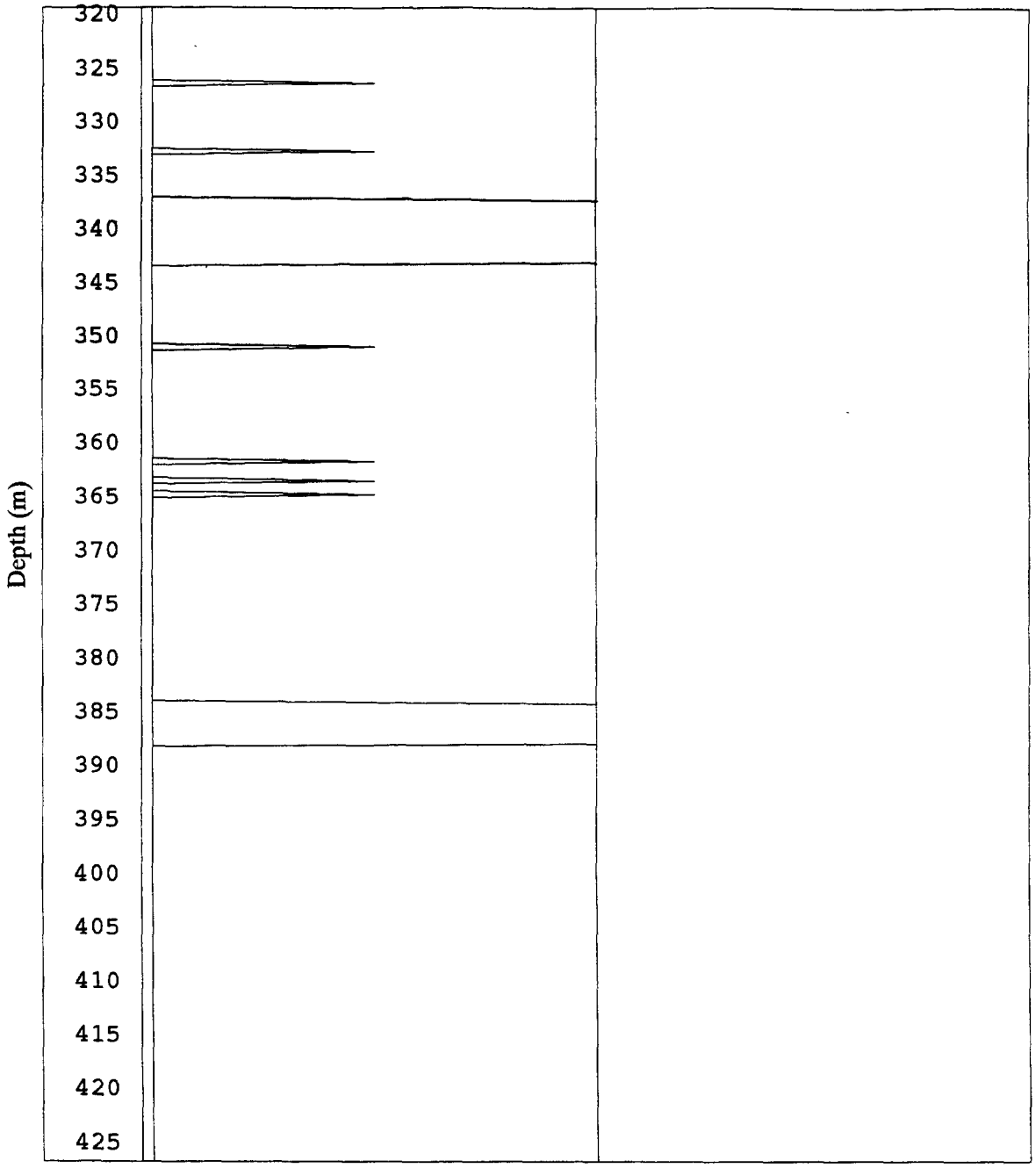

Figure USBM-1.3. USBM-1 fracture interpretation (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) (continued).

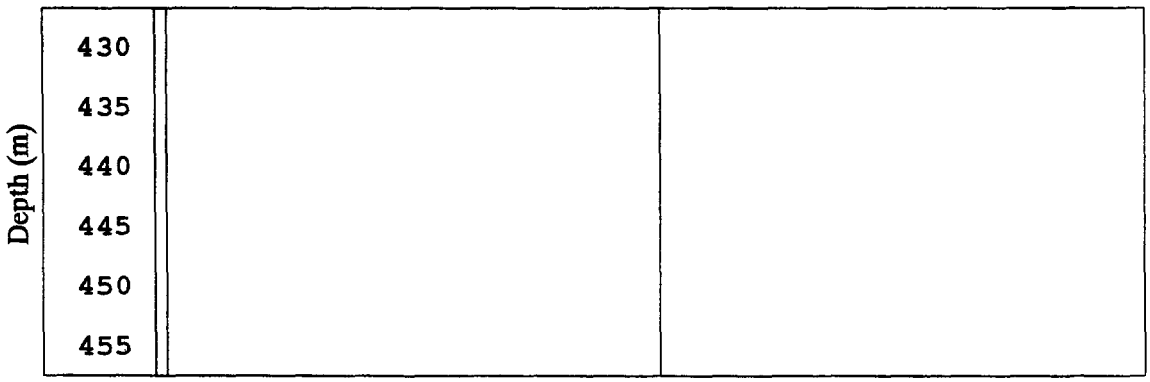

Figure USBM-1.3. USBM-1 fracture interpretation (1 = no fracture; 2 = small/medium fracture; 3 = large fracture or fault) (continued).

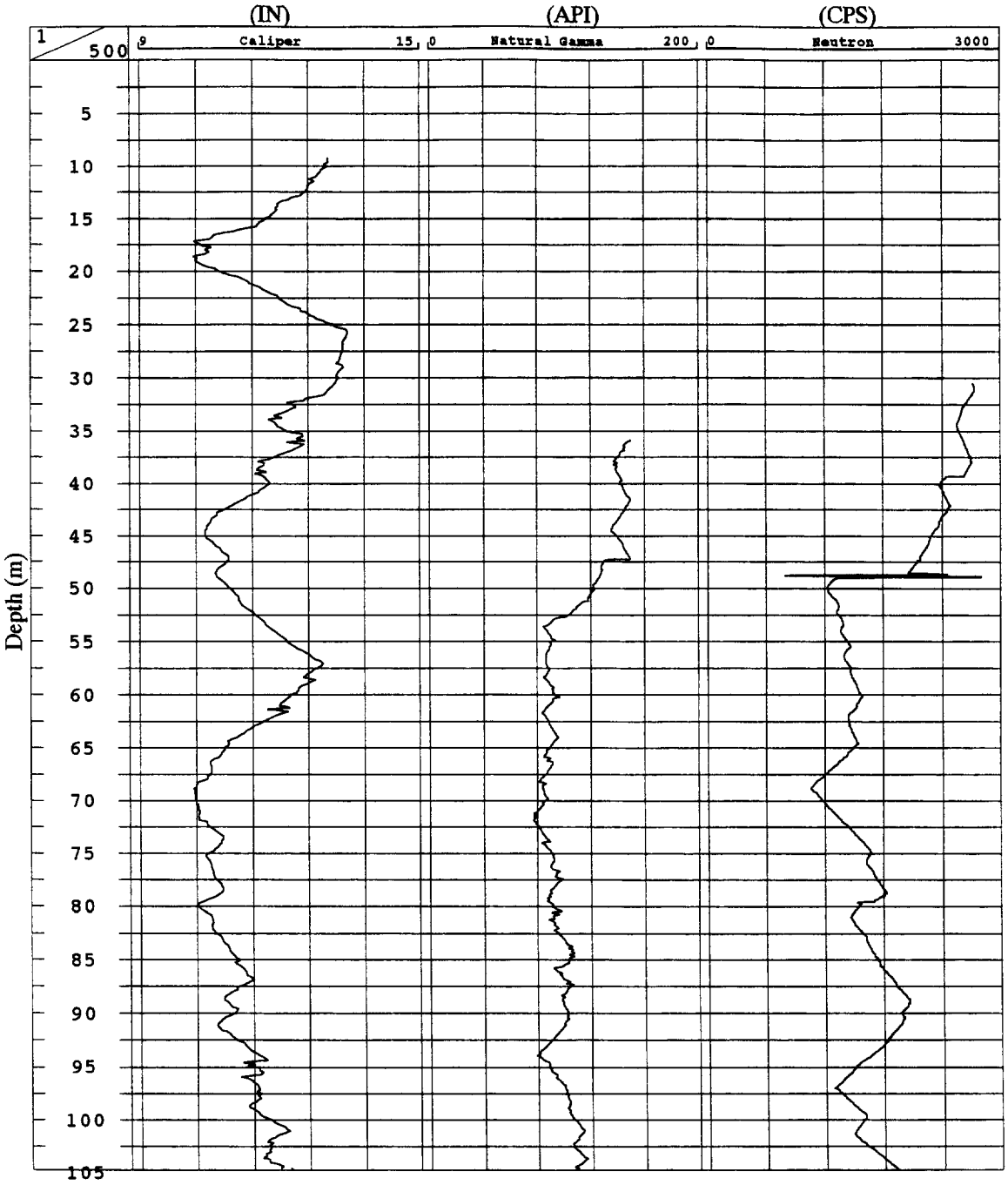

Figure USBM-1.4. USBM-1 caliper, natural gamma and neutron logs.

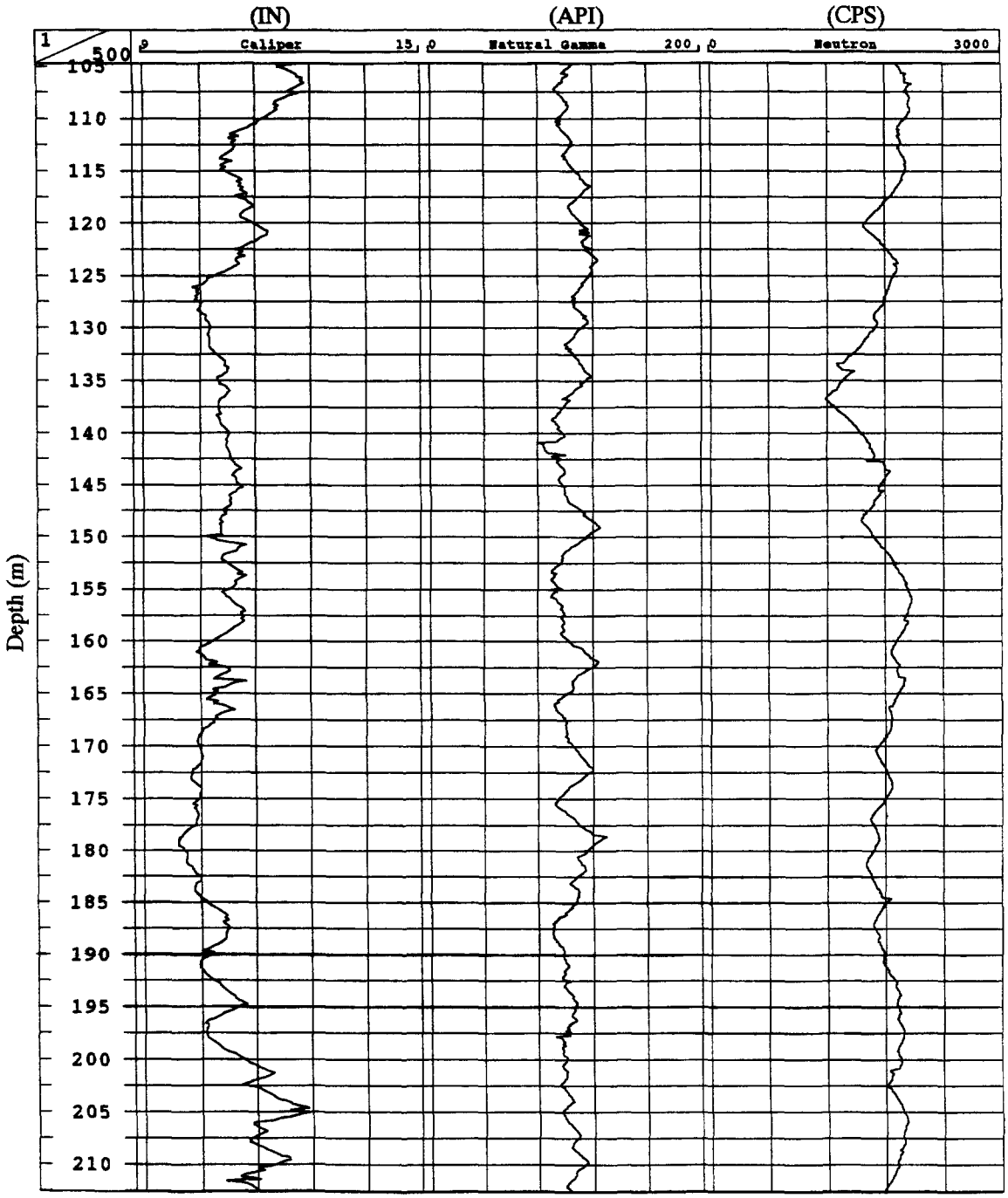

Figure USBM-1.4. USBM-1 caliper, natural gamma and neutron logs (continued).

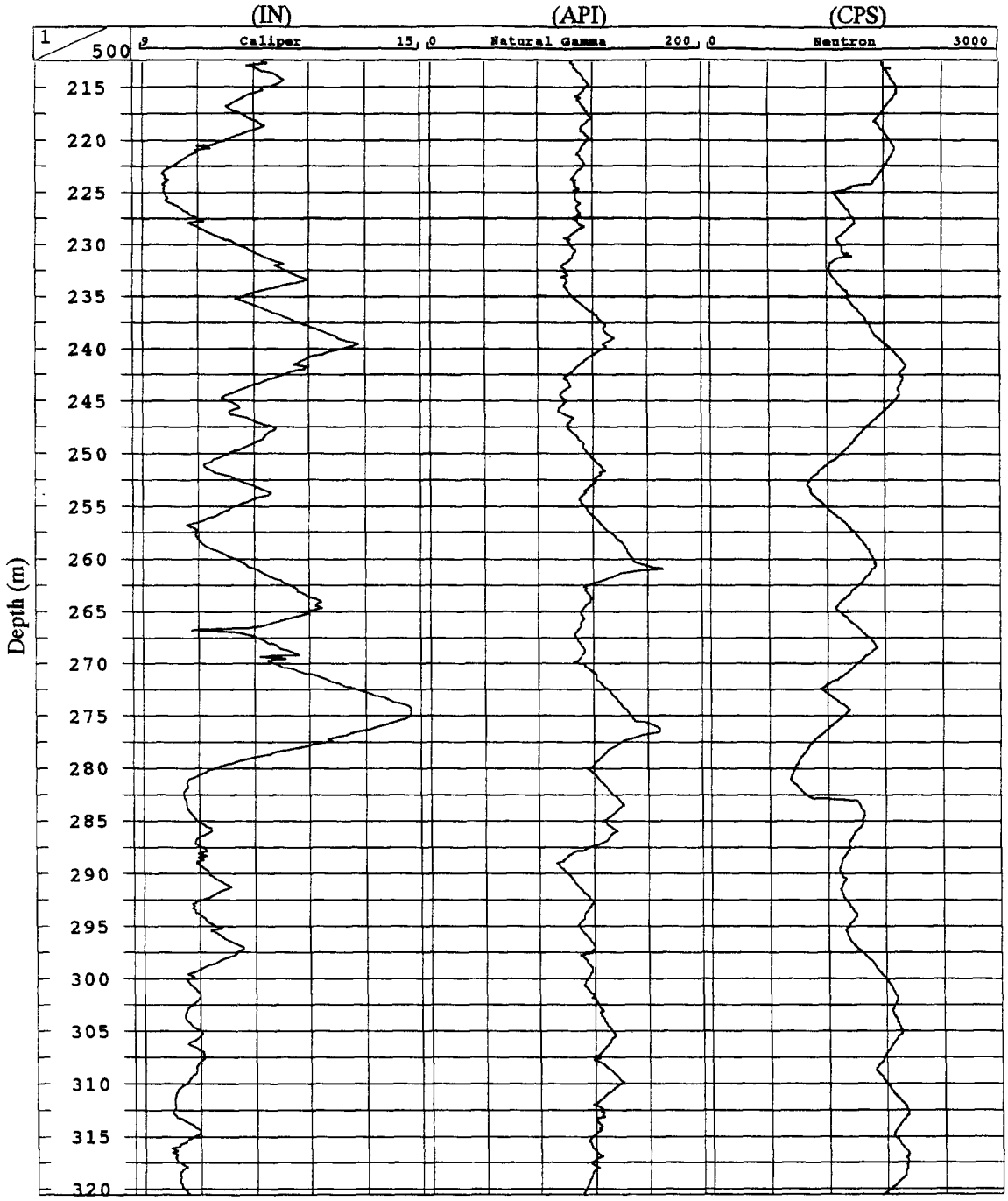

Figure USBM-1.4. USBM-1 caliper, natural gamma and neutron logs (continued).

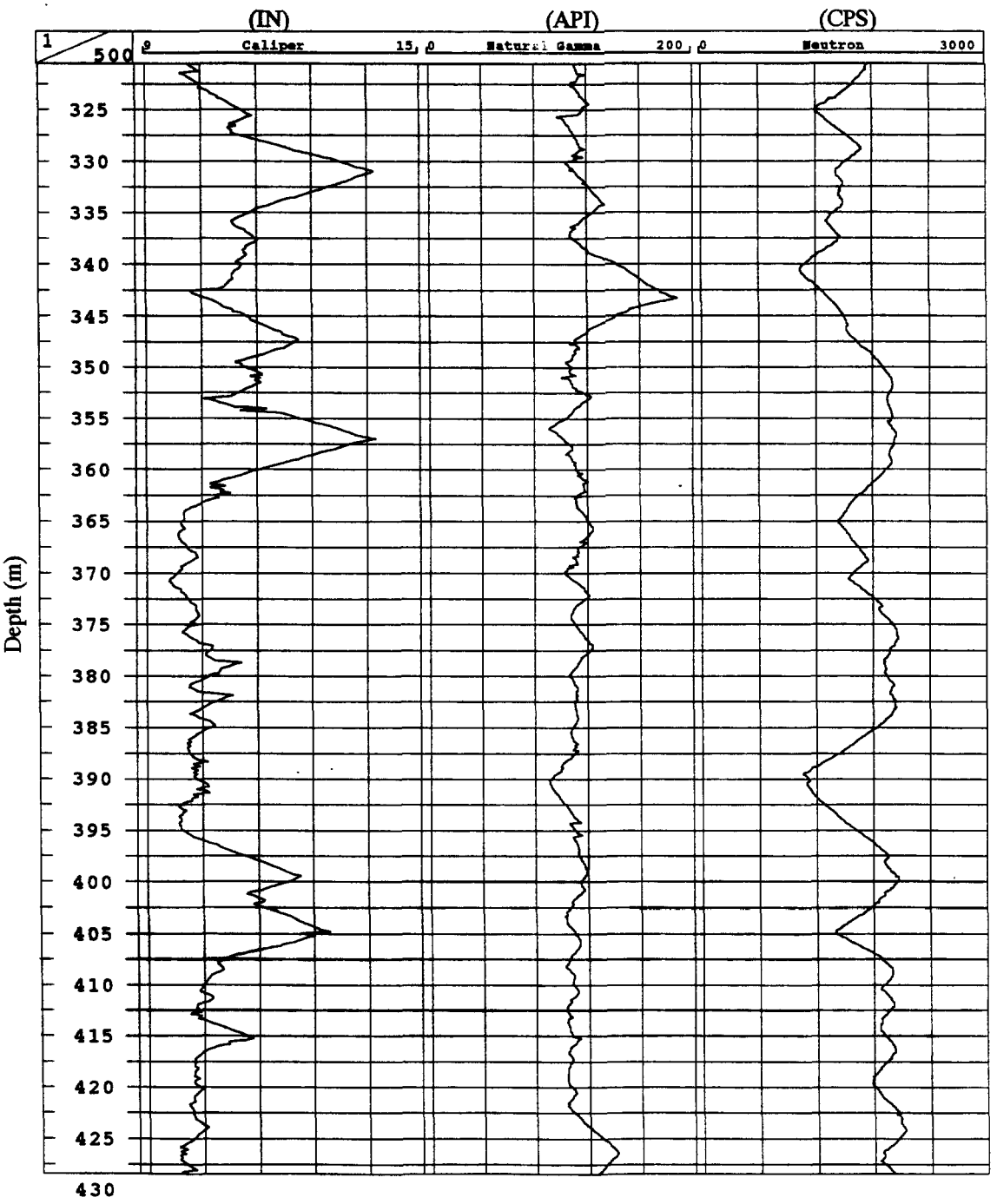

Figure USBM-1.4. USBM-1 caliper, natural gamma and neutron logs (continued).

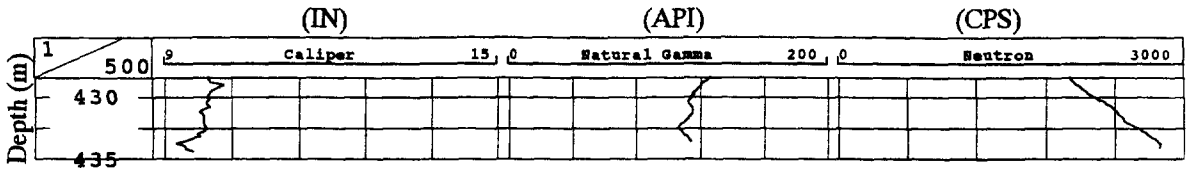

Figure USBM-1.4. USBM-1 caliper, natural gamma and neutron logs (continued).

ECH-D

Available Data

- Slug Test
- Water Level
- Caliper Log
- Gamma-Gamma Log
- Natural Gamma Log
- Neutron Log
- Spontaneous Potential Log
- Resistivity Log

Analysis	
Date:	7/19/1962
Method: Bouwer & Rice, 1976	
H (m):	321
R_c (m):	0.15
R_w (m):	0.15
L_w (m):	321
D (m):	1,000
A	5.26
B	9.38
L_N (R_c/R_w):	5.78
L_N ($D-H/R_w$):	6.0
Hydraulic Conductivity (cm/sec):	5.58E-07

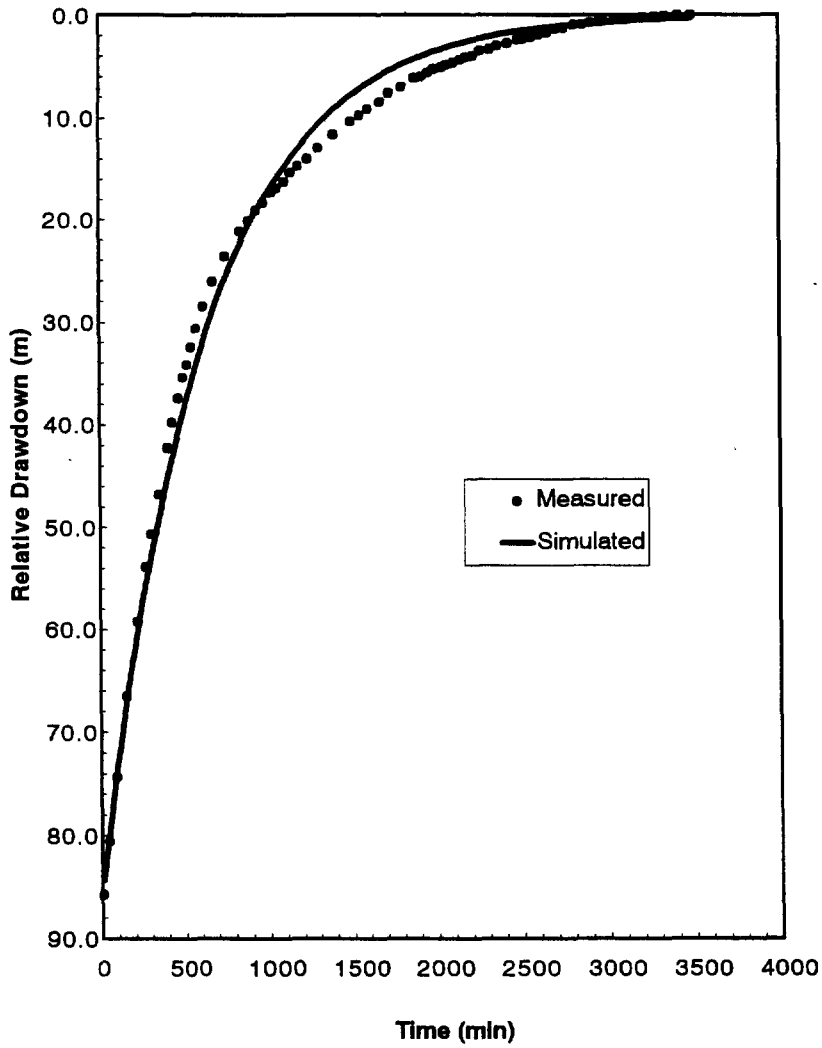

Figure ECH-D.1 ECH-D slug test analysis (1963).

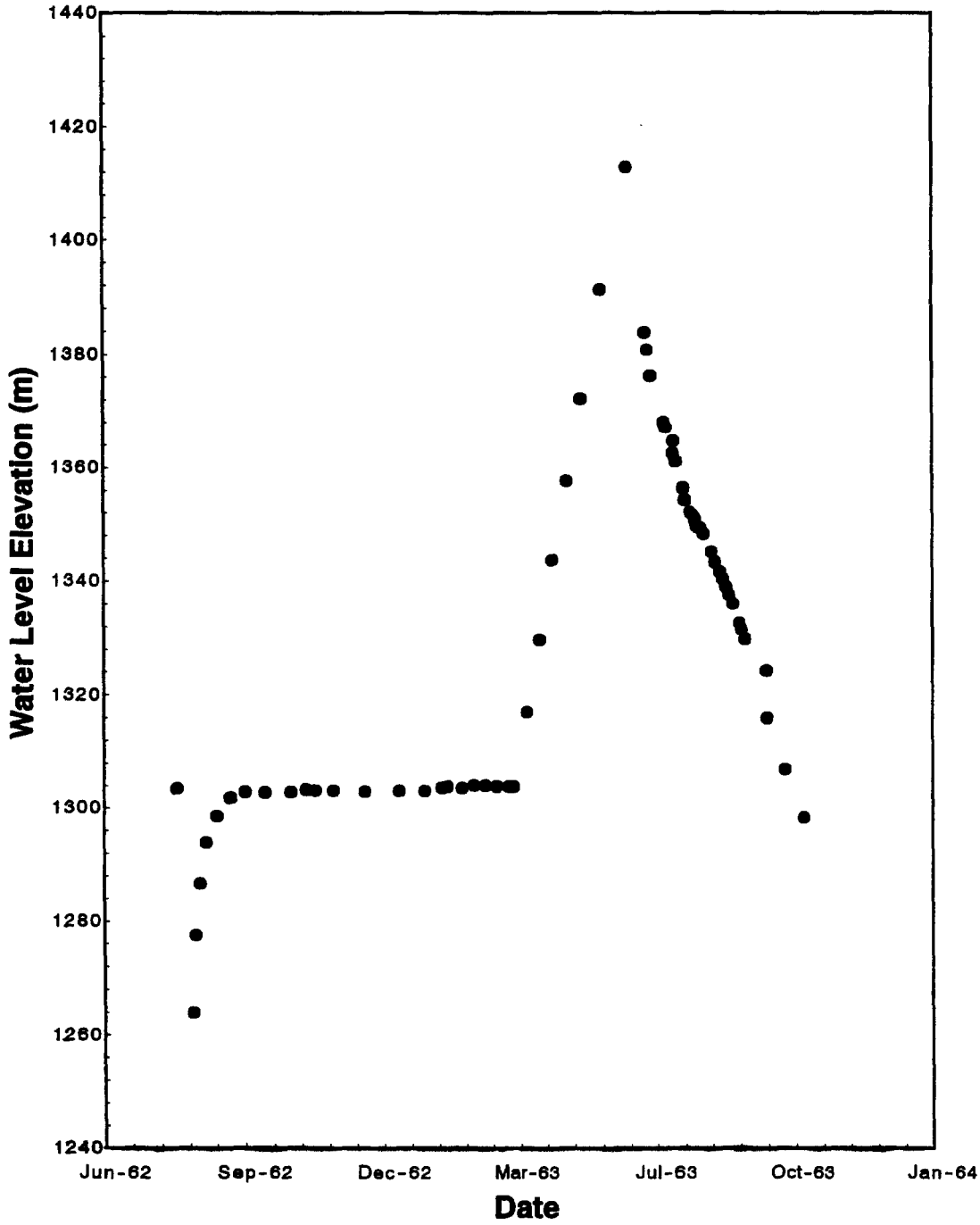

Figure ECH-D.2 Water level vs. time for ECH-D.

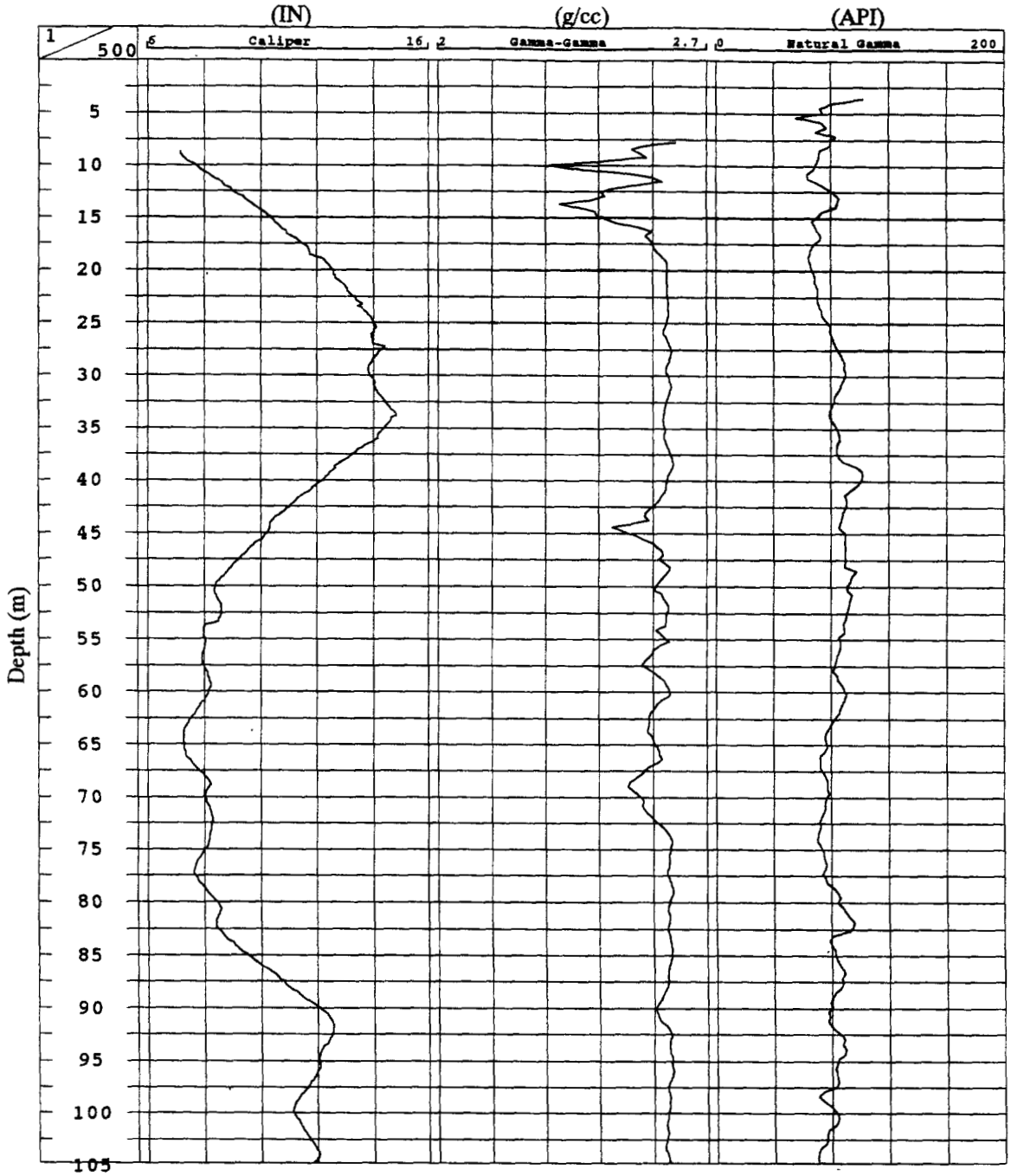

Figure ECH-D.3. ECH-D caliper, gamma-gamma density and natural gamma logs.

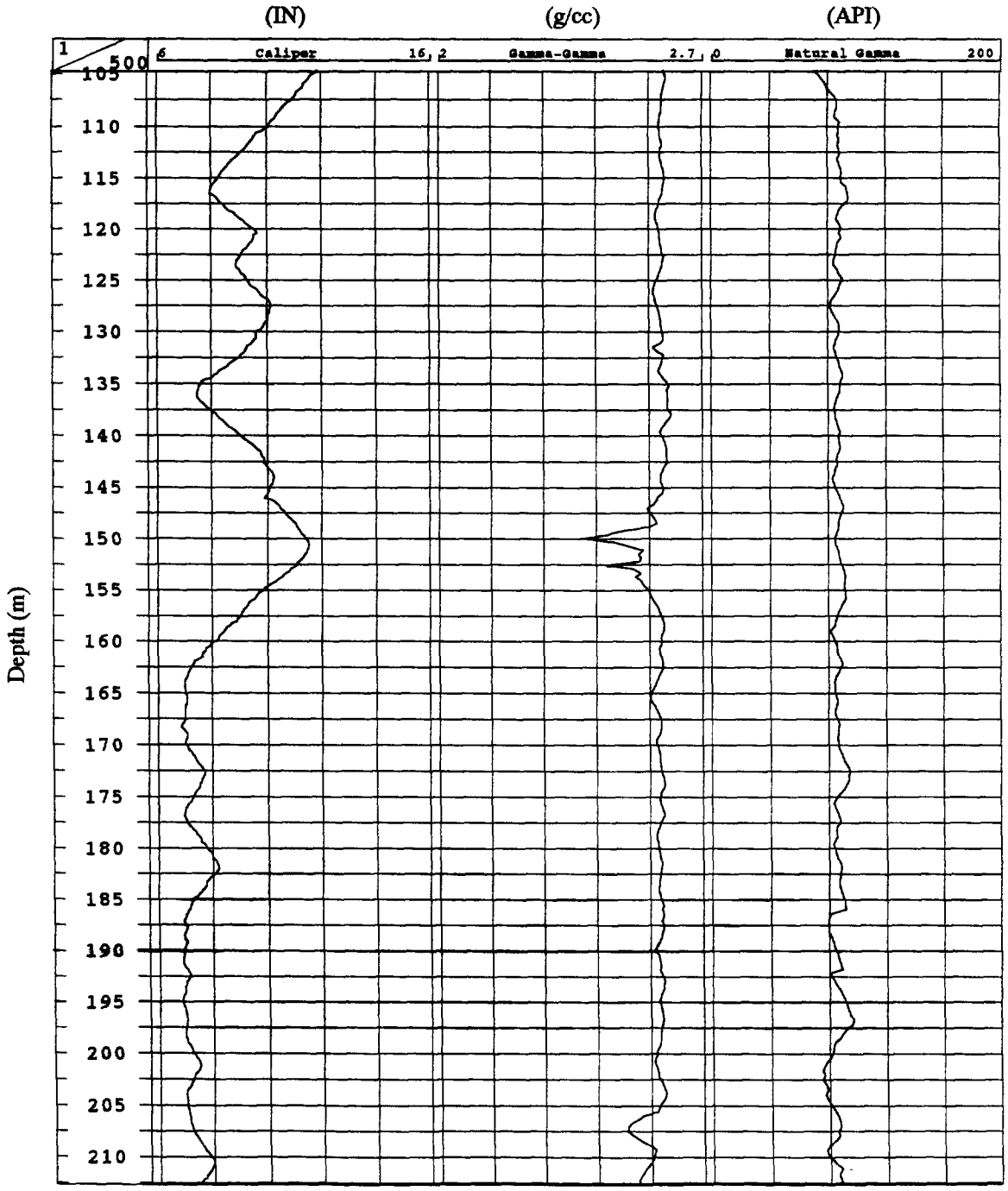

Figure ECH-D.3. ECH-D caliper, gamma-gamma density and natural gamma logs (continued).

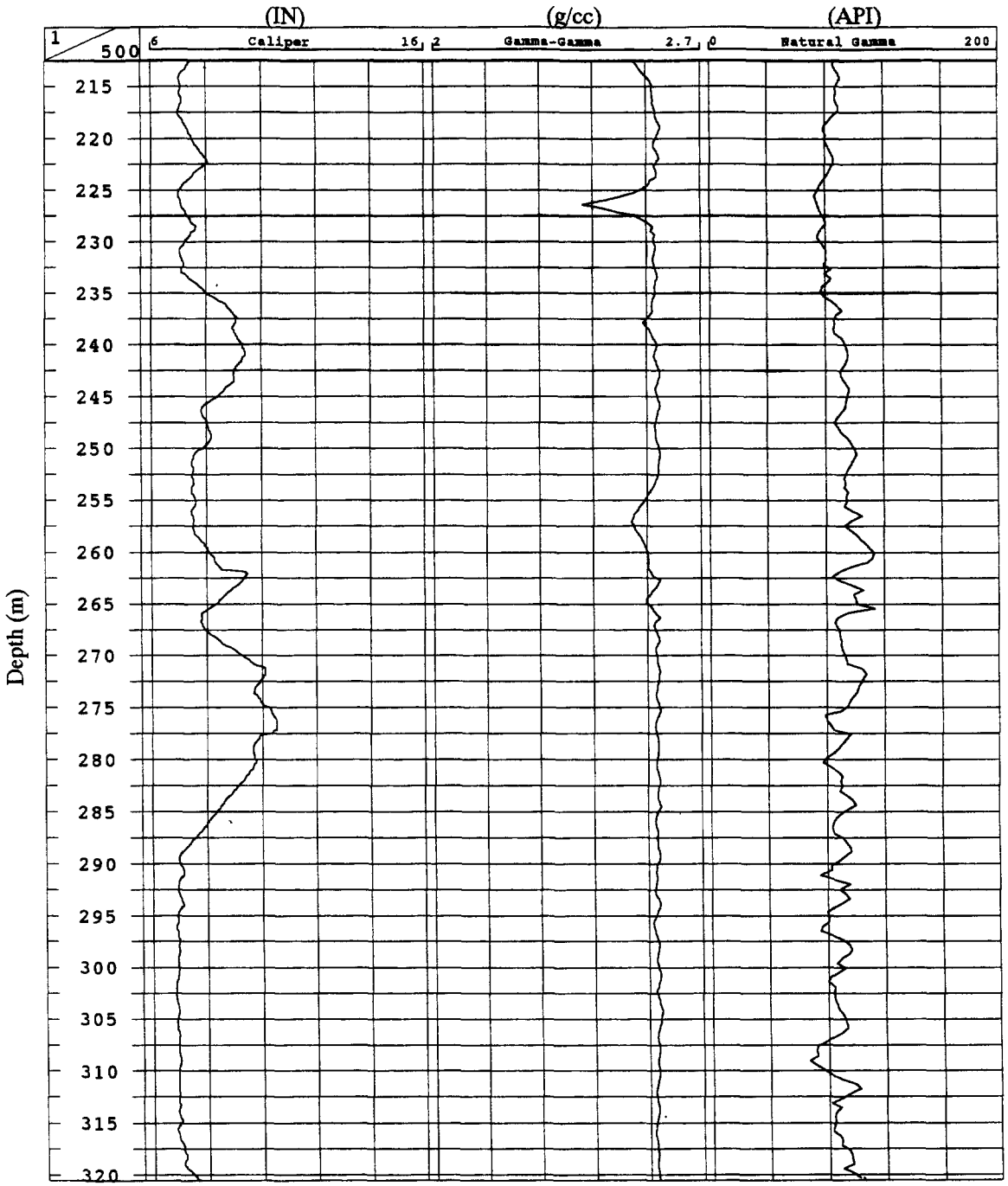

Figure ECH-D.3. ECH-D caliper, gamma-gamma density and natural gamma logs (continued).

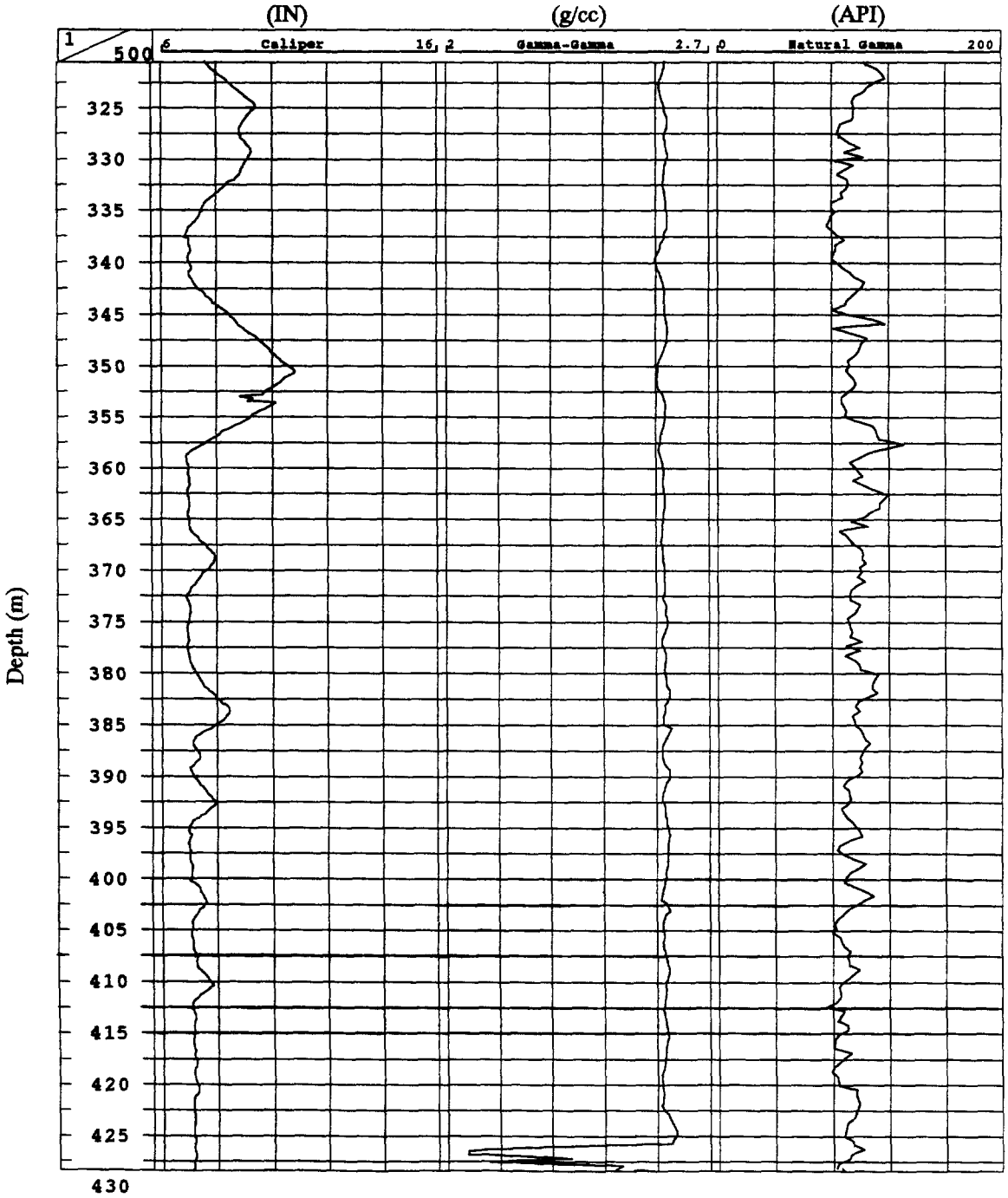

Figure ECH-D.3. ECH-D caliper, gamma-gamma density and natural gamma logs (continued).

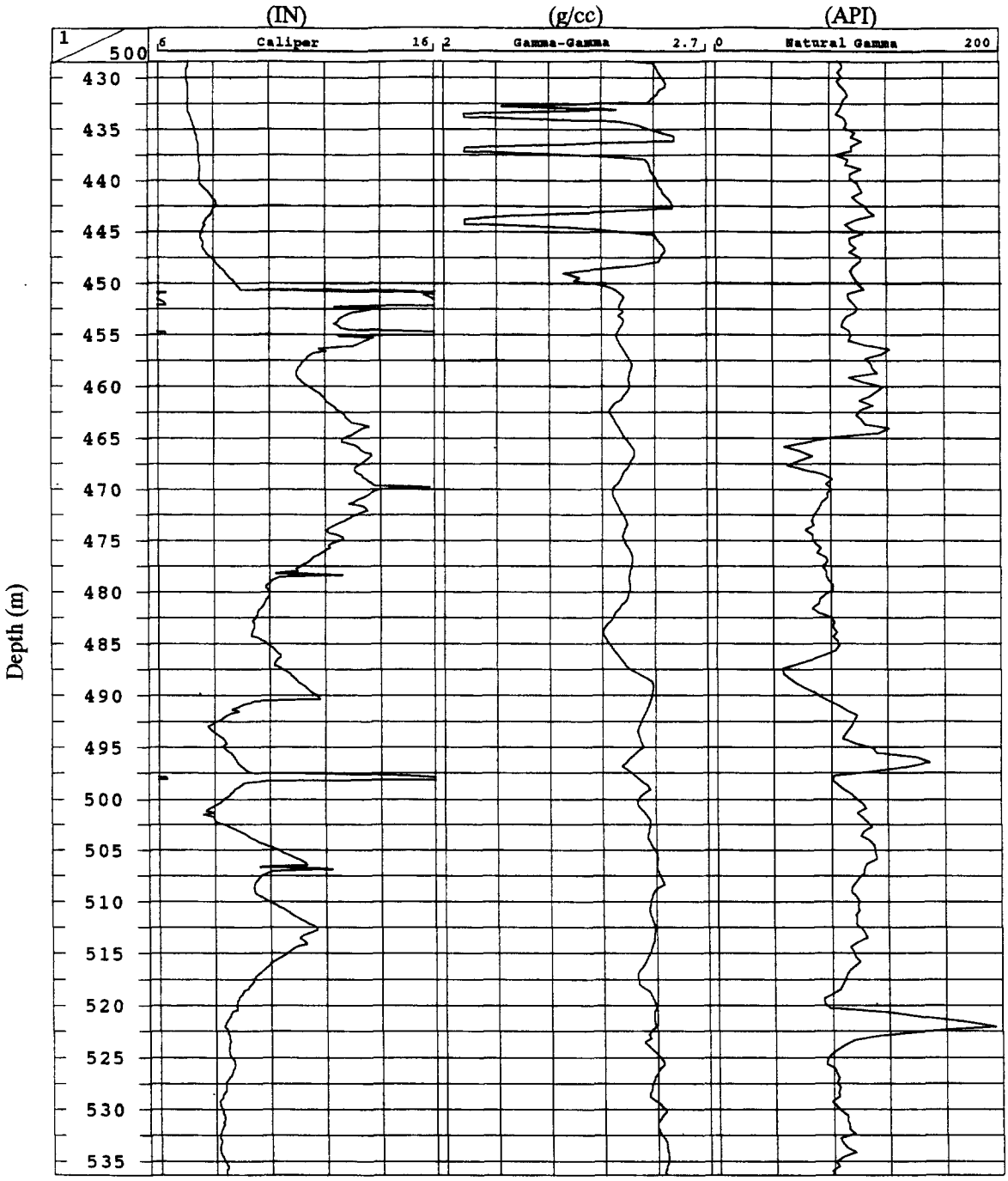

Figure ECH-D.3. ECH-D caliper, gamma-gamma density and natural gamma logs (continued).

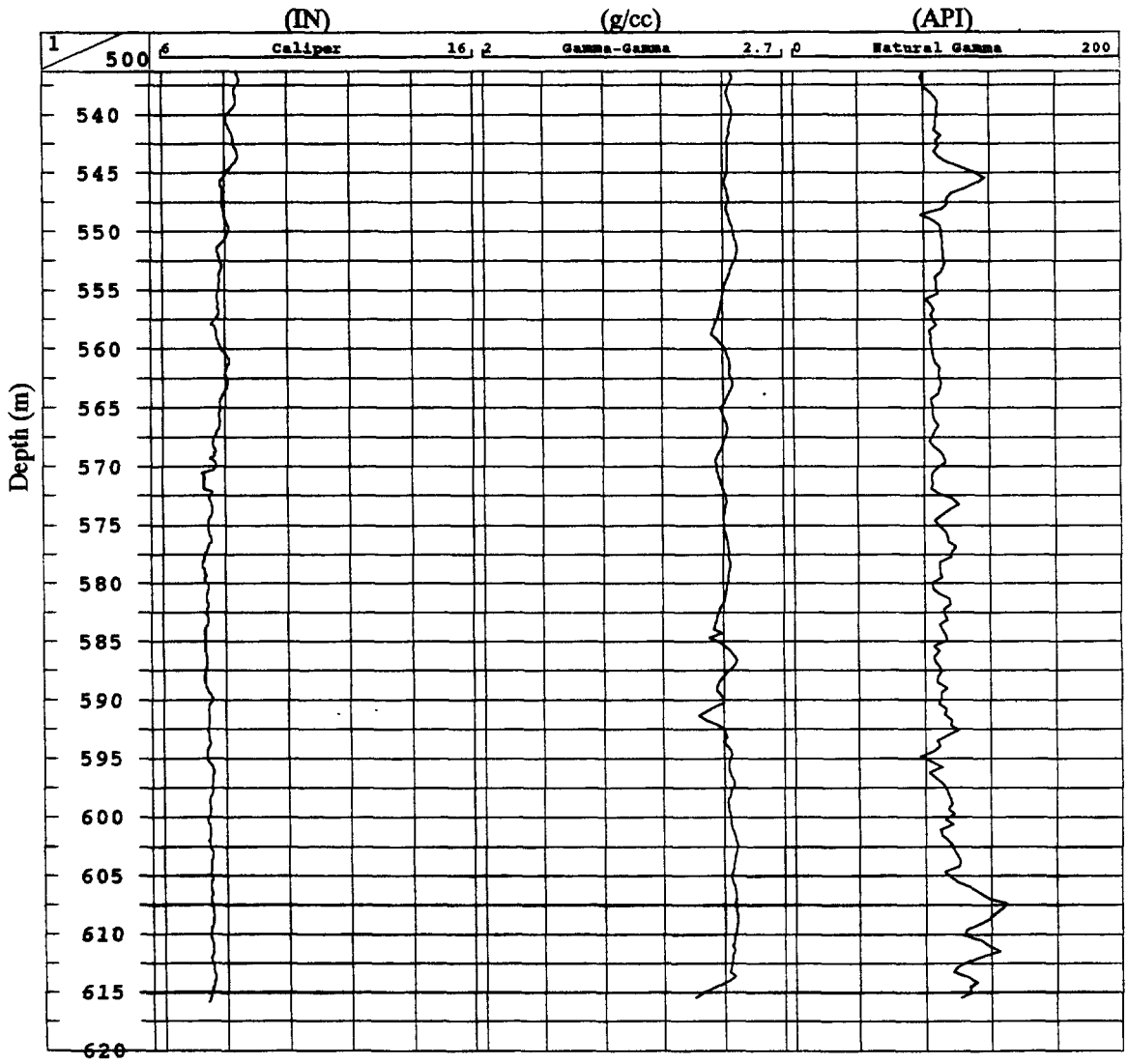

Figure ECH-D.3. ECH-D caliper, gamma-gamma density and natural gamma logs (continued).

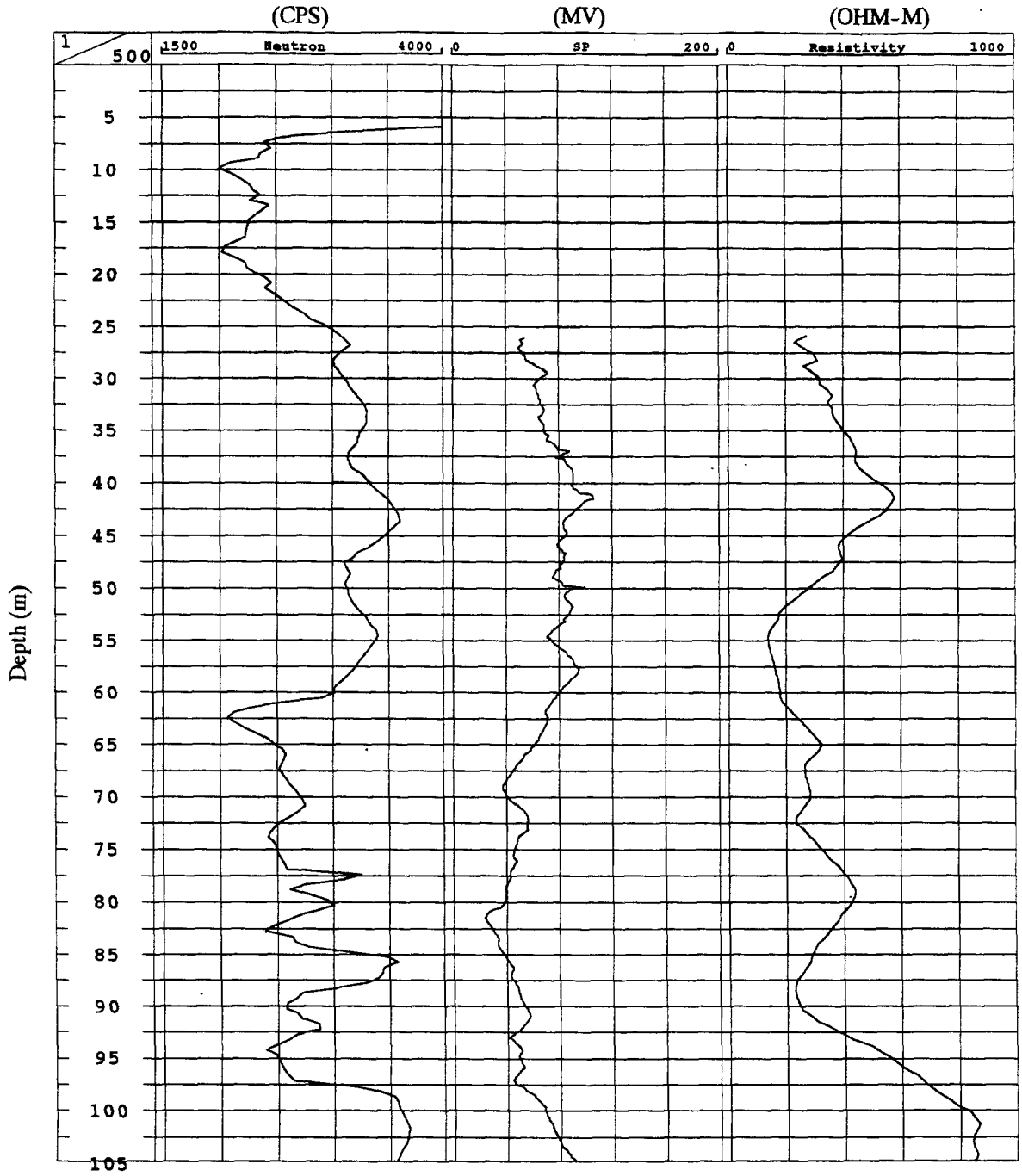

Figure ECH-D.4. ECH-D neutron, spontaneous potential and resistivity logs.

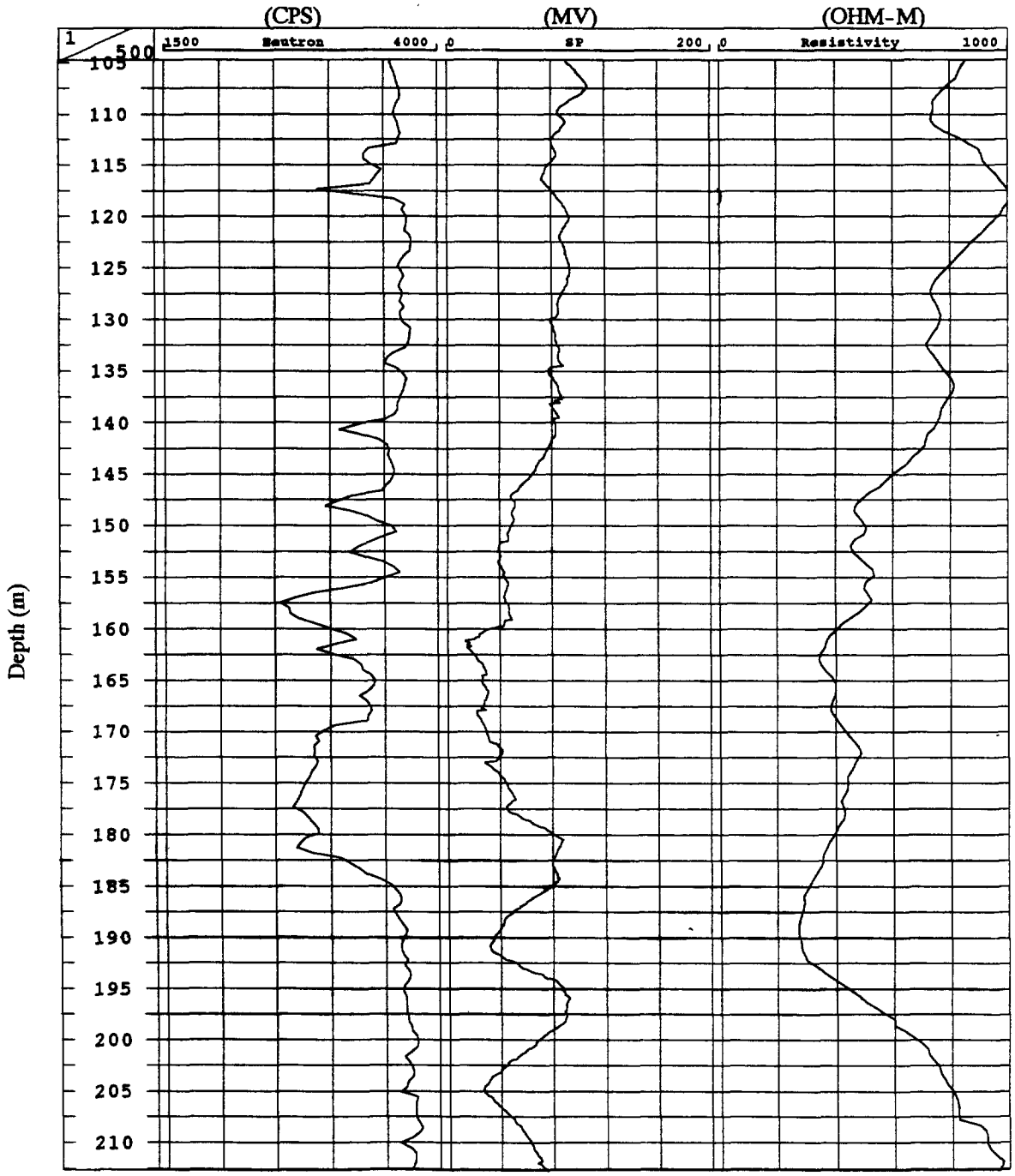

Figure ECH-D.4. ECH-D neutron, spontaneous potential and resistivity logs (continued).

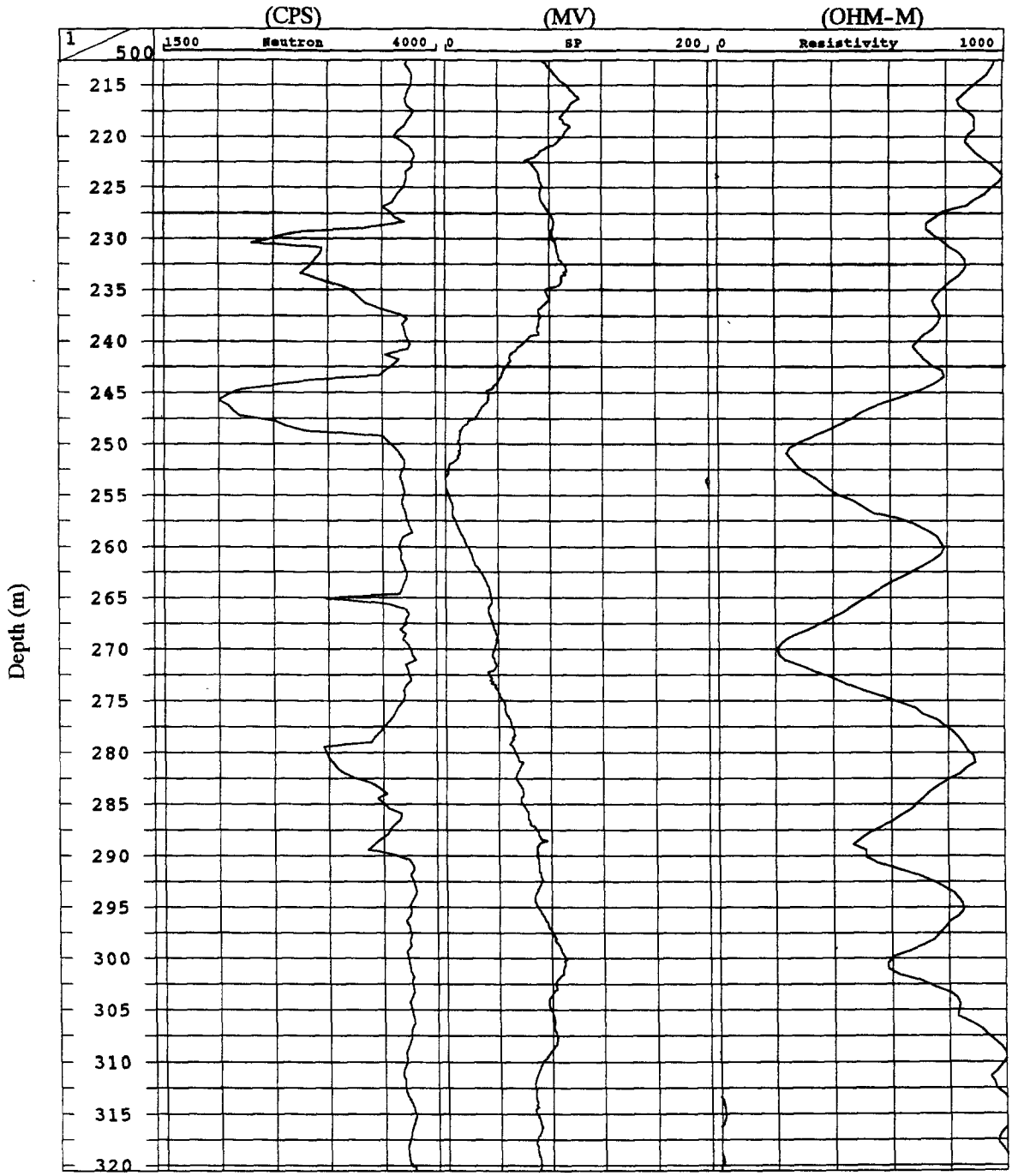

Figure ECH-D.4. ECH-D neutron, spontaneous potential and resistivity logs (continued).

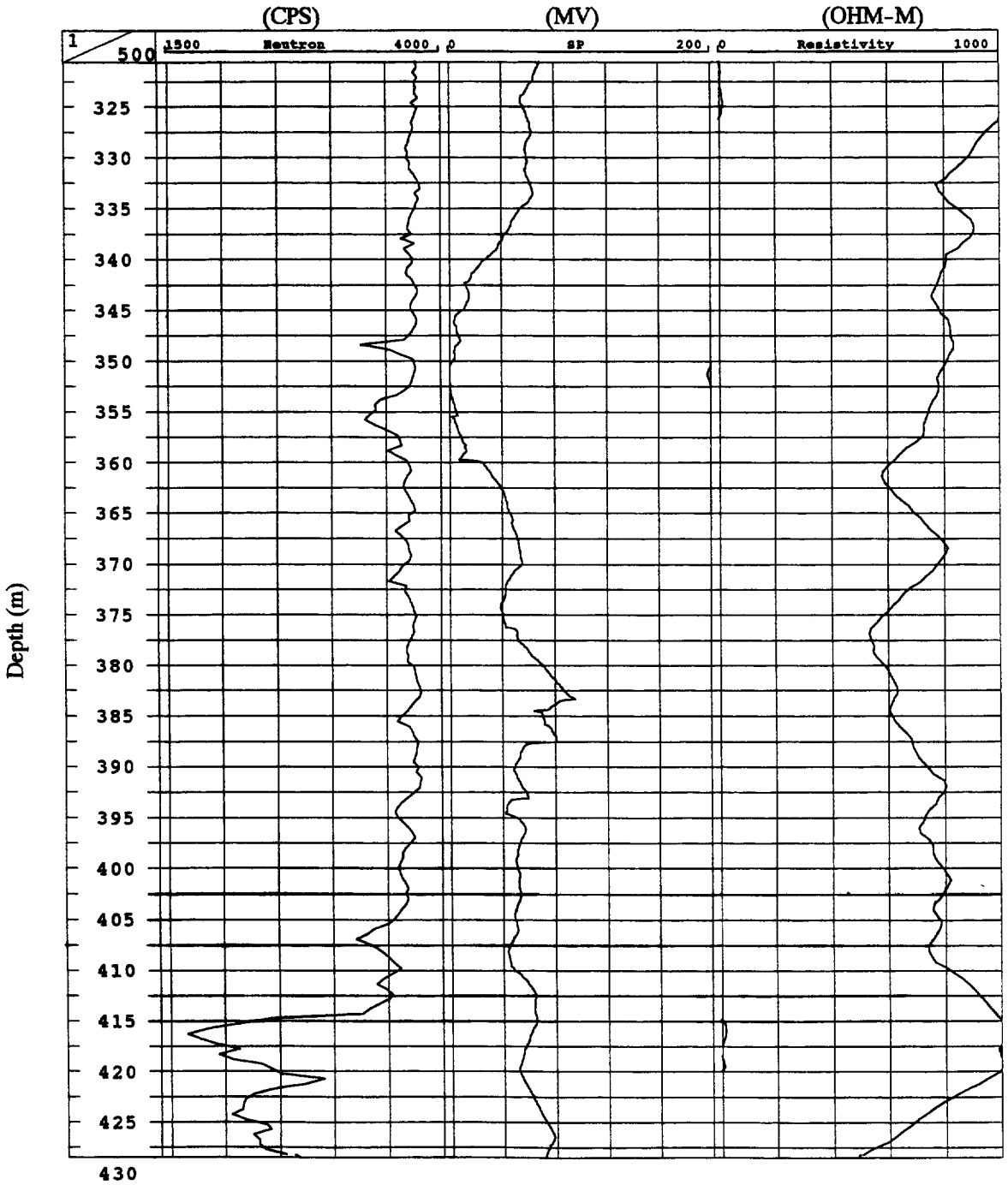

Figure ECH-D.4. ECH-D neutron, spontaneous potential and resistivity logs (continued).

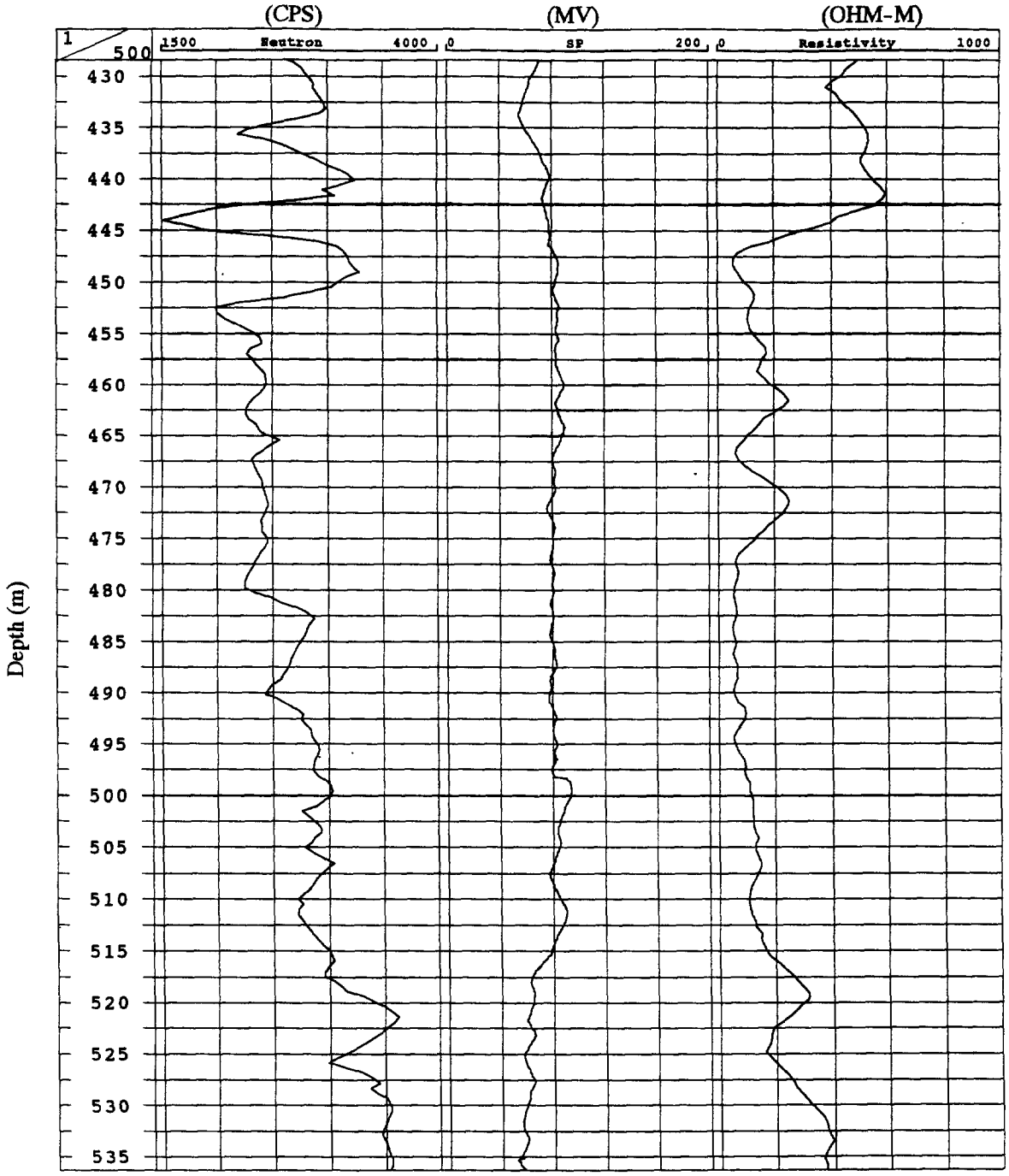

Figure ECH-D.4. ECH-D neutron, spontaneous potential and resistivity logs (continued).

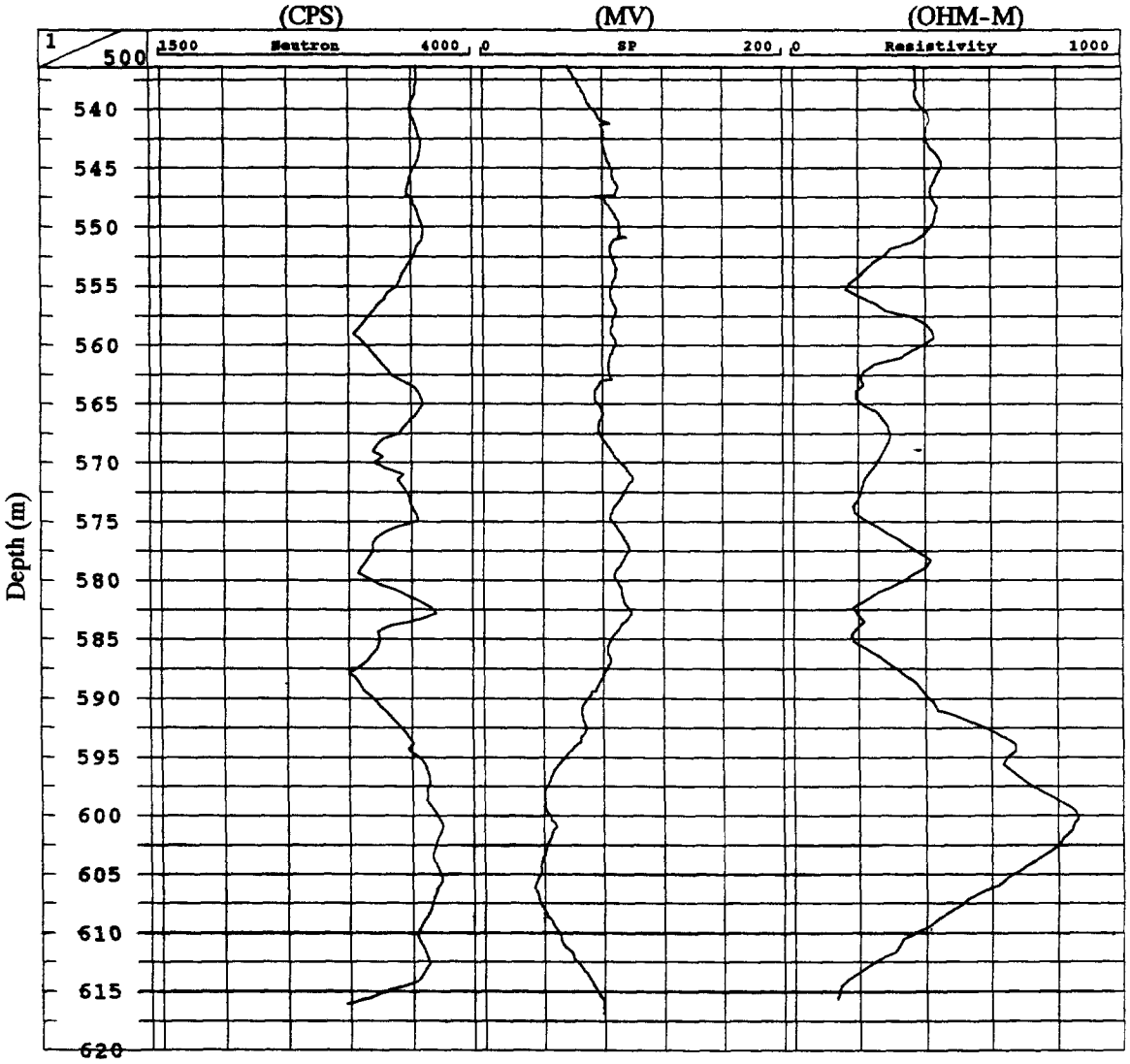

Figure ECH-D.4. ECH-D neutron, spontaneous potential and resistivity logs (continued).

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University and Community
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July 14, 2000

MEMORANDUM

TO: Distribution

FROM: Marjory Jones

Enclosed for your information is a copy of the final report entitled "Project Shoal Area - Field Data Summary Report," by T. Mihevc, G. Pohll and B. Lyles, DRI Pub. No. 45175, DOE/NV/11508-54, May 2000.

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