CONTRACTORS REPORT
SERIES 89-19

Defence Research Establishment Pacific
Centre de recherches pour la défense pacifique

MEASUREMENT OF GEOPHYSICAL PROPERTIES OF ARCTIC SEDIMENT CORES

Larry A. Mayer and Janice Marsters

DEPT. OF OCEANOGRAPHY, DALHOUSIE UNIVERSITY, HALIFAX, N.S.

for

DEFENCE RESEARCH ESTABLISHMENT PACIFIC
Research and Development Branch
Department of National Defence

Canada

DREP CRS-89-19

Measurement of Geophysical Properties of Arctic Sediment Cores

Larry A. Mayer and

Janice Marsters

Department of Oceanography

Dalhousie University

Halifax, N.S.

B3H 4J1

DSS Contract # W7708-7-9408/01-SB

Scientific Authority: Dr. John Ozard

INTRODUCTION:

In support of research conducted at the Defence Research Establishment Pacific the physical and acoustic properties of a number of Arctic cores were measured by scientists at Dalhousie University, Halifax. This report represents the preliminary presentation of the results of these measurements and includes all determinations completed as of 31 August 1988.

A total of 55 cores from four diverse locations have been analyzed:

1. Lincoln Sea: approximately 80 nm from Alert - 1 core
2. Ice Island Cores: in region of Nansen Channel - 3 cores
   in region of Sverdrup Channel - 3 cores
   on outershelf off Nansen Channel - 4 cores
   in region of Meighan Plateau and Slope, and Peary Channel - 6 cores
3. Arctic Inter-Island Channels - Norwegian Bay - 22 cores
4. Hudson Bay - 13 cores

This document presents lithologic descriptions, acoustic (velocity and attenuation) and physical property (saturated bulk density and water content) measurements from these cores. Porosity and grain size measurements are still in progress and will be reported in a supplemental report.

METHODS:

Corers:

The quality of physical and acoustic property measurements is directly related to the degree to which the sampling procedure disturbs the material. The degree of disturbance is, in turn, related to the ratio of the core diameter to the wall thickness of the corer and thus, for the most part, the wider the core barrel, the higher the quality of the sample. The data presented in this report represents samples taken with three different corers:

Lincoln Sea - approx. 3 cm diameter corer

Ice Island and Inter-Island Channels - 6 cm diameter Benthos corer

Hudson Bay - 10 cm diameter piston corer

The wider diameter of the corer used in Hudson Bay implies that, in general, these samples should be the least disturbed and thus the most reliable measurements. The wide diameter also permits the measurement of acoustic properties simultaneously along the core axis (longitudinal) and across the core axis (transverse) and thus provides two independent measurements at each level (see acoustic property discussion).

Acoustic properties:

In order to make acoustic and physical property measurements the cores were split along their longitudinal axis at the Dalhousie core laboratory. One half of the split core

was used for lithological descriptions and preserved for archive while the other half was used for sampling and analyses.

Velocity:

Compressional wave speed and attenuation measurements were made at approximately 10 cm intervals using the Dalhousie Digital Sediment Velocimeter (DSV) (Fig. 1). The DSV is a computer-controlled system that uses two, or four, orthogonally arranged probes, inserted into the sediment core. An extremely high-speed A/D converter (20 MHz) digitizes the entire wave form for the calculation of attenuation and measures the time of flight of a sound wave through the sediment. When only two probes are used (cores less than 10 cm in diameter) they are oriented longitudinally (along the length of the core) and have a separation of 7 cm. When four robes are used, simultaneous longitudinal and transverse (across core = 5 cm separation) measurements are made. The temperatures of both the sediment and the lab are also monitored and recorded digitally. A calibration measurement using distilled water is made before each core section is analyzed. This calibration measurement is used to monitor transducer separation and degradation as well as to provide the standard against which attenuation calculations are made.

Velocity calculations are made by determining the time of flight between the transmit pulse and the received waveform. Both transmit and received waveforms are displayed in real time, on a NICOLET digital oscilloscope. An automatic detection algorithm using a simple threshold detect, determines the position of the first break of the received waveform and displays the pick in expanded view on the oscilloscope. This pick is reviewed by the operator and can be accepted or manually overridden if deemed erroneous. All velocity calculations are corrected to -1°C using the equations of Wilson (1960).

Attenuation:

The waveform data collected with the DSV was post-processed to calculate net acoustic attenuation in the ultrasonic waveband (100 kHz to 1 MHz). The procedure utilizes both the water calibration wave pulse and the waveform transmitted through the sediment sample downcore. The relative spectral energy as a function of frequency between the reference and the sample signal quantifies the attenuation.

Figure 2a shows a typical series of transmitted waveforms displayed as a function of depth downcore. This core consisted entirely of a uniform olive green silty mud. A comparison of the transmitted waveform through the clay with the pulse propagated through the distilled water reveals the drop out of higher frequencies in the sample pulse near the first instance of energy arrival (at 50 microsec). The consistent amplitude and phase between adjacent waveforms in the clay establish the repeatability of this kind of measurement.

To calculate attenuation these waveforms were sampled between 35 and 75 microsec and their amplitude spectra were calculated using the maximum entropy method (MEM). In Fig. 2b the spectra for the water calibration pulse (dashed line) and for the sample signal (solid line) are pictured for the waveform closest to the surface of the core. These spectra clearly and quantitatively demonstrate the relative decrease in spectral amplitude

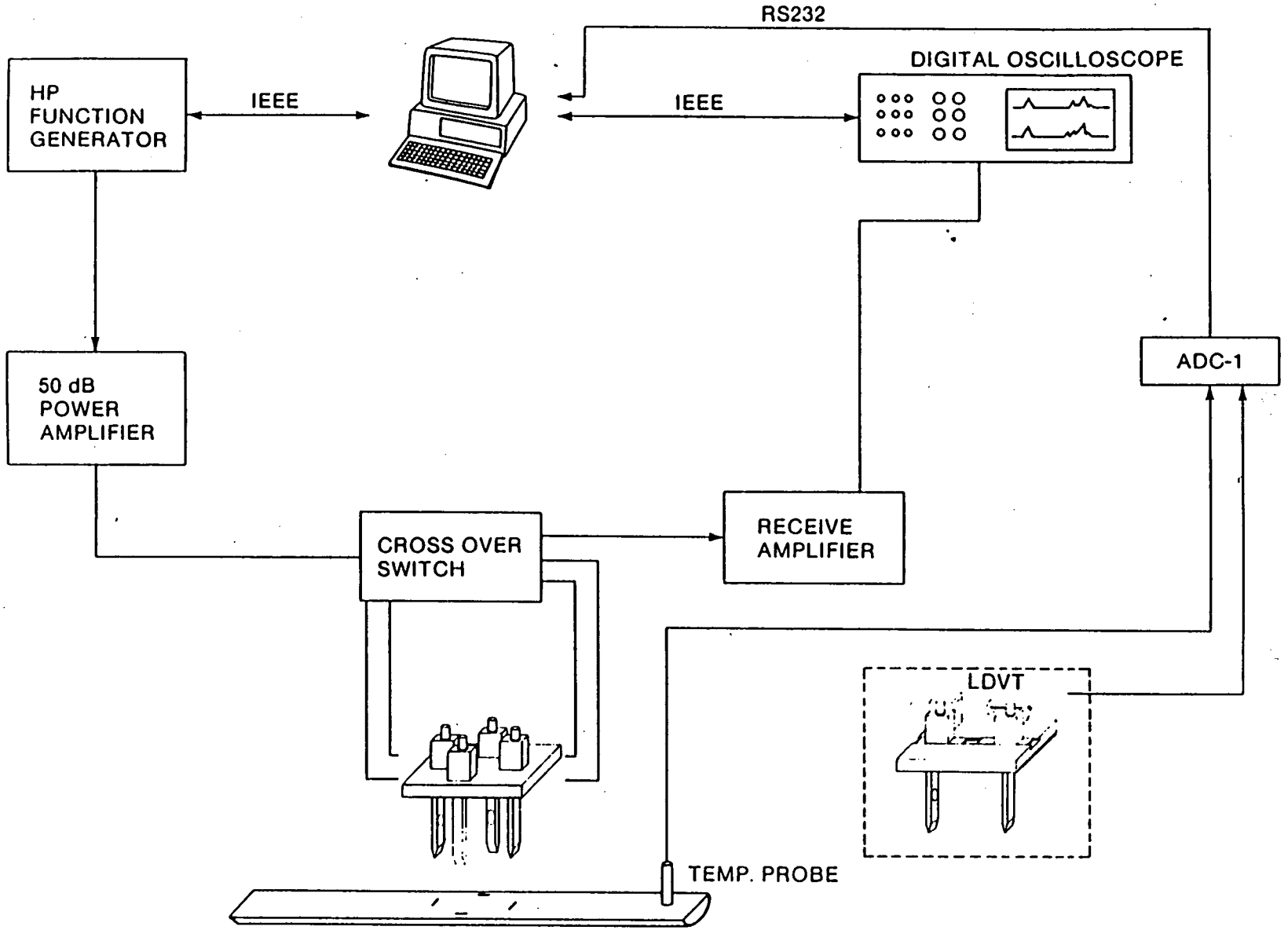

Figure 1. Schematic of Digital Velocimeter System.

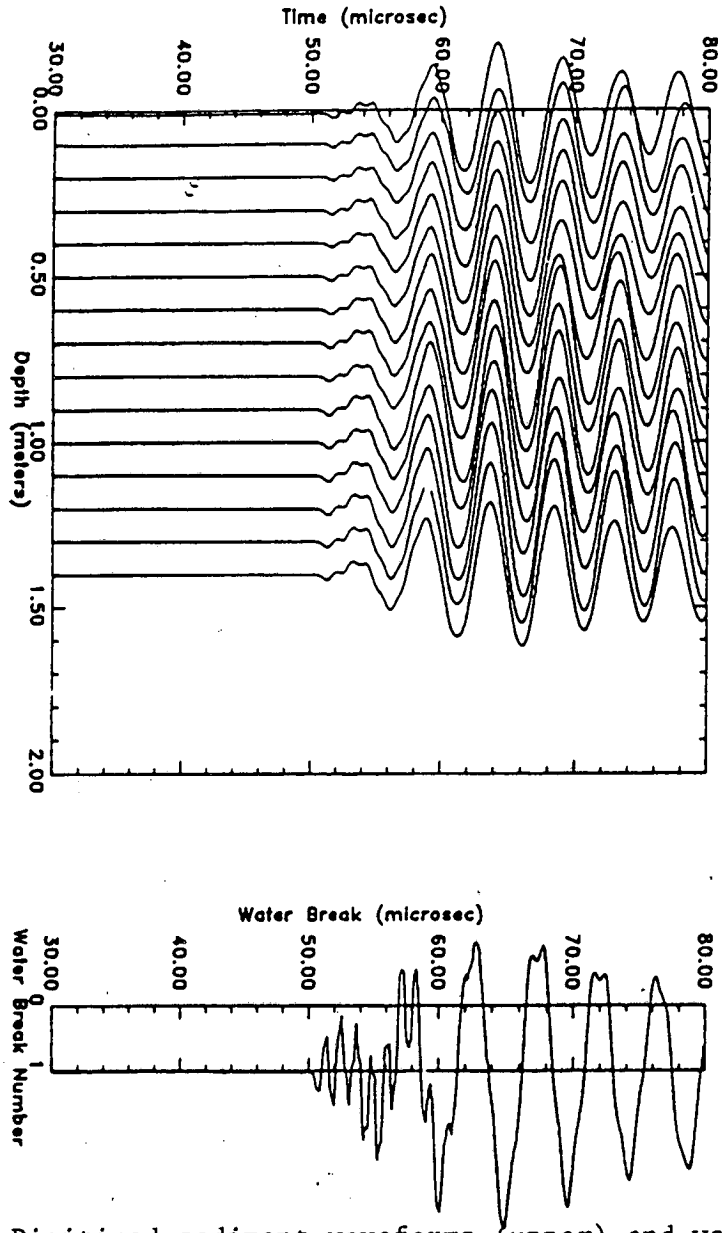

Figure 2a. Digitized sediment waveforms (upper) and water calibration

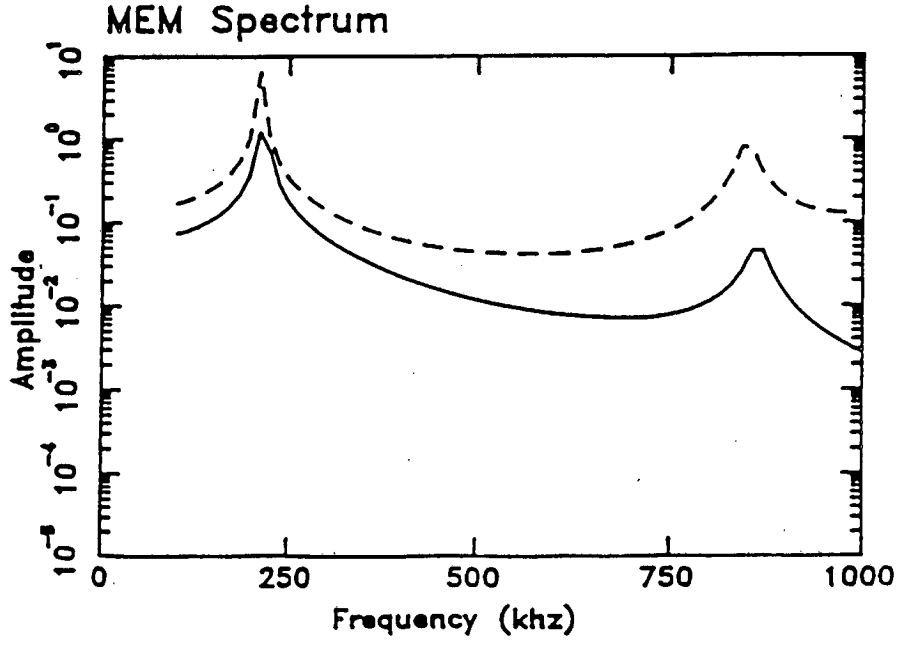

Figure 2b. Spectrum of water calibration (dashed) and sediment wave (solid)

as a function of frequency. If the spectrum of the water waveform is W(f) and the sample waveform is S(f), then the net attenuation, A(f), at a given frequency, f, is given by

$$A(f) = -8.686\ log\ (S(f)/W(f))/dx\ in\ dB/meter$$

where dx is the transducer spacing.

This procedure was performed using both Fourier techniques and the MEM, with similar estimates resulting. However, the Fourier derived values exhibited more random variation associated with side lobes produced by windowing and therefore only the MEM results are presented here.

In Fig. 3a net attenuation estimates for all waveforms in the example core are plotted as a function of frequency. Estimates are only plotted for those spectral amplitudes that are at least 0.5% of the maximum values in both the water calibration and sample spectra. The attenuation values show a net increase as frequency increases; in addition the estimates are repeatable between adjacent measurements. In the plots of down core attenuation, the net attenuations at the middle of the ultrasonic waveband (500 kHz are presented). In Fig. 3b, the expected net attenuation based on Blot's theory is superimposed on the attenuation estimates assuming a clay medium with a grain size of 6 microns and porosities of 60, 70 and 80%. This plot illustrates the feasibility of extending the ultrasonic results to lower, seismic frequency, but it is not meant to rigorously model the data presented in this report.

A second, newly developed attenuation calculating method has also been applied to the data. This technique uses a causal (Butterworth) filter to separate the waveforms (both water calibration and received waves) into discrete frequency bands and then directly compares the ratio of waveform amplitudes. While this technique is computationally more intensive, it is free of the potential problems that can result from spectral analyses of short time series. A comparison of the results of the spectral and amplitude techniques for core 87-028-068 is shown in Fig. 4. The consistency of the results of these two independent techniques gives us confidence in the reliability of our measurements.

Physical Properties:

In the middle of each 7 cm interval across which velocity and attenuation measurements were made, a density and water content sample was taken. Saturated bulk density was determined with a penta-pycnometer which uses the displacement of helium gas to calculate the volume of the sample. The saturated bulk density is then calculated as the ratio of the wet mass to the volume of the wet sample:

$$\rho sat = Saturated\ bulk\ density = \frac{mass\ of\ wet\ sample}{volume\ of\ wet\ sample} \quad \frac{gms}{cm^3}$$

The samples were then dried at 110°C for 24 hours in order to calculate water content, expressed as a percentage of the dry weight of the sample.

$$Water\ content = \frac{mass\ of\ wet\ sample - mass\ of\ dry\ sample}{mass\ of\ dry\ sample} * 100\%$$

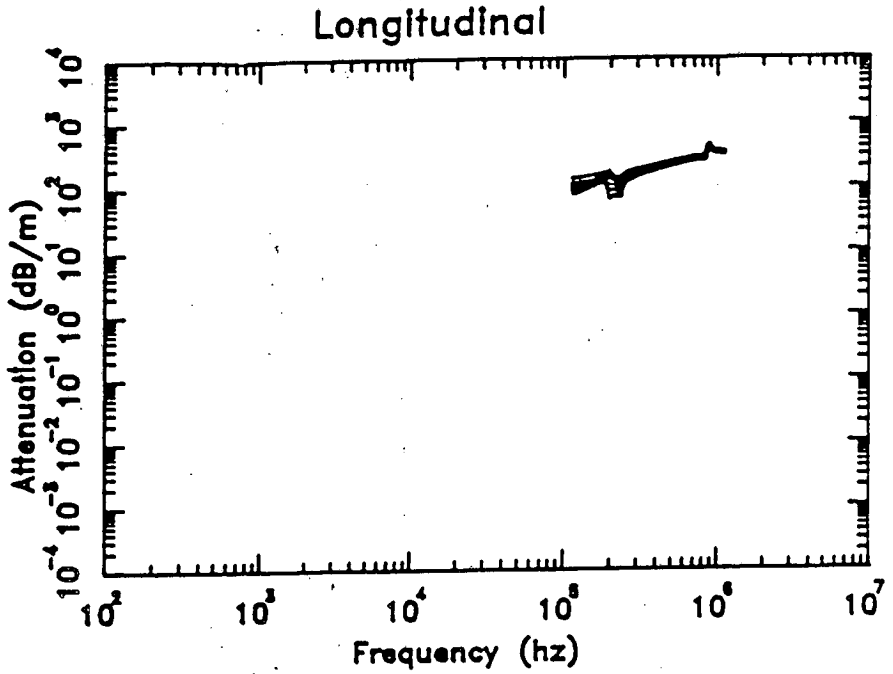

Figure 3a. Superposition of all attenuation vs. frequency estimates for clay sequence.

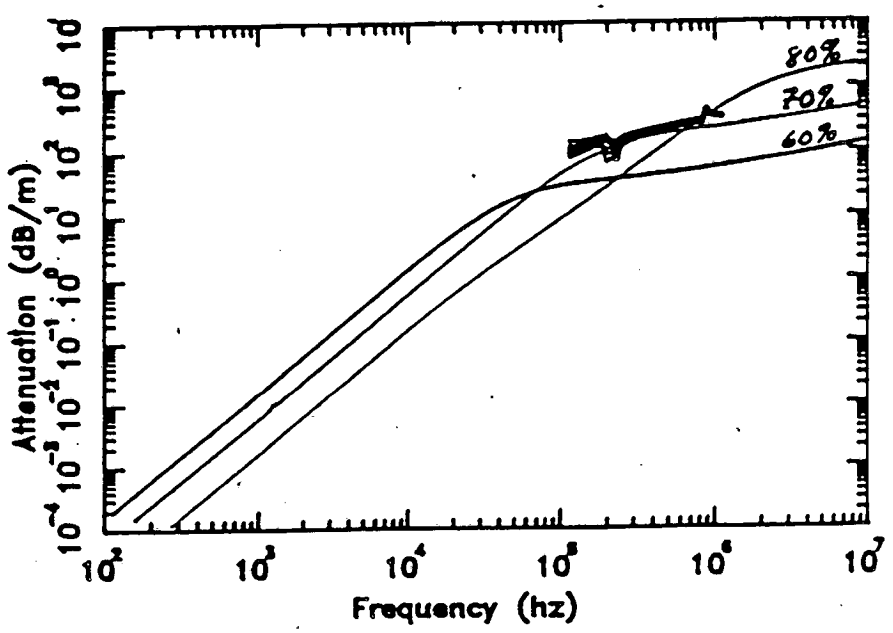

Figure 3b. Comparison of measured attenuation in clay with predicted (from Biot Model) attenuation (6 micron)

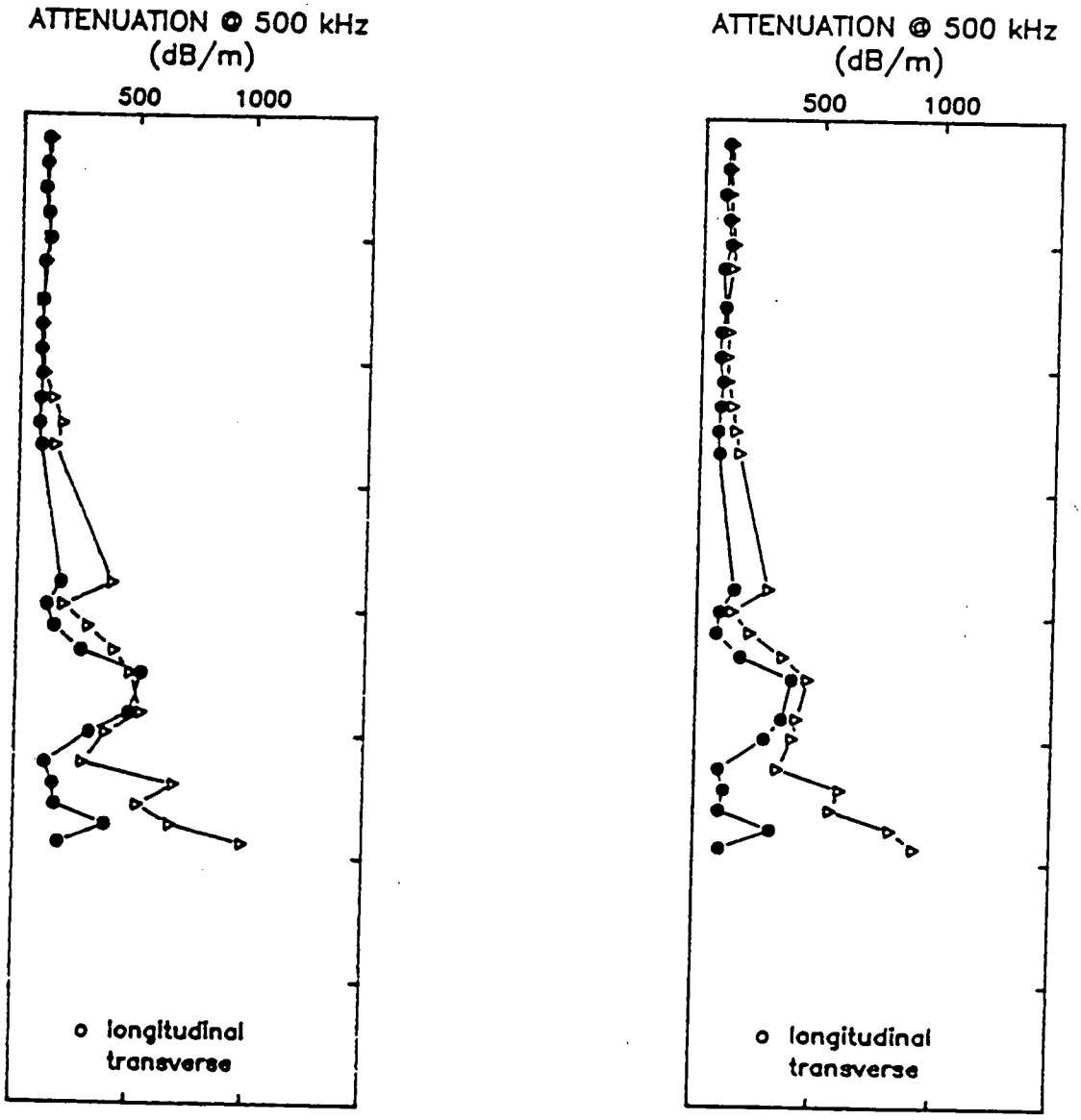

Figure 4. Comparison of spectral ratio technique (left) with amplitude ratio technique for Core 87028-068.

A correction for salt content was applied using Noorany's (1984) equation for fluid content. Small subsamples were placed in a centrifuge to obtain pore water samples and salinity measured using a refraction meter.

RESULTS:

The lithologic, acoustic and physical property results are presented in both graphic and tabular form. Each region will be presented separately. .

TABLE 1 - Summary of Core Locations and Depths

Core	Latitude	Longitude	Depth (m)
ICE ISLAND CORES			
85200-003	81.723N	93.410W	283
85200-006	81.723N	93.410W	283
85200-022	81.141N	96.153W	160
86200-006	80.995N	97.219W	289
86200-018	80.893N	97.826W	297
86200-054	80.086N	96.921W	165
87200-009	82.160N	102.565W	1150
87200-018	81.607N	98.697W	547
87200-020	80.777N	96.063W	300
87200-024	80.608N	103.302W	480
88200-004	80.167N	105.867W	424
88200-014	81.348N	104.805W	874
88200-016	81.620N	105.972W	1818
88200-022	80.903N	112.682W	1831
88200-026	80.535N	106.452W	501
88200-036	80.141N	105.570W	429
ARCTIC INTER-ISLAND CHANNEL CORES			
86100-002	77.252N	107.599W	152
87100-002	77.170N	103.667W	339
87100-003	77.170N	103.667W	339
87100-006	77.100N	103.695W	114
87100-008	77.148N	103.670W	345
87027-003	76.992N	92.325W	206
87027-004	77.020N	90.951W	140
87027-006	77.000N	92.633W	215
87027-008	76.785N	92.700W	184
87027-009	76.803N	92.592W	142
87027-010	76.917N	92.533W	215
87027-011	76.933N	92.683W	266
87027-014	77.150N	92.233W	399
87027-015	77.067N	91.383W	169
87027-016	77.044N	90.804W	89
87027-026	76.260N	88.710W	315
87027-027	77.219N	89.020W	366
87027-029	77.139N	89.430W	350
87027-032	77.035N	89.731W	252
87027-033	77.038N	89.883W	153
87027-034	77.041N	90.027W	122
87027-043	77.000N	90.218W	91

TABLE 1 - Summary of Core Locations and Depths (cont'd)

Core	Latitude	Longitude	Depth (m)
HUDSON BAY CORES			
87028-001	63.026N	81.082W	273
87028-004	63.009N	81.082W	271
87028-015	61.591N	86.321W	214
87028-029	60.606N	88.187W	180
87028-035	60.358N	86.033W	183
87028-043	55.352N	78.237W	118
87028-047	55.162N	78.210W	46
87028-048	55.376N	77.678W	59
87028-068	55.228N	77.019W	88
87028-069	55.477N	77.963W	165
87028-070	55.287N	77.998W	64
87028-074	55.102N	80.495W	95
87028-090	58.654N	90.285W	155
DREP CORE 1	Lincoln Sea (80km from Alert)		430

TABLE 2a - Physical Properties for Gravity Core 85200-003

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.20	1.66	66.2	1444.	14.2
0.30	1.63	67.8	1444.	12.5
0.40	1.68	65.0	1450.	8.3
0.50	1.76	60.1	1477.	28.3
0.60	1.71	62.8	1470.	21.7
0.70	1.73	61.2	1471.	20.6

TABLE 2b - Grain Size Data for Gravity Core 85200-003

Subbottom Depth Interval (m)	% Gravel	% Sand	% Silt	% Clay
0.00-0.06	--	2	28	70
0.08-0.12	10	1	9	80
0.12-0.22	--	tr	10	90
0.22-0.32	--	tr	55	45
0.32-0.46	--	tr	60	39
0.46-0.53	4	4	62	30
0.53-0.57	1	tr	83	12
0.57-0.63	--	8	70	22
0.63-0.67	--	--	79	21
0.77-0.80	--	1	53	46
0.80-0.81	--	2	54	44

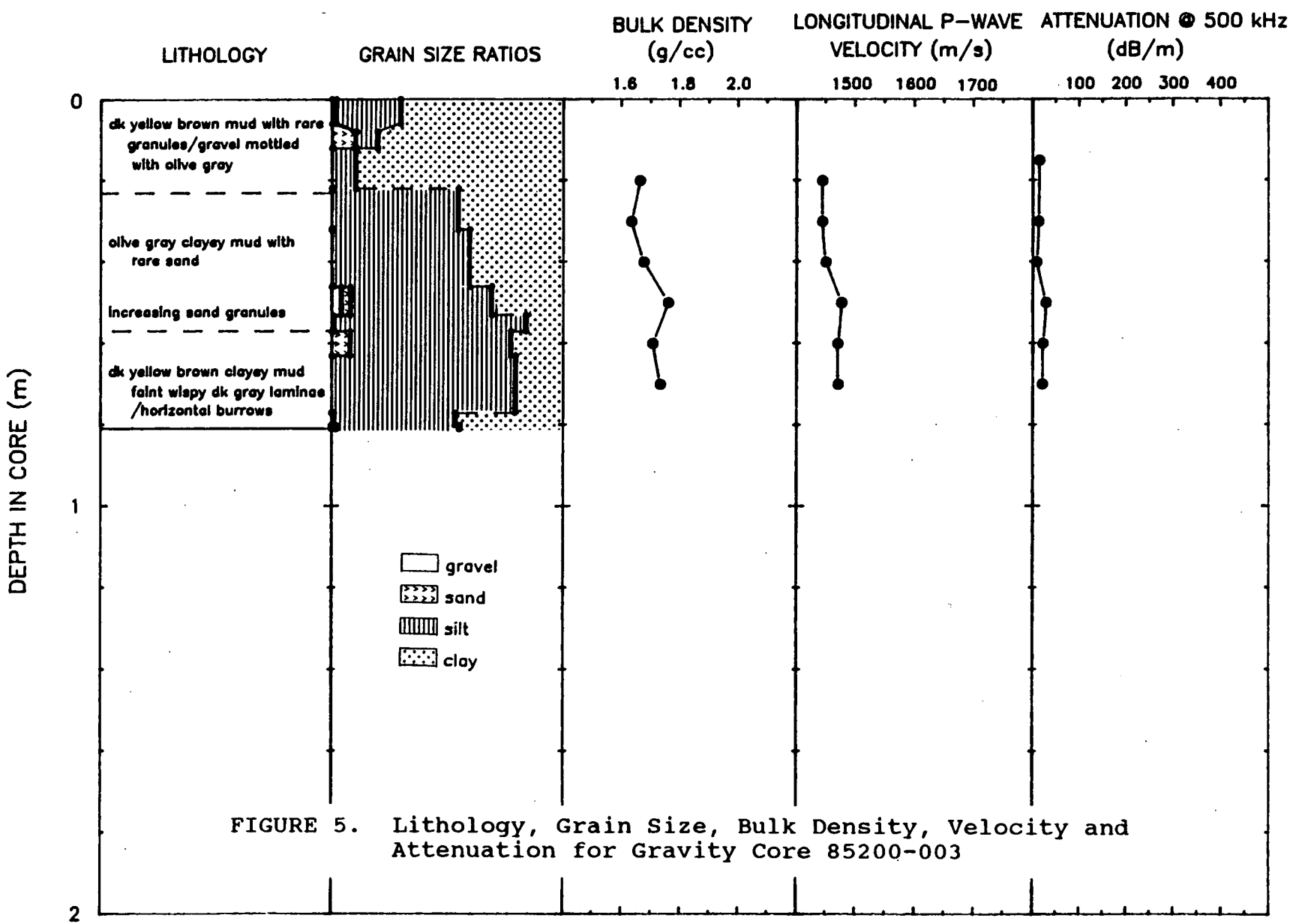

FIGURE 5. Lithology, Grain Size, Bulk Density, Velocity and Attenuation for Gravity Core 85200-003

TABLE 3a - Physical Properties for Gravity Core 85200-006

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.25	1.68	64.3	1454.	18.4
0.35	1.65	65.1	1454.	67.1
0.45	1.68	63.0	1459.	81.0
0.55	1.72	63.1	1466.	72.4
0.65	1.72	63.6	1463.	76.5
0.75	1.68	63.6	1459.	69.4
0.85	1.68	63.7	1456.	87.9
0.95	1.68	64.1	1456.	79.2
1.05	1.69	63.5	1465.	96.8
1.15	1.68	62.6	1468.	83.7
1.25	1.68	63.2	1470.	119.7
1.35	1.72	62.9	1474.	99.0
1.44	1.72	63.8	1469.	****
1.57	1.72	63.5	1458.	86.7
1.66	1.78	59.0	1473.	54.4
1.75	1.75	59.6	1470.	47.3
1.85	1.79	59.7	1471.	53.9
1.95	1.75	61.4	1483.	67.5
2.05	1.77	59.0	1482.	77.2
2.15	1.79	58.3	1476.	67.5

TABLE 3b - Grain Size Data for Gravity Core 85200-006

Subbottom Depth Interval (m)	% Gravel	% Sand	% Silt	% Clay
0.00-0.08	84	1	3	12
0.10-0.20	--	--	25	75
0.25-0.45	--	--	70	30
0.45-0.48	--	1	88	11
0.50-0.52	--	25	75	--
0.95-1.00	4	1	72	23
1.85-1.90	12	tr	54	34
2.03-2.24	tr	1	52	47

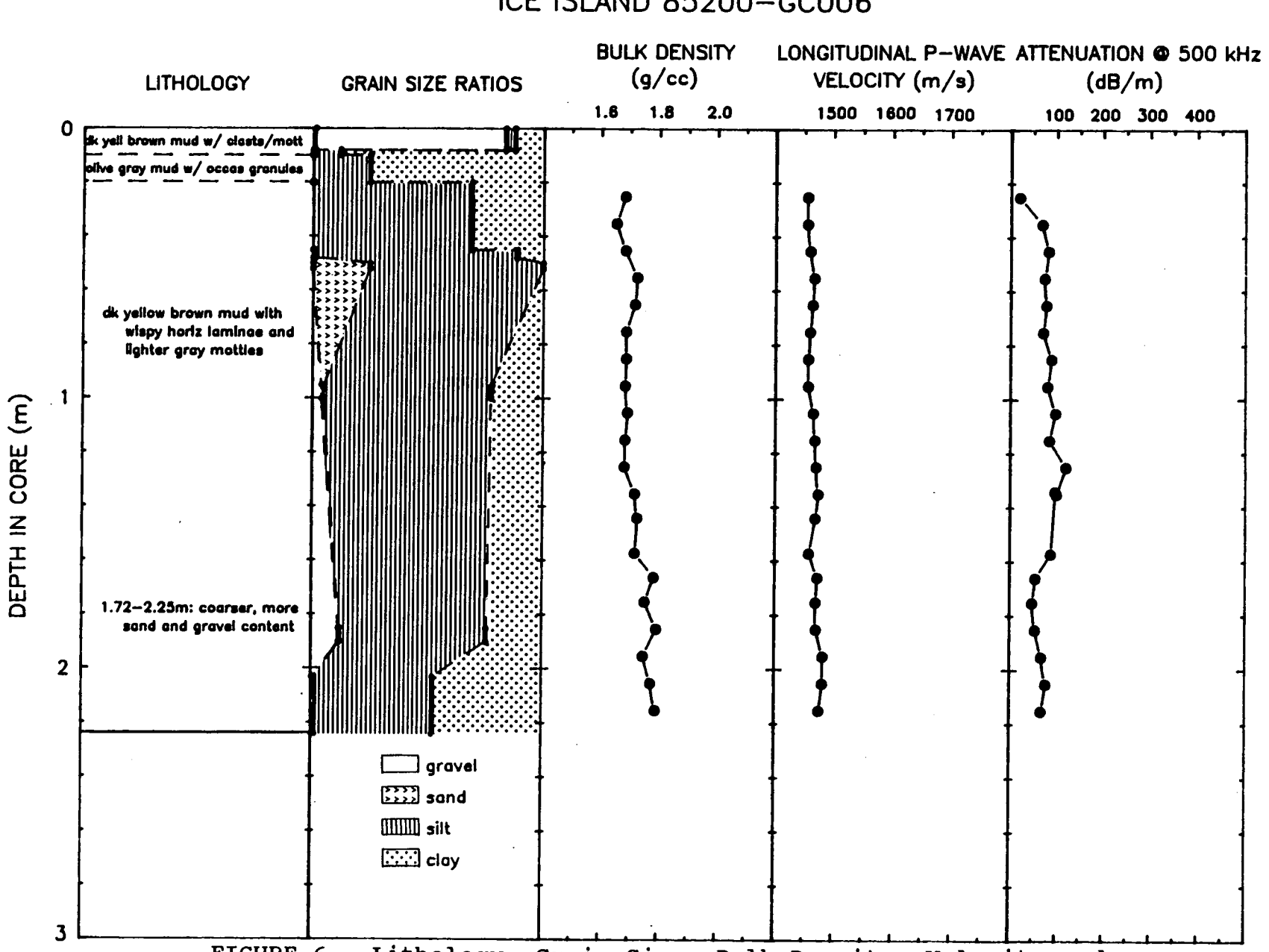

FIGURE 6. Lithology, Grain Size, Bulk Density, Velocity and Attenuation for Gravity Core 85200-006

TABLE 4a - Physical Properties for Gravity Core 85200-022

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.08	1.67	67.0	1445.	45.5
0.17	1.67	67.5	1434.	53.2
0.35	1.57	72.5	1418.	3.2

TABLE 4b - Grain Size Data for Gravity Core 85200-022

Subbottom Depth Interval (m)	% Gravel	% Sand	% Silt	% Clay
0.00-0.04	--	22	59	20
0.04-0.17	--	1	19	80
0.17-0.20	--	tr	49	51
0.20-0.23	--	10	38	52
0.30-0.42	--	tr	52	48

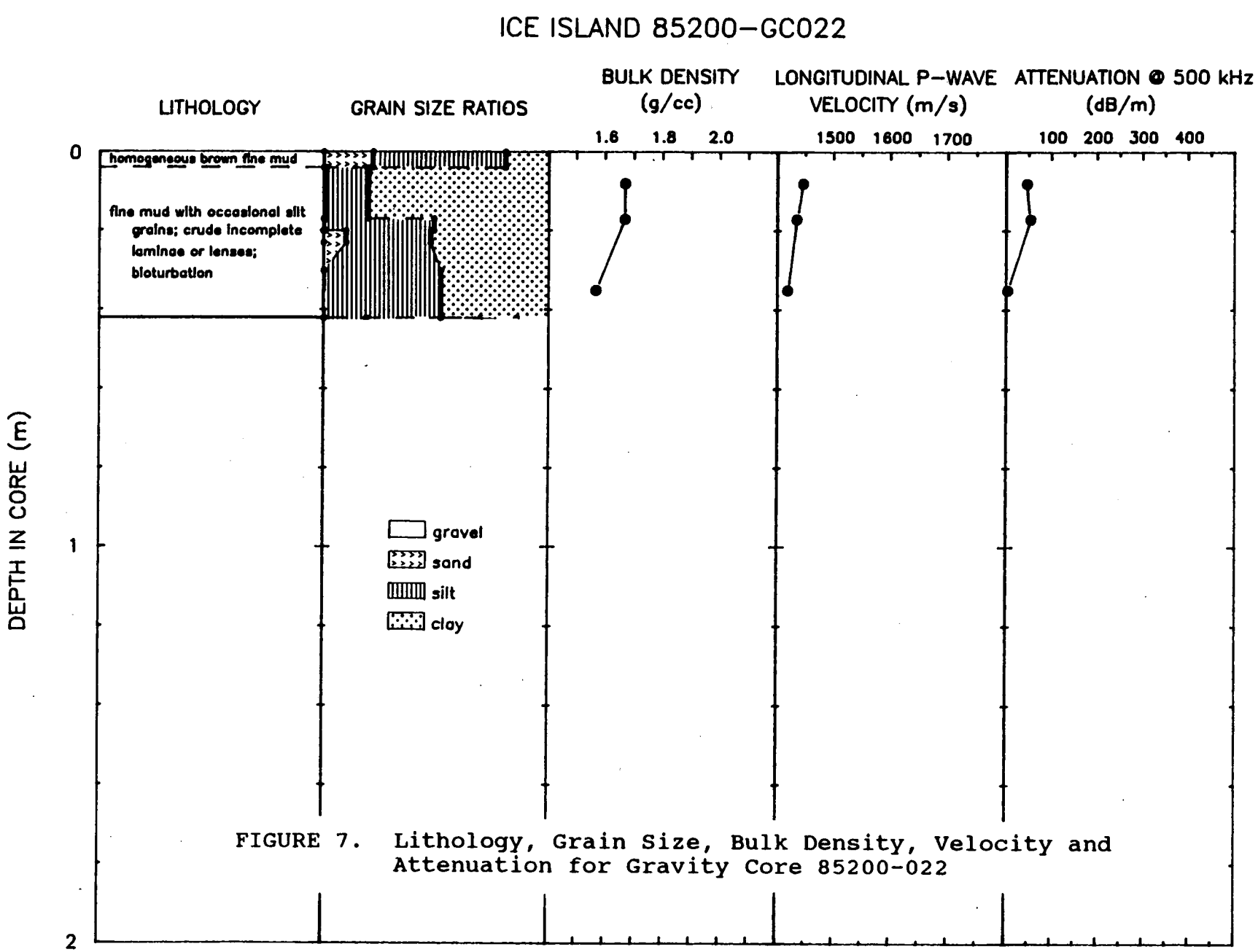

FIGURE 7. Lithology, Grain Size, Bulk Density, Velocity and Attenuation for Gravity Core 85200-022

TABLE 5a -- Physical Properties for Gravity Core 86200-006

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.15	1.63	70.2	1427.	35.7
0.25	1.54	75.0	1418.	42.9
0.35	1.60	71.9	1420.	50.3
0.45	1.56	71.5	1418.	34.6
0.55	1.51	76.3	1411.	-0.4
0.65	1.48	77.9	1413.	45.0
0.75	1.46	79.1	1411.	22.8
0.85	1.44	78.3	1406.	43.3
0.95	1.48	77.7	1411.	39.3
1.05	1.57	72.0	1427.	58.5
1.15	1.67	66.4	1479.	132.2
1.25	2.09	40.6	1590.	159.1

TABLE 5b - Grain Size Data for Gravity Core 86200-006

Subbottom Depth Interval (m)	% Gravel	% Sand	% Silt	% Clay
0.00-0.04	4	25	30	40
0.04-0.20	--	tr	24	75
0.20-0.40	--	--	88	11
0.40-0.50	--	--	37	63
0.58-0.60	--	61	33	6
0.60-0.70	--	--	30	70
0.76-0.80	--	--	39	61
0.80-0.85	--	--	39	61
0.85-0.94	--	37	61	2
0.94-1.18	--	12	54	35
1.18-1.32	19	19	33	29

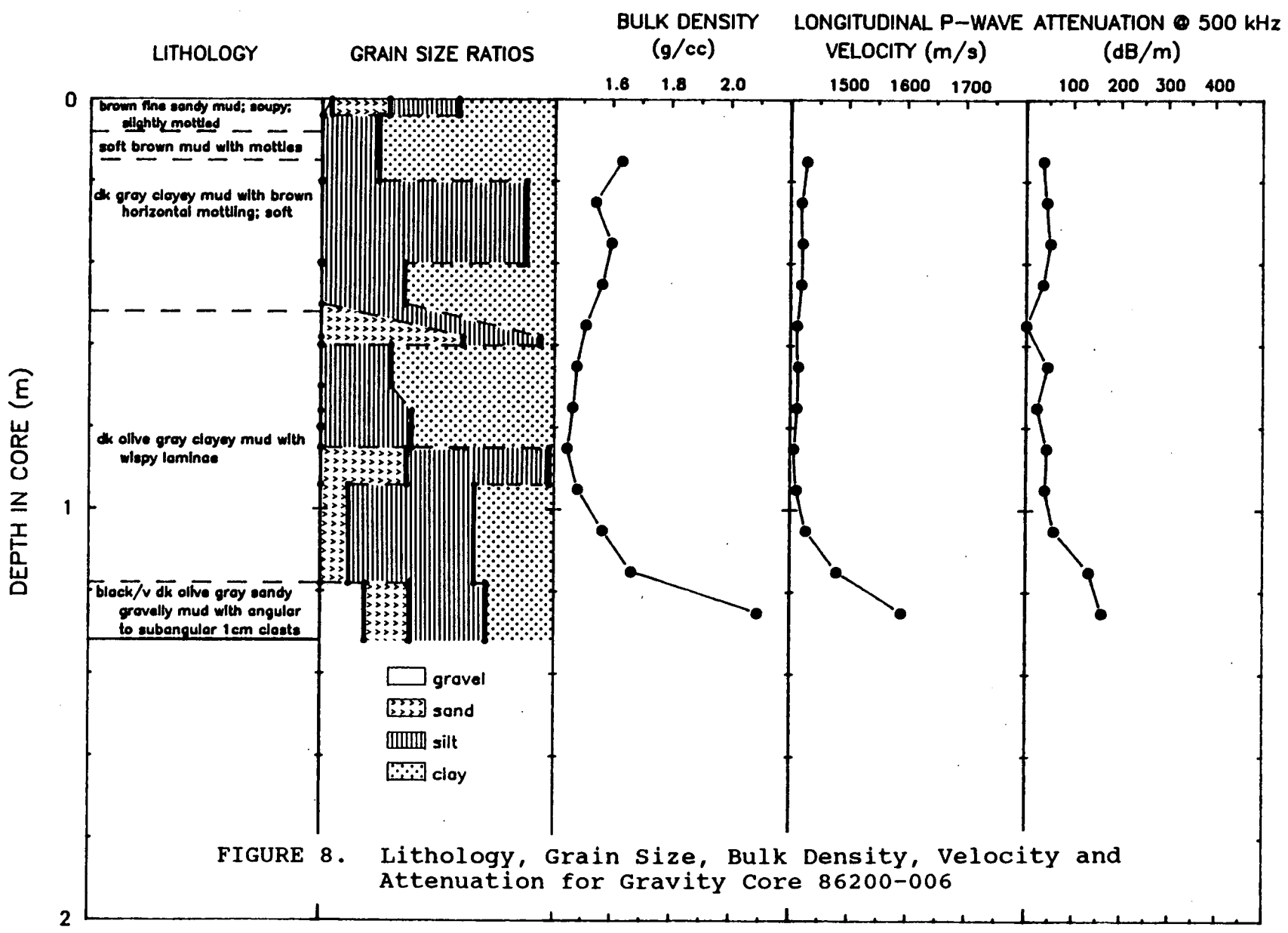

FIGURE 8. Lithology, Grain Size, Bulk Density, Velocity and Attenuation for Gravity Core 86200-006

TABLE 6a - Physical Properties for Gravity Core 86200-018

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.10	1.61	70.3	1433.	69.9
0.20	1.60	71.1	1441.	85.9
0.30	1.65	68.0	1432.	10.7
0.40	1.61	69.8	1426.	45.9
0.50	1.60	71.9	1424.	14.2
0.60	1.58	71.6	1423.	52.7
0.70	1.59	71.8	1422.	24.5
0.80	****	****	1430.	44.2
0.90	1.61	69.8	1424.	8.1
1.00	1.61	71.1	1425.	26.3
1.10	1.55	74.0	1421.	40.6
1.20	1.64	68.9	1432.	53.1
1.30	1.55	74.5	1421.	29.4
1.39	1.52	75.6	1421.	16.1
1.57	1.74	63.1	1475.	99.9
1.66	1.54	73.8	1426.	8.6
1.75	1.55	74.4	1421.	59.3
1.85	1.67	67.1	1453.	85.4
1.95	2.03	44.9	1608.	205.3
2.05	2.04	44.0	1770.	405.6
2.15	2.15	37.7	1791.	****

TABLE 6b - Grain Size Data for Gravity Core 86200-018

Subbottom Depth Interval (m)	% Gravel	% Sand	% Silt	% Clay
0.00-0.10	--	20	30	50
0.10-0.16	--	--	36	63
0.16-0.22	--	11	65	22
0.22-0.80	--	tr	82	19
0.80-0.82	--	25	66	9
0.94-0.95	--	60	26	14
1.01-1.03	--	--	30	70
1.03-1.14	--	30	70	4
1.14-1.20	--	tr	58	42
1.20-1.22	--	3	68	30
1.22-1.30	--	--	32	68
1.30-1.40	--	--	28	72
1.40-1.60	--	11	66	23
1.60-1.65	--	--	31	69
1.65-1.76	--	--	39	61
1.76-1.93	--	--	39	61
1.93-1.95	--	81	16	3
1.95-2.05	21	20	34	25
2.10-2.26	5	20	50	25

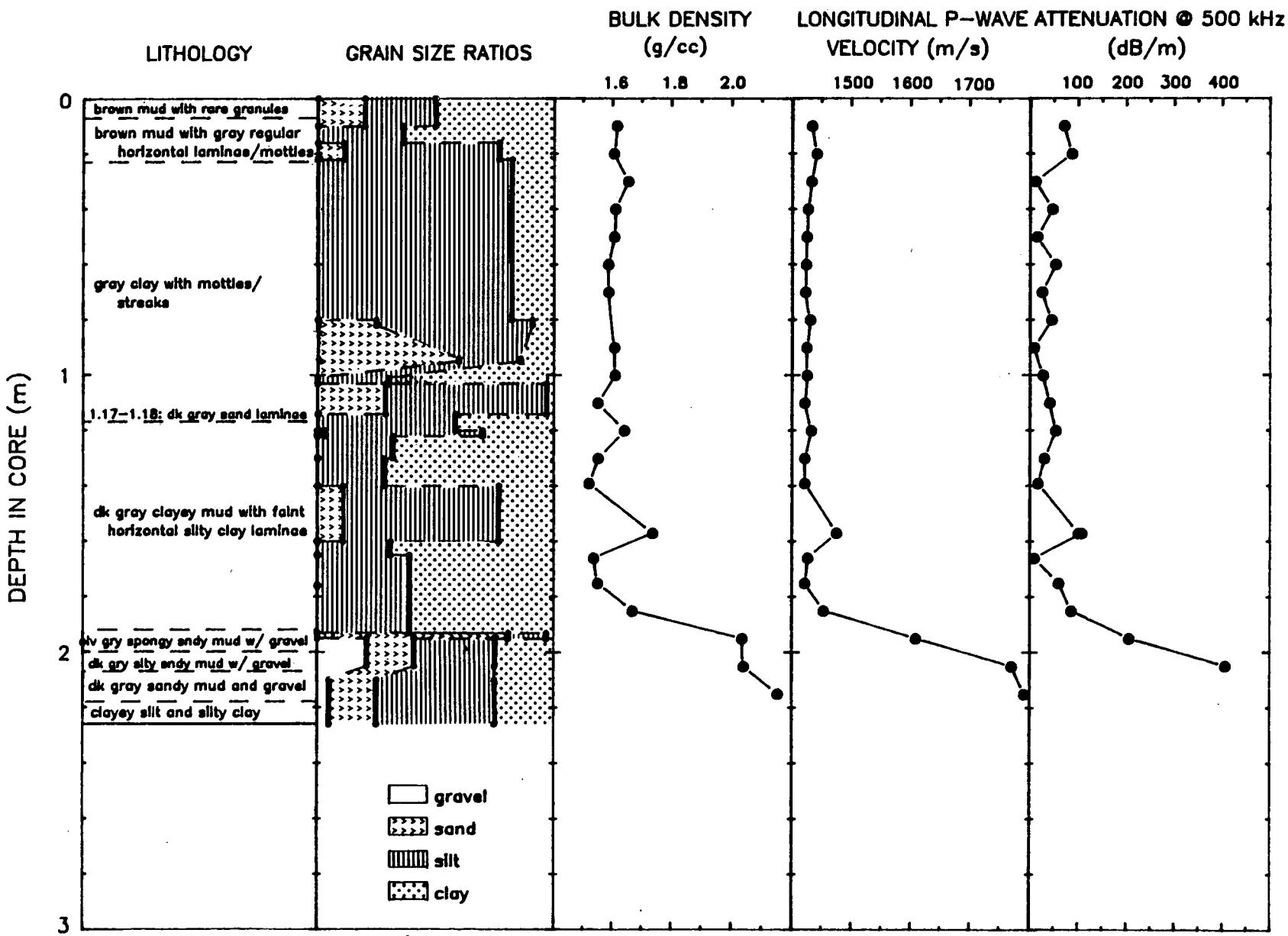

FIGURE 9. Lithology, Grain Size, Bulk Density, Velocity and Attenuation for Gravity Core 86200-018

TABLE 7a - Physical Properties for Gravity Core 86200-054

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.10	1.69	65.0	1444.	53.
0.20	****	****	1527.	110.
0.30	1.63	67.1	1529.	75.
0.40	1.74	61.0	1491.	140.
0.50	1.85	53.2	1525.	105.
0.60	1.80	57.7	1503.	432.
0.70	1.82	57.9	1494.	380.
0.80	1.77	60.2	1466.	354.
0.90	1.60	71.1	1473.	382.
1.00	1.61	69.8	1514.	375.
1.10	1.73	63.0	1468.	390.
1.20	1.77	60.3	1467.	375.
1.30	1.82	57.8	****	****
1.40	2.00	45.4	1479.	394.

TABLE 7b - Grain Size Data for Gravity Core 86200-054

Subbottom Depth Interval (m)	% Gravel	% Sand	% Silt	% Clay
0.00-0.04	10	23	22	46
0.04-0.20	--	2	86	12
0.20-0.48	--	tr	55	44
0.58-0.77	--	--	35	66

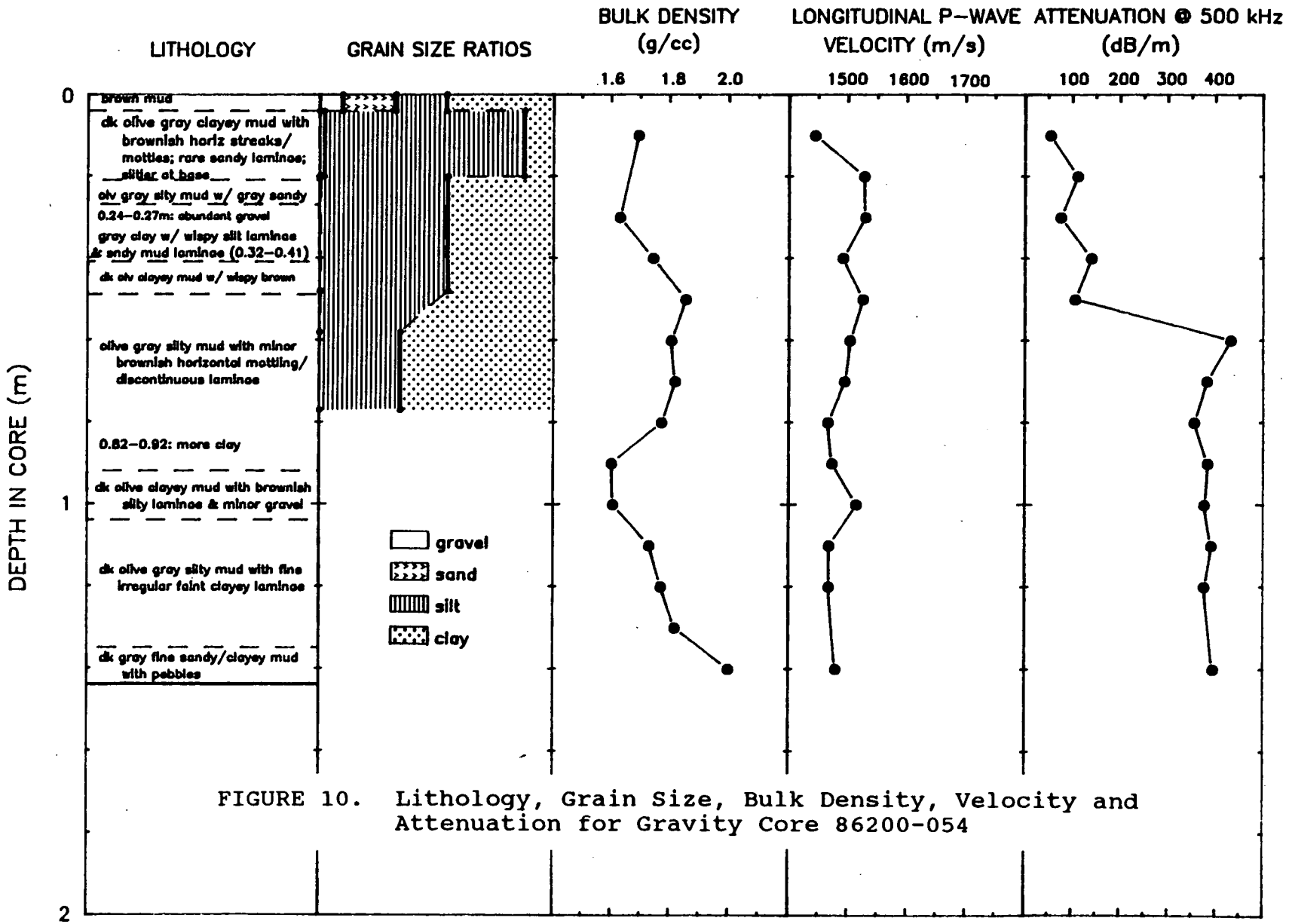

FIGURE 10. Lithology, Grain Size, Bulk Density, Velocity and Attenuation for Gravity Core 86200-054

TABLE 8a - Physical Properties for Gravity Core 87200-009

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.18	1.90	52.5	1752.	369.
0.37	1.96	49.3	1576.	502.
0.47	1.98	46.8	1586.	459.
0.56	2.01	46.3	1633.	12.
0.65	2.00	46.8	1602.	441.

TABLE 8b - Grain Size Data for Gravity Core 87200-009

Subbottom Depth Interval (m)	% Gravel	% Sand	% Silt	% Clay
0.00-0.05	96	tr	1	2
0.05-0.09	19	27	40	15
0.08-0.12	90	2	6	2
0.25-0.30	5	23	58	14
0.35-0.37	11	23	56	10
0.50-0.53	5	21	43	31
0.65-0.70	30	17	47	5

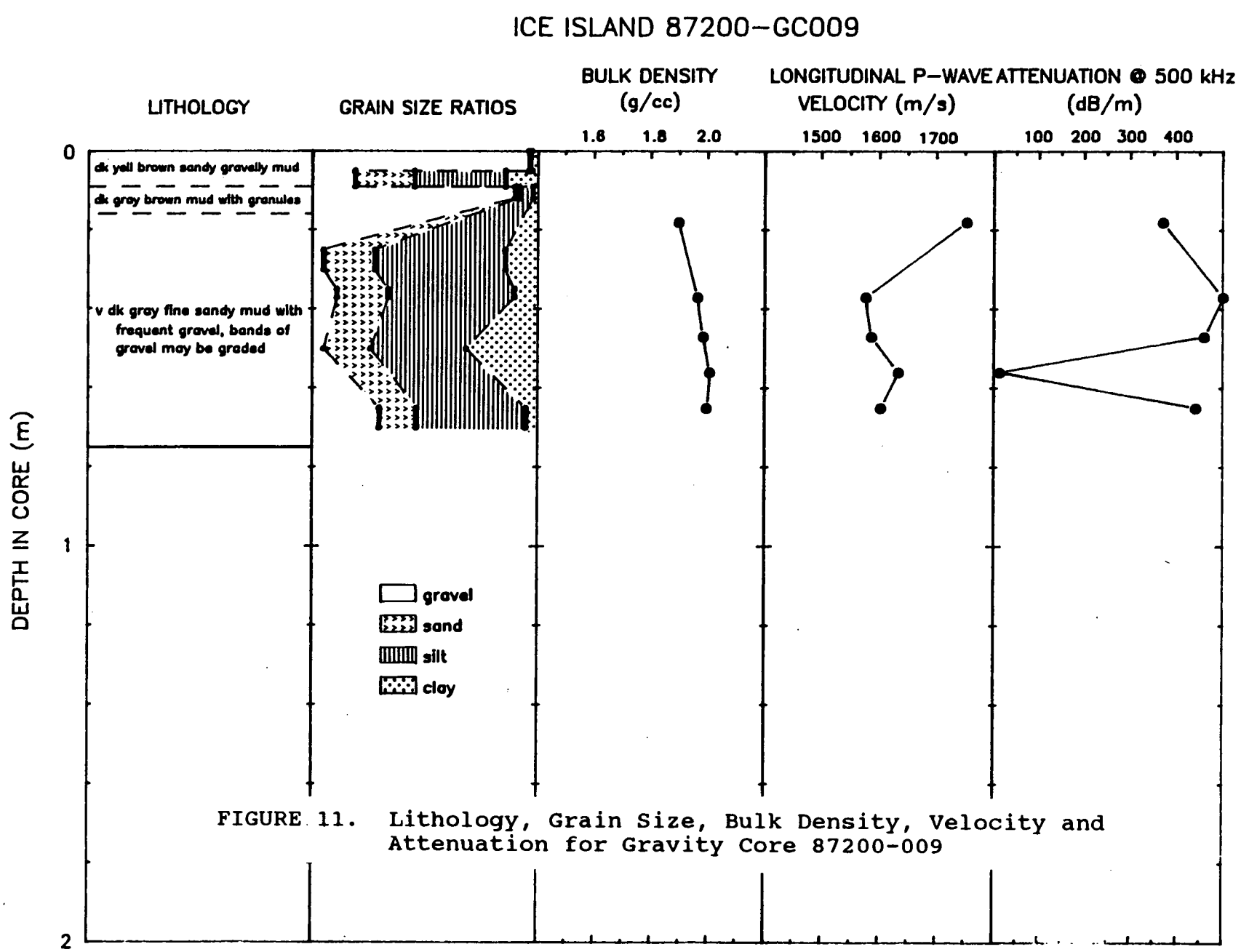

FIGURE 11. Lithology, Grain Size, Bulk Density, Velocity and Attenuation for Gravity Core 87200-009

TABLE 9 - Physical Properties for Gravity Core 87200-018

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.07	1.81	59.1	1465.	152.
0.16	1.86	54.5	1519.	236.
0.36	1.95	49.1	1572.	466.
0.45	1.98	47.9	1623.	177.
0.54	1.95	48.8	1561.	454.

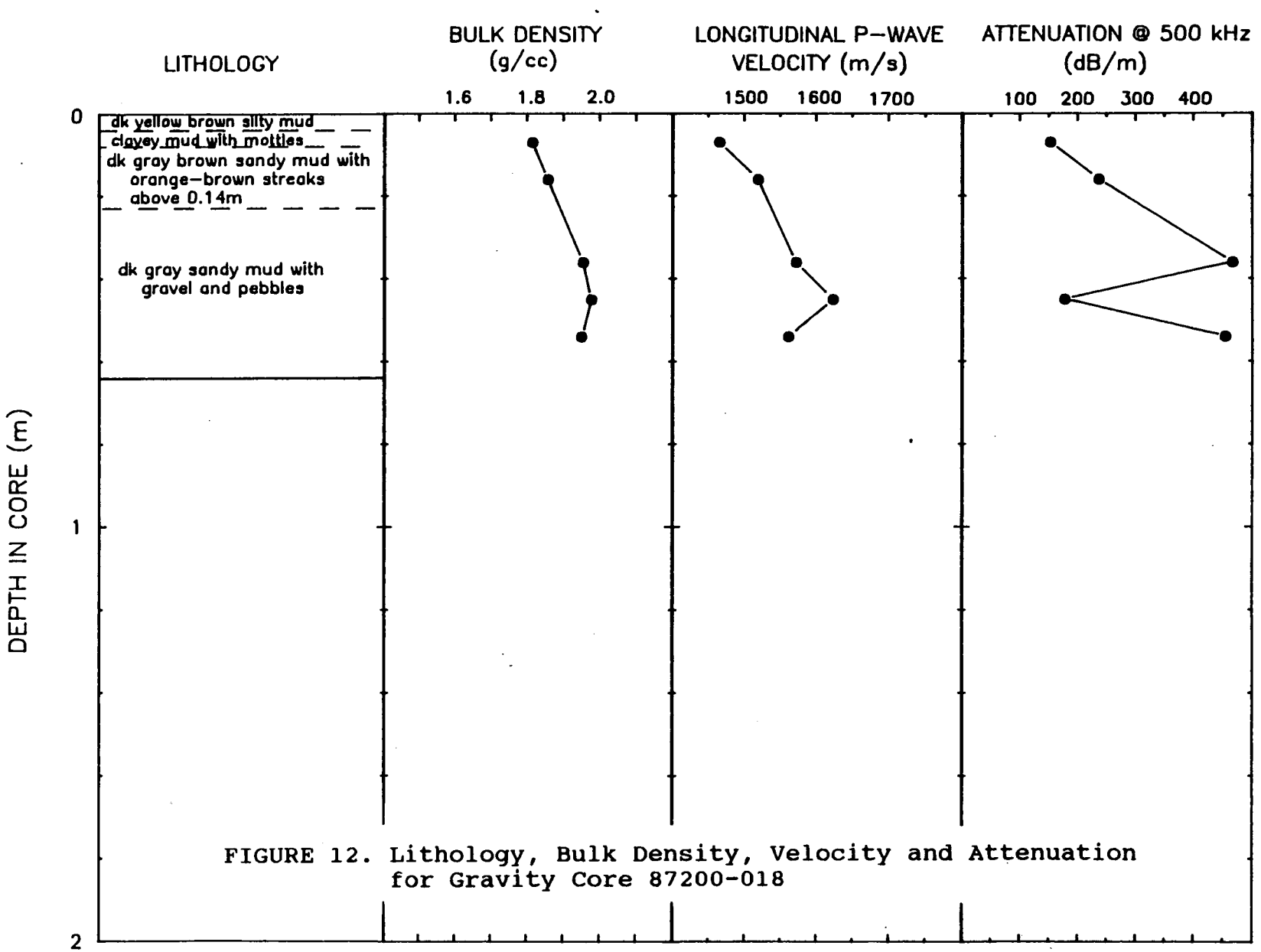

FIGURE 12. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87200-018

TABLE 10a - Physical Properties for Gravity Core 87200-020

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.08	****	****	1438.	58.
0.12	1.71	65.0	****	****
0.17	****	****	1442.	46.
0.24	1.66	67.1	****	****
0.26	****	****	1454.	44.
0.33	1.82	58.7	****	****
0.35	****	****	1455.	67.
0.43	1.61	70.8	****	****
0.45	****	****	1432.	66.
0.52	1.59	72.4	****	****
0.57	****	****	1440.	53.
0.61	1.70	63.8	****	****

TABLE 10b - Grain Size Data for Gravity Core 87200-020

Subbottom Depth Interval (m)	% Gravel	% Sand	% Silt	% Clay
0.00-0.04	--	12	26	62
0.04-0.08	--	2	24	74
0.08-0.15	--	1	88	11
0.15-0.65	--	1	56	43

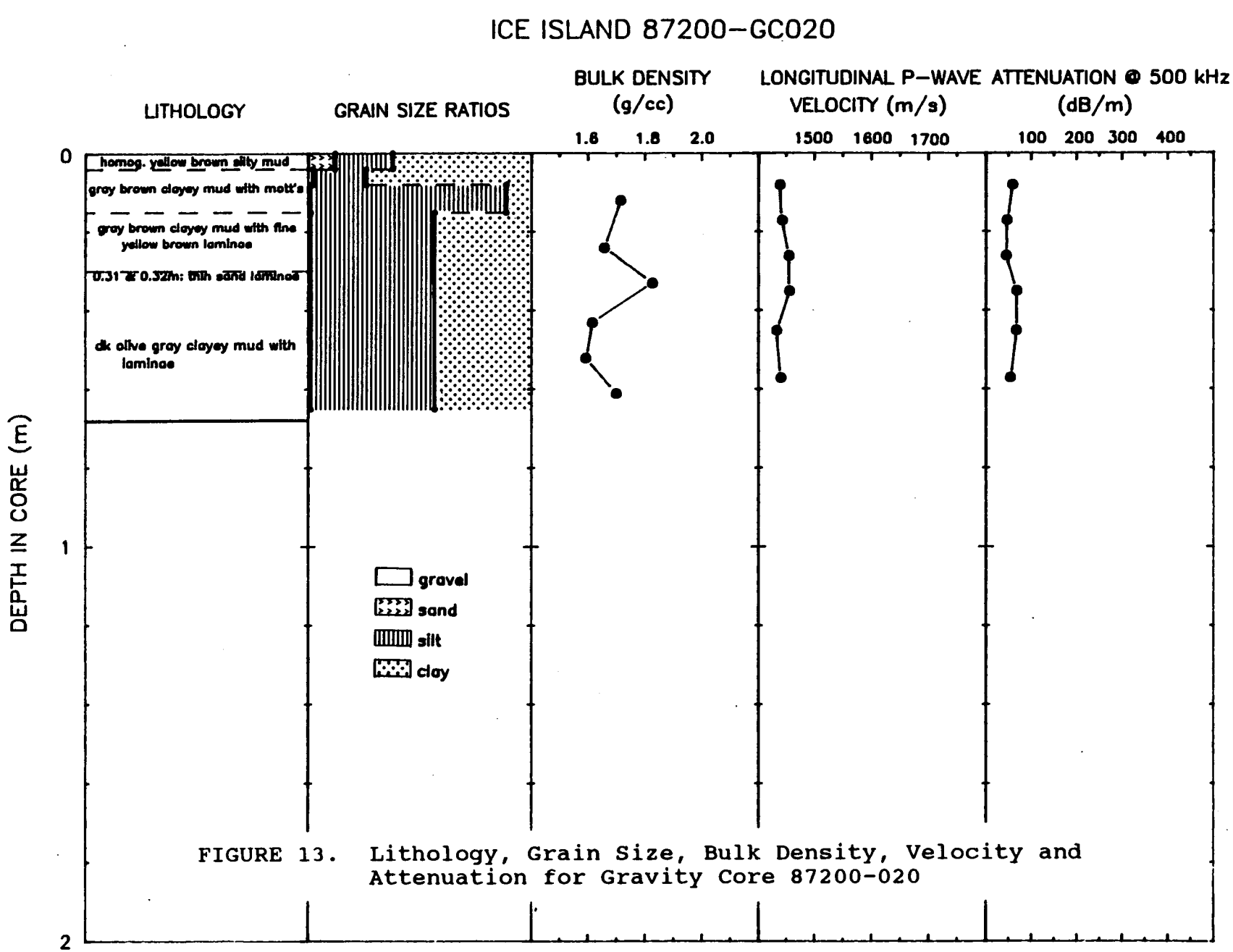

FIGURE 13. Lithology, Grain Size, Bulk Density, Velocity and Attenuation for Gravity Core 87200-020

TABLE 11a - Physical Properties for Gravity Core 87200-024

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.09	1.82	55.7	1508.	228.
0.20	1.96	48.5	1554.	151.
0.30	1.98	47.7	1585.	88.
0.40	2.00	46.4	1593.	66.
0.50	1.95	46.7	1581.	420.
0.60	1.99	47.0	1572.	472.
0.70	1.98	46.6	1635.	211.
0.80	1.99	46.9	1572.	- 2.
0.90	2.01	45.7	1703.	177.
1.00	2.00	46.8	1572.	-14.
1.10	2.01	44.2	1581.	44.
1.25	2.02	45.7	1592.	42.

TABLE 11b - Grain Size Data for Gravity Core 87200-024

Subbottom Depth Interval (m)	% Gravel	% Sand	% Silt	% Clay
0.00-0.06	6	32	49	13
0.15-0.20	30	25	28	18
0.30-0.34	4	33	54	9
0.36-0.40	26	26	42	6
0.53-0.57	5	31	41	22
0.59-0.65	15	29	48	8
0.85-0.89	4	33	56	7
0.92-0.95	4	33	57	6
1.07-1.11	7	31	51	11
1.12-1.15	12	25	51	13
1.23-1.27	7	33	53	7

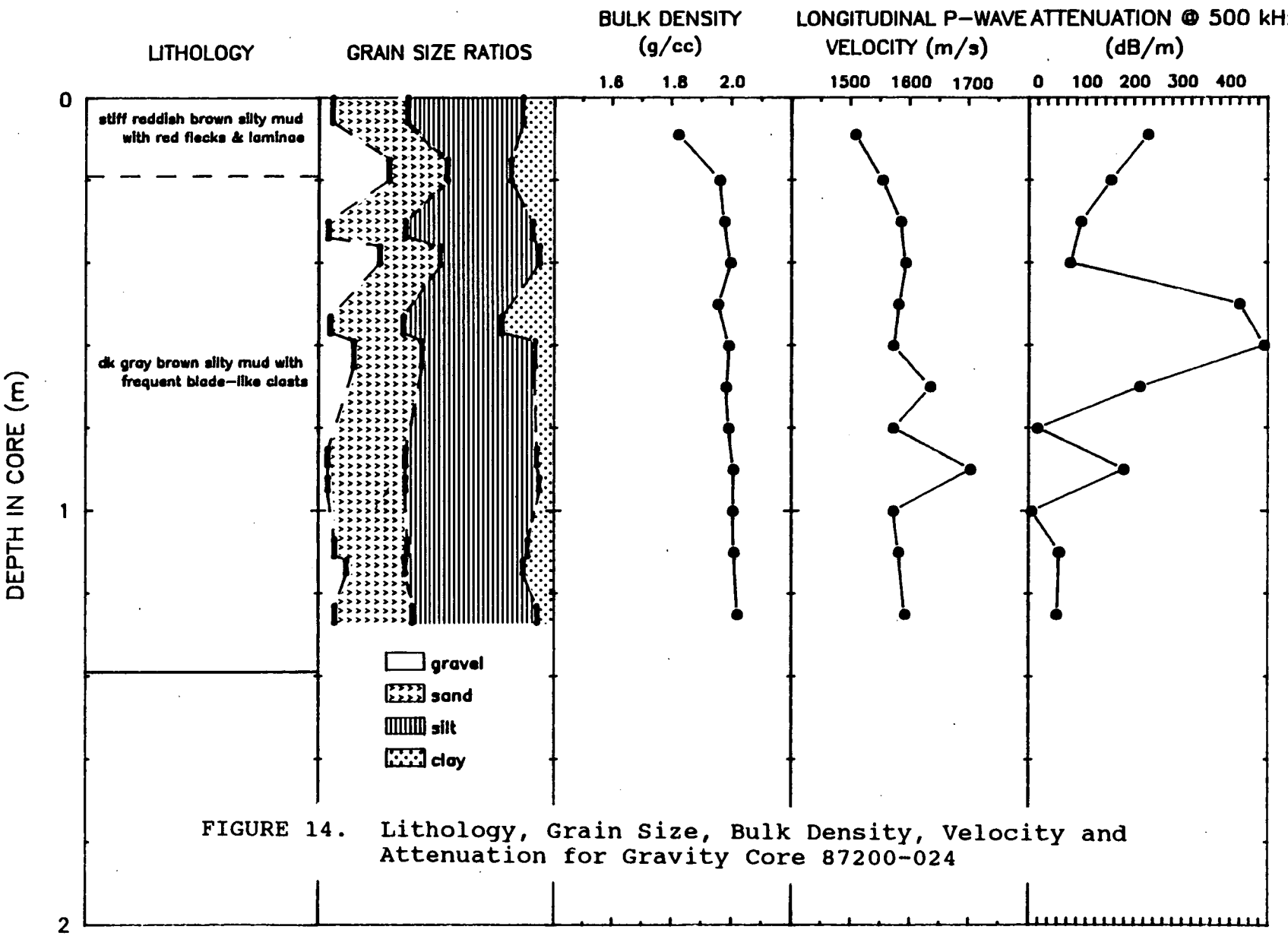

FIGURE 14. Lithology, Grain Size, Bulk Density, Velocity and Attenuation for Gravity Core 87200-024

TABLE 12 - Physical Properties for Gravity Core 88200-004

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.92	1.92	49.6	1516.	112.
1.08	1.97	49.1	1568.	122.
1.20	1.97	47.6	1571.	117.
1.30	2.04	44.1	1666.	80.
1.40	2.08	43.7	1616.	157.
1.50	2.06	41.4	1654.	67.
1.63	2.12	39.0	1675.	172.
1.85	2.04	41.4	1613.	85.
1.97	2.10	39.0	1681.	246.

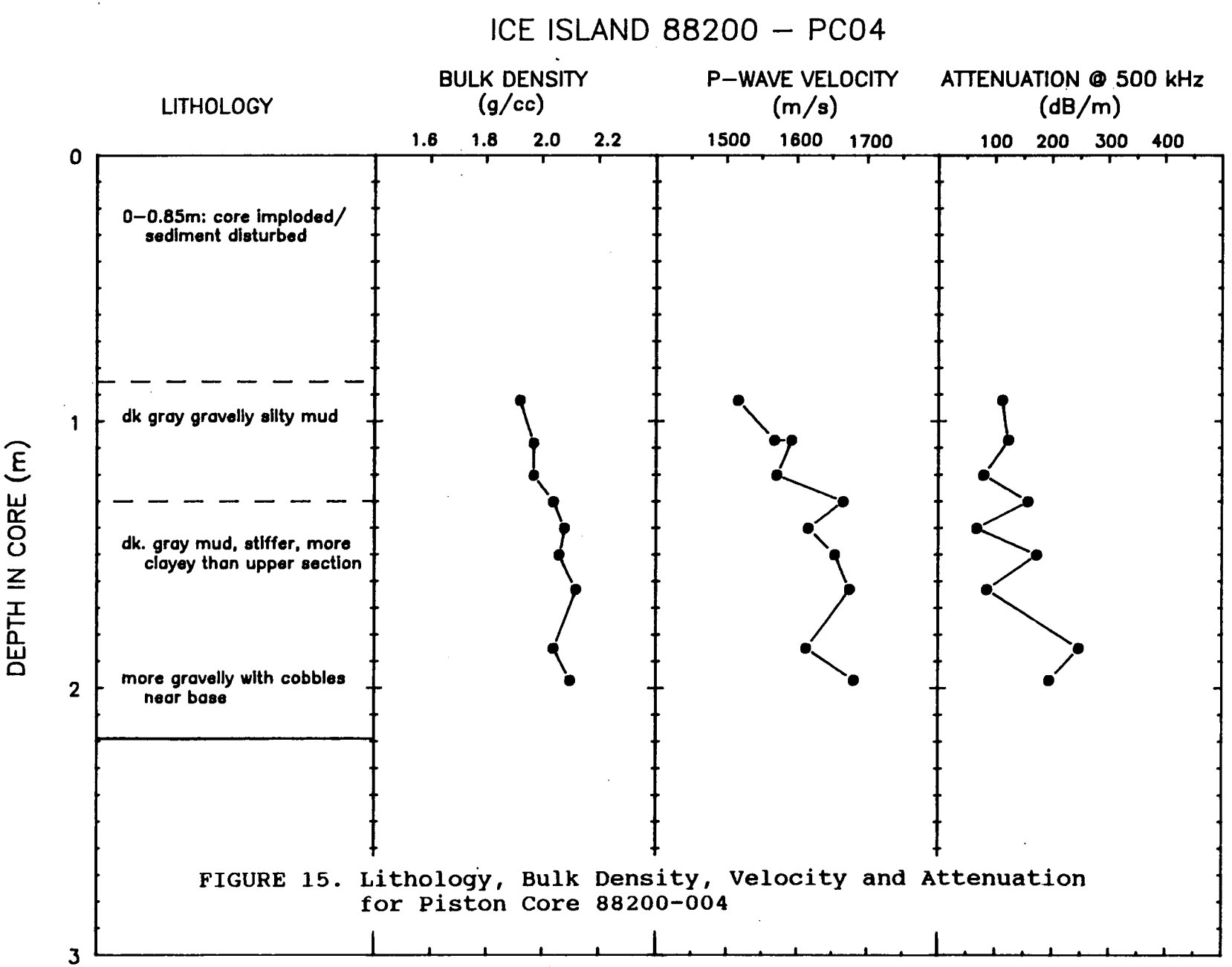

FIGURE 15. Lithology, Bulk Density, Velocity and Attenuation for Piston Core 88200-004

TABLE 13a - Physical Properties for Gravity Core 88200-014

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.06	1.90	54.1	1530.	191.
0.15	1.85	56.7	1537.	107.
0.26	1.98	47.0	1559.	130.

TABLE 13b - Grain Size Data for Gravity Core 88200-014

Subbottom Depth Interval (m)	% Gravel	% Sand	% Silt	% Clay
0.00-0.03	6	22	52	20
0.03-0.05	5	44	16	35
0.19-0.21	3	30	62	6
0.29-0.31	7	20	19	54

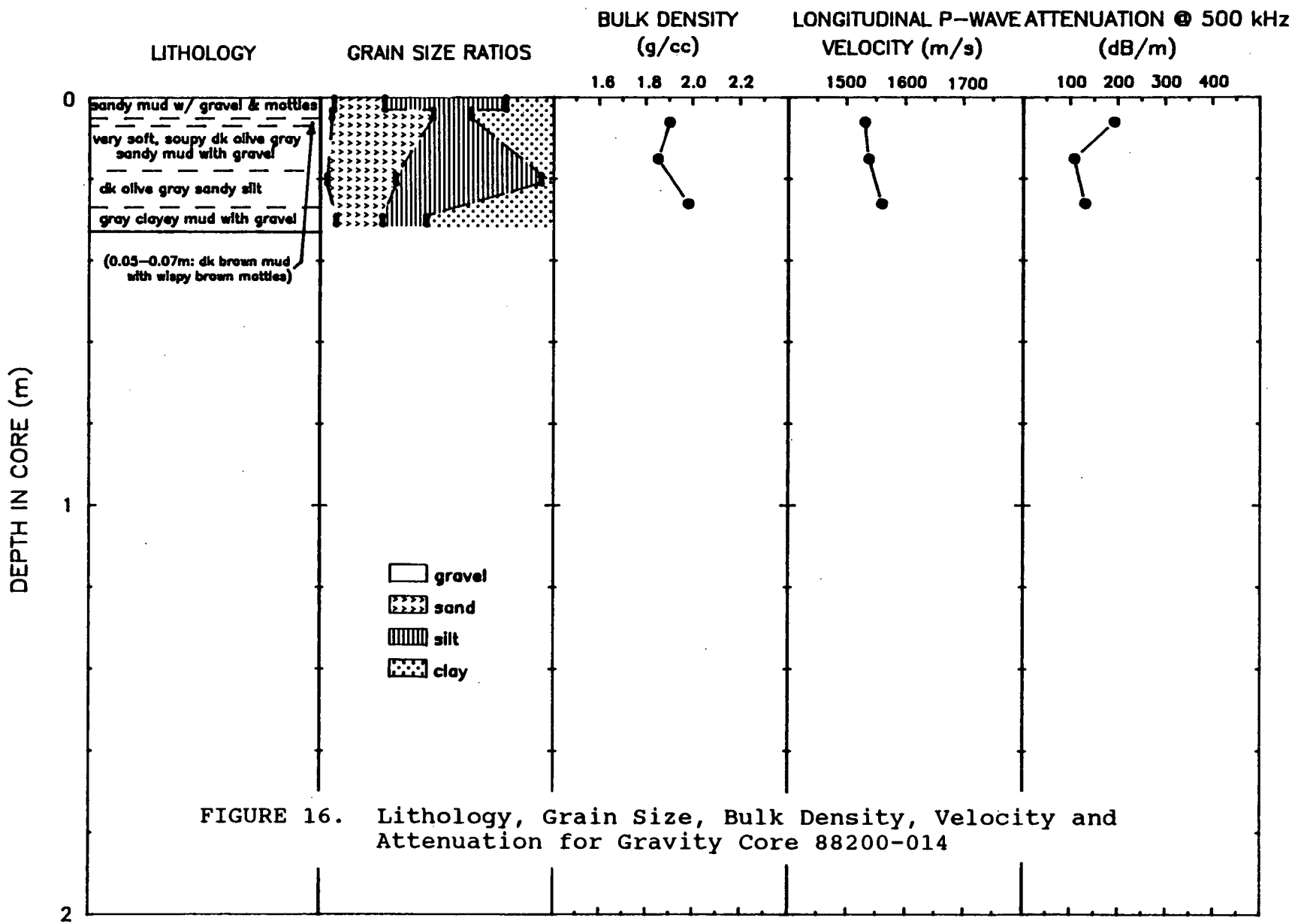

FIGURE 16. Lithology, Grain Size, Bulk Density, Velocity and Attenuation for Gravity Core 88200-014

TABLE 14a - Physical Properties for Gravity Core 88200-016

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.11	1.84	55.9	1564.	361.
0.20	1.89	55.2	1558.	217.

TABLE 14b - Grain Size Data for Gravity Core 88200-016

Subbottom Depth Interval (m)	% Gravel	% Sand	% Silt	% Clay
0.00-0.04	6	21	52	22
0.10-0.12	7	22	60	11
0.18-0.20	2	27	45	26
0.24-0.26	--	49	35	16

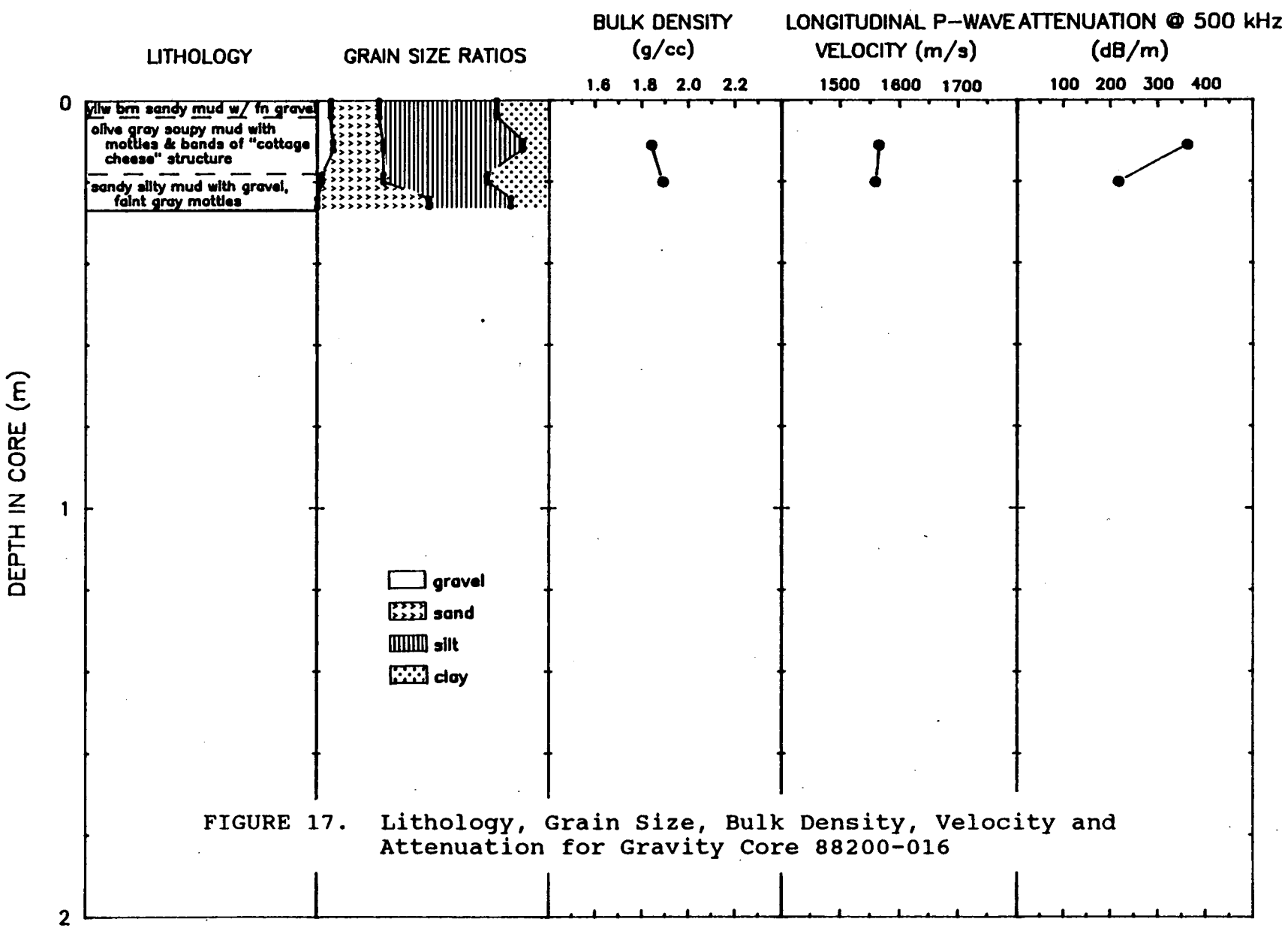

FIGURE 17. Lithology, Grain Size, Bulk Density, Velocity and Attenuation for Gravity Core 88200-016

TABLE 15a - Physical Properties for Gravity Core 88200-022

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.07	1.91	53.2	1531.	107.
0.18	1.83	57.3	1506.	98.
0.29	1.93	51.8	1532.	99.
0.39	2.03	45.9	1620.	250.
0.49	2.01	****	1629.	207.

TABLE 15b - Grain Size Data for Gravity Core 88200-022

Subbottom Depth Interval (m)	% Gravel	% Sand	% Silt	% Clay
0.00-0.04	3	16	52	31
0.04-0.14	5	10	55	30
0.14-0.22	--	18	49	33
0.22-0.27	tr	72	15	13
0.27-0.36	6	24	58	12
0.36-0.47	23	15	41	21
0.47-0.60	5	29	43	23

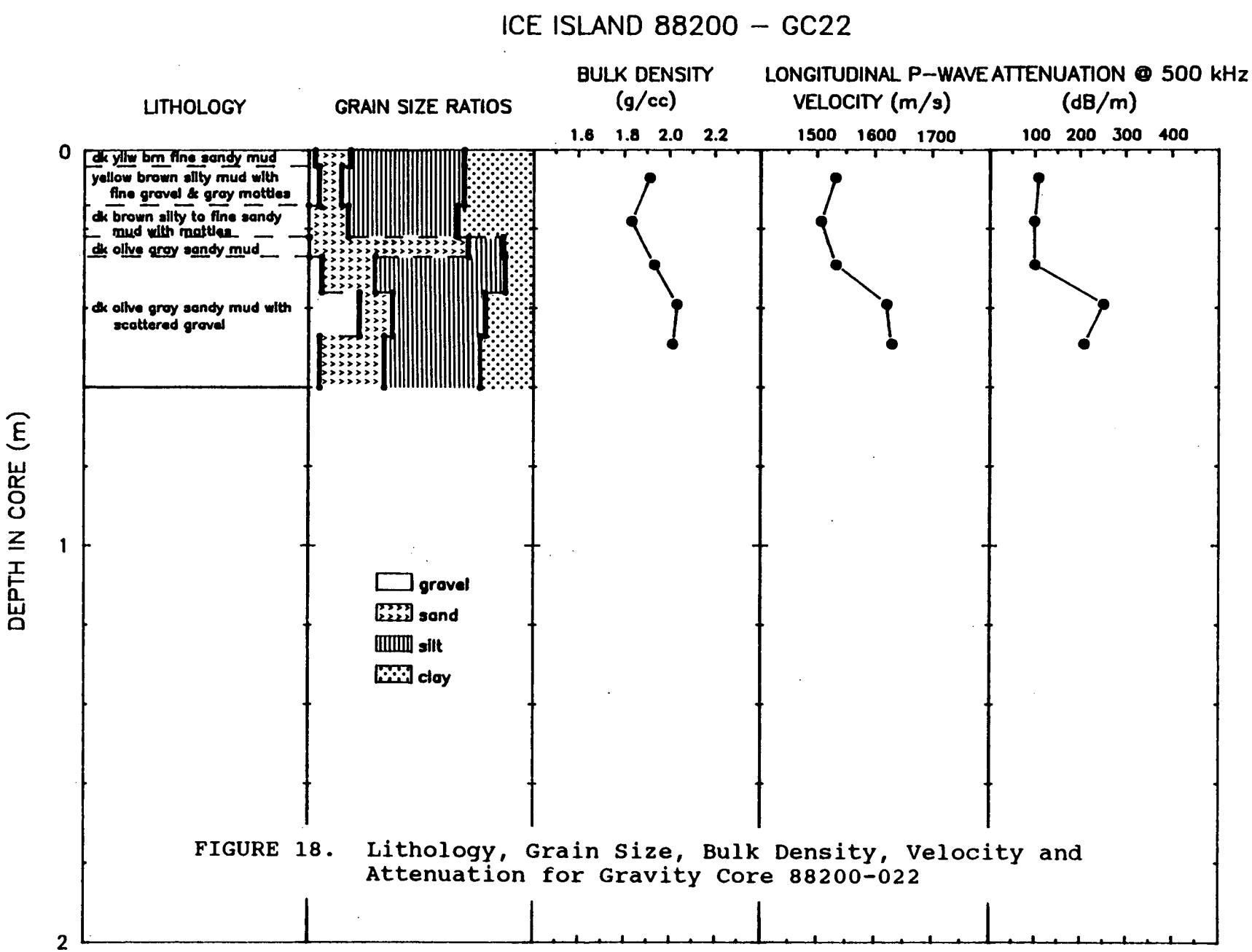

FIGURE 18. Lithology, Grain Size, Bulk Density, Velocity and Attenuation for Gravity Core 88200-022

TABLE 16a - Physical Properties for Gravity Core 88200-026

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.06	1.90	53.7	1507.	60.
0.15	1.84	55.2	1504.	144.
0.24	1.97	49.7	1558.	116.
0.33	1.92	48.2	1562.	93.

TABLE 16b - Grain Size Data for Gravity Core 88200-026

Subbottom Depth Interval (m)	% Gravel	% Sand	% Silt	% Clay
0.00-0.04	1	16	25	58
0.04-0.14	5	20	55	20
0.14-0.20	tr	5	62	33
0.20-0.25	12	24	55	9
0.25-0.33	11	23	56	10
0.33-0.42	4	33	56	7

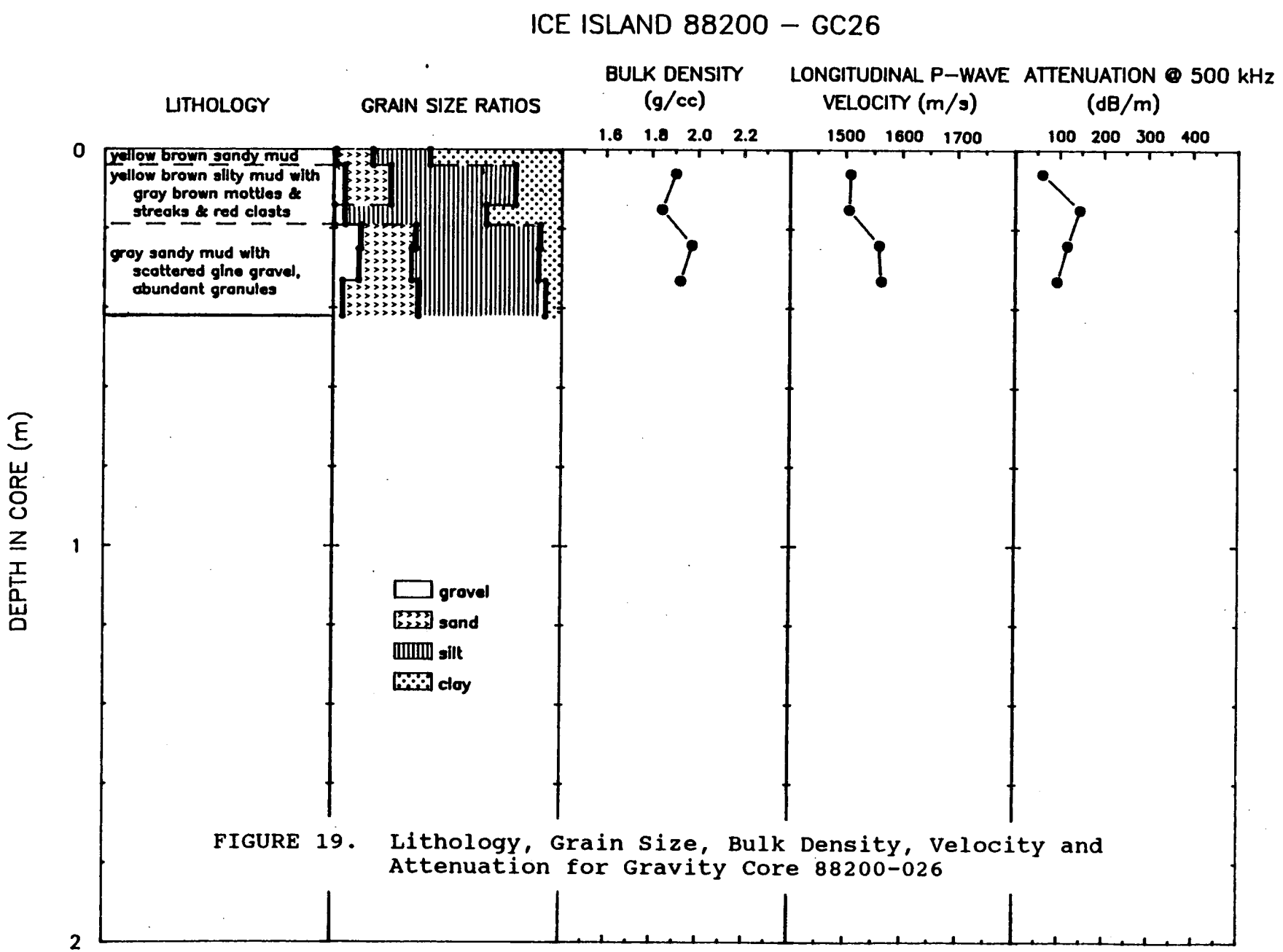

FIGURE 19. Lithology, Grain Size, Bulk Density, Velocity and Attenuation for Gravity Core 88200-026

TABLE 17a - Physical Properties for Piston Core 88200-036

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.04	1.58	73.6	****	****
0.11	1.57	72.1	1457.	134.
0.21	1.95	51.2	1943.	441.
0.30	1.94	50.3	1552.	351.
0.40	2.05	44.1	1605.	417.
0.50	2.08	42.6	1617.	370.
0.58	2.04	42.8	1635.	93.
0.75	2.08	42.1	1624.	163.
0.83	2.06	42.7	1667.	135.
0.95	2.09	40.3	1666.	112.
1.04	2.05	40.9	1625.	33.

TABLE 17b - Grain Size Data for Gravity Core 88200-036

Subbottom Depth Interval (m)	% Gravel	% Sand	% Silt	% Clay
0.00-0.07	1	6	65	28
0.07-0.12	--	1	20	79
0.12-0.20	tr	30	65	5
0.20-0.25	9	11	60	20
0.40-1.14	2	10	58	30

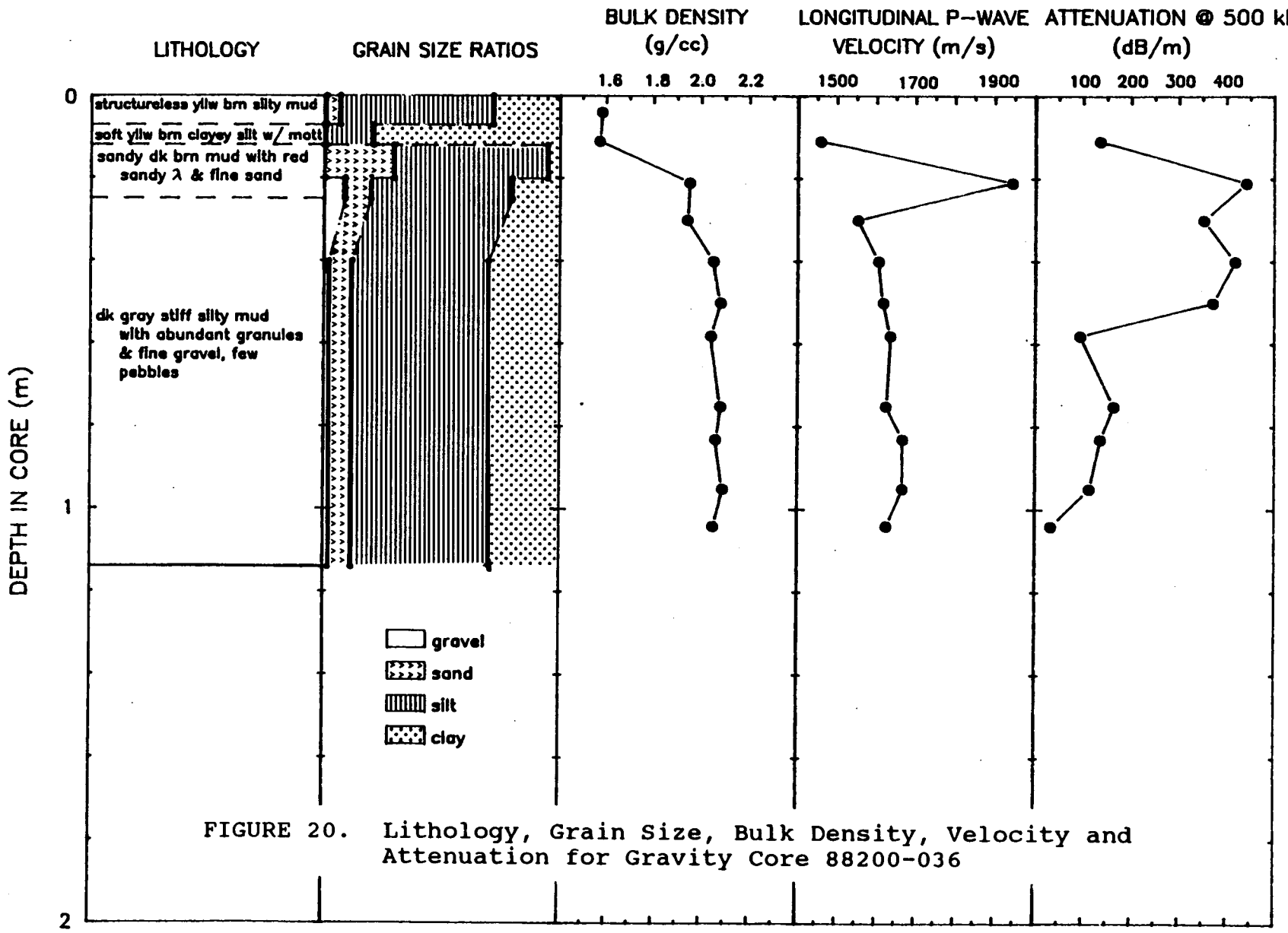

FIGURE 20. Lithology, Grain Size, Bulk Density, Velocity and Attenuation for Gravity Core 88200-036

ARCTIC INTER-ISLAND CHANNEL CORES

TABLE 18 - Physical Properties for Gravity Core 86100-002

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.10	****	****	1508.	347.
0.20	****	****	1519.	287.
0.28	1.61	70.3	****	****
0.34	1.63	69.4	****	****
0.50	1.68	65.2	1518.	105.
0.60	1.70	66.6	1464.	95.

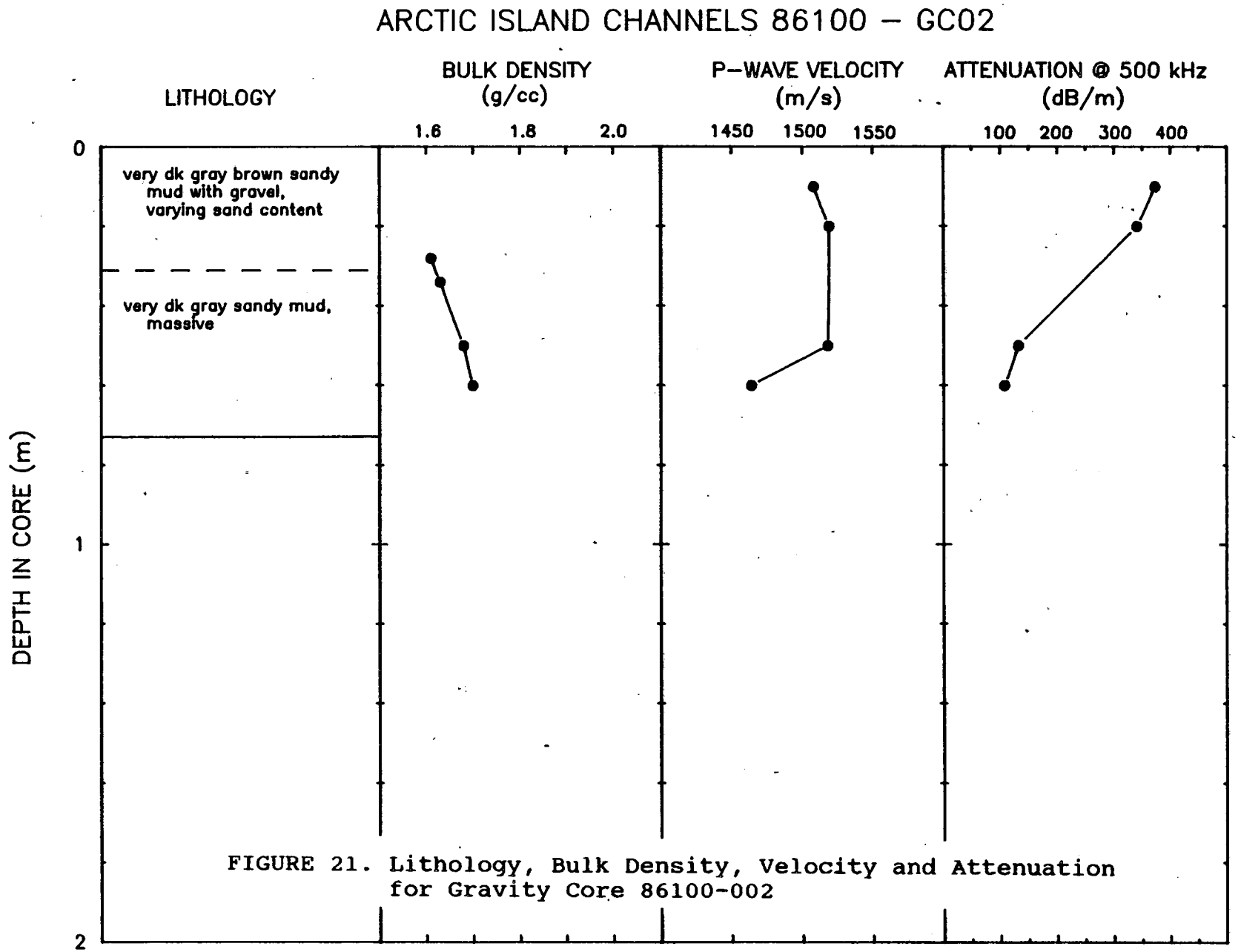

FIGURE 21. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 86100-002

TABLE 19 - Physical Properties for Gravity Core 87100-002

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.08	1.70	64.3	1462.	89.
0.18	1.63	67.9	1455.	61.
0.28	1.64	69.2	1453.	76.
0.38	1.77	61.4	1477.	72.

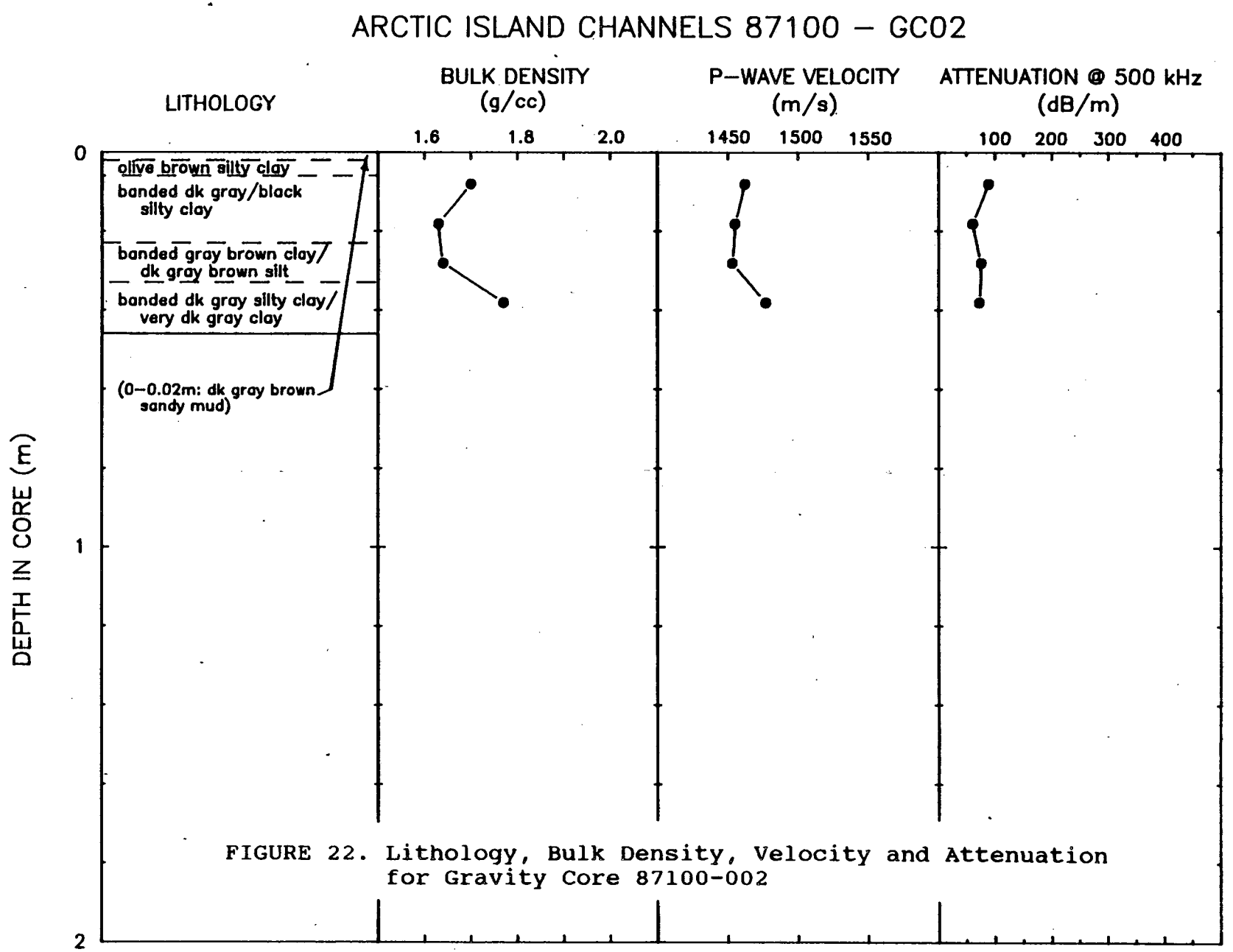

FIGURE 22. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87100-002

TABLE 20 - Physical Properties for Gravity Core 87100-003

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.06	1.60	70.6	1444.	69.
0.13	1.77	61.5	1469.	85.
0.21	1.72	63.6	****	****

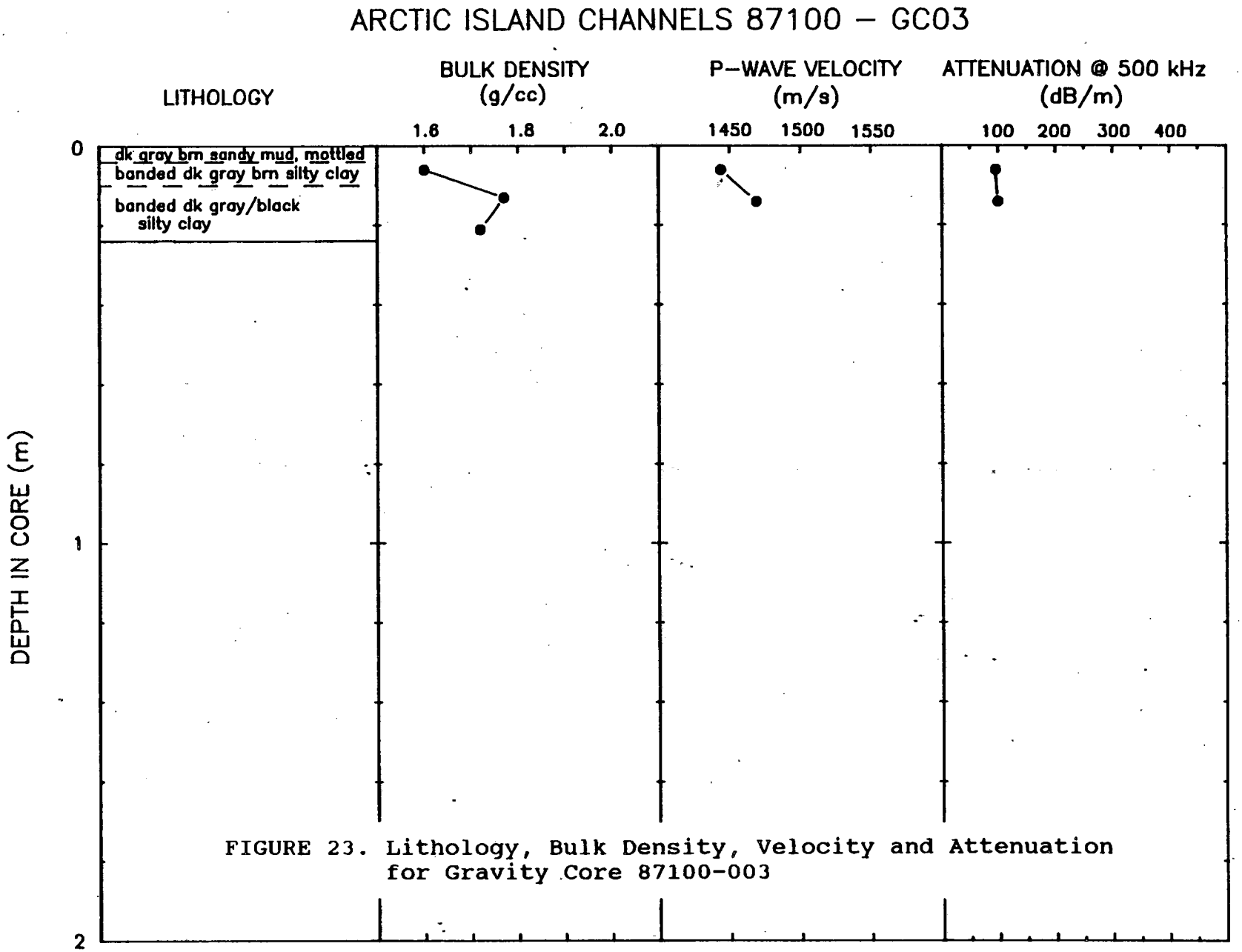

FIGURE 23. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87100-003

TABLE 21 - Physical Properties for Gravity Core 87100-006

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.06	1.79	59.5	1510.	230.
0.15	1.78	60.4	1514.	132.
0.24	1.72	63.2	1491.	182.
0.30	1.85	55.0	****	****

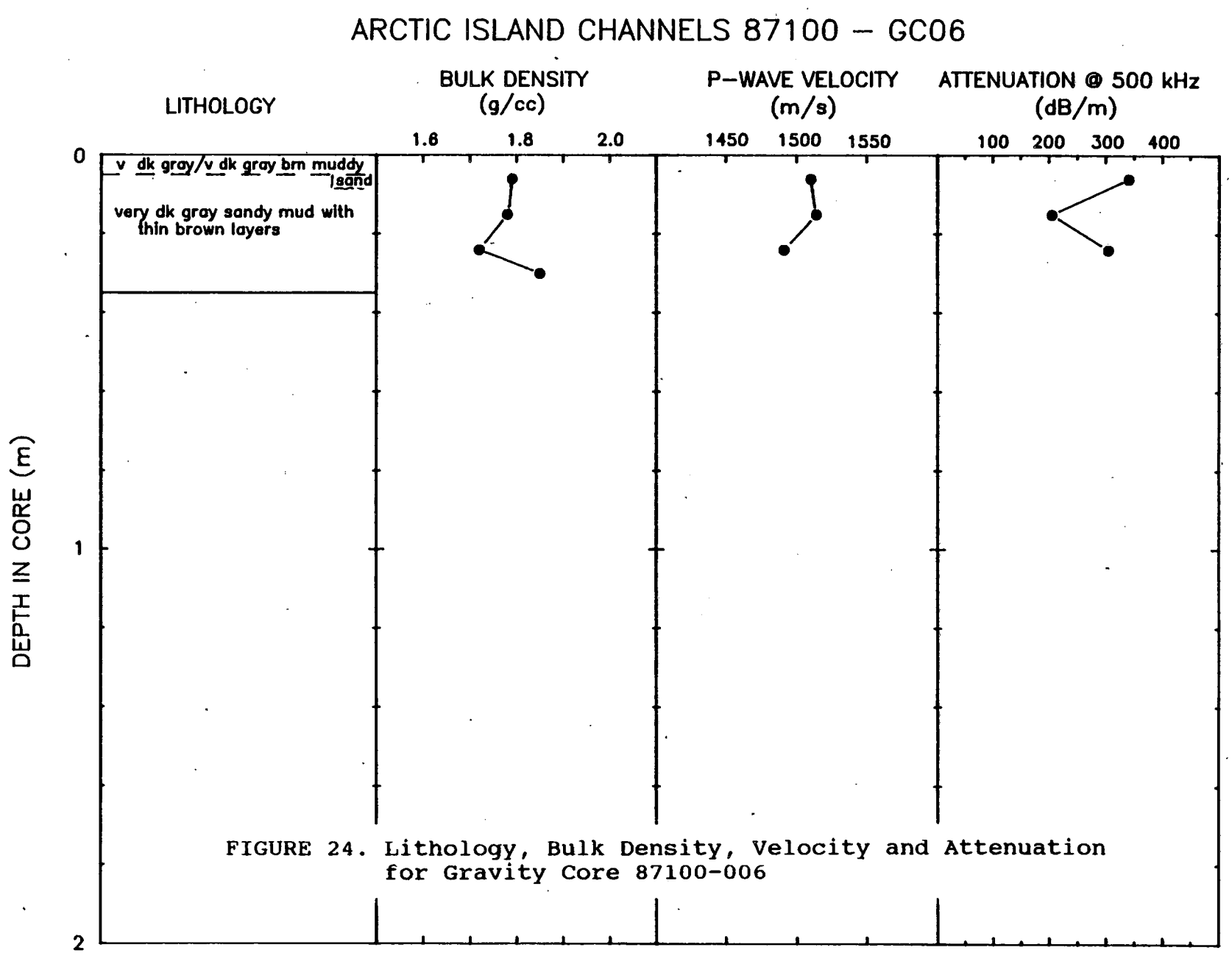

FIGURE 24. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87100-006

TABLE 22 - Physical Properties for Gravity Core 87100-008

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.04	1.63	****	****	****
0.16	1.66	60.4	1450.	30.
0.26	1.60	63.2	1442.	23.
0.35	1.64	55.0	1440.	- 4.
0.50	1.65	****	1447.	35.
0.60	1.71	****	1451.	-15.
0.70	1.78	****	1471.	58.
0.80	1.69	****	1482.	****

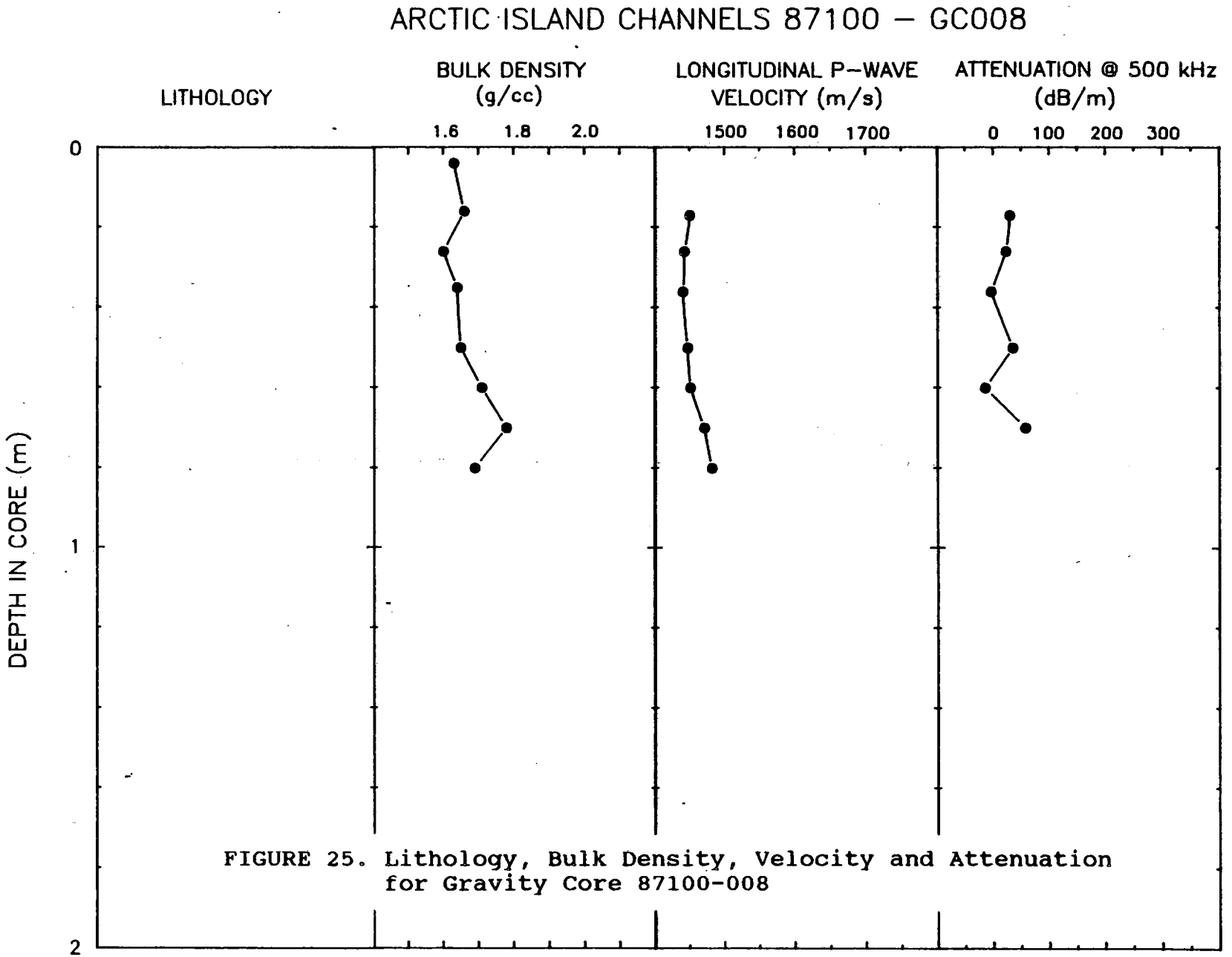

FIGURE 25. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87100-008

TABLE 23 - Physical Properties for Gravity Core 87027-003

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.15	1.61	69.7	1470.	95.
0.25	1.61	67.6	1461.	109.
0.35	1.79	59.7	1483.	209.
0.45	1.78	61.1	1490.	367.
0.55	2.07	41.5	1655.	446.

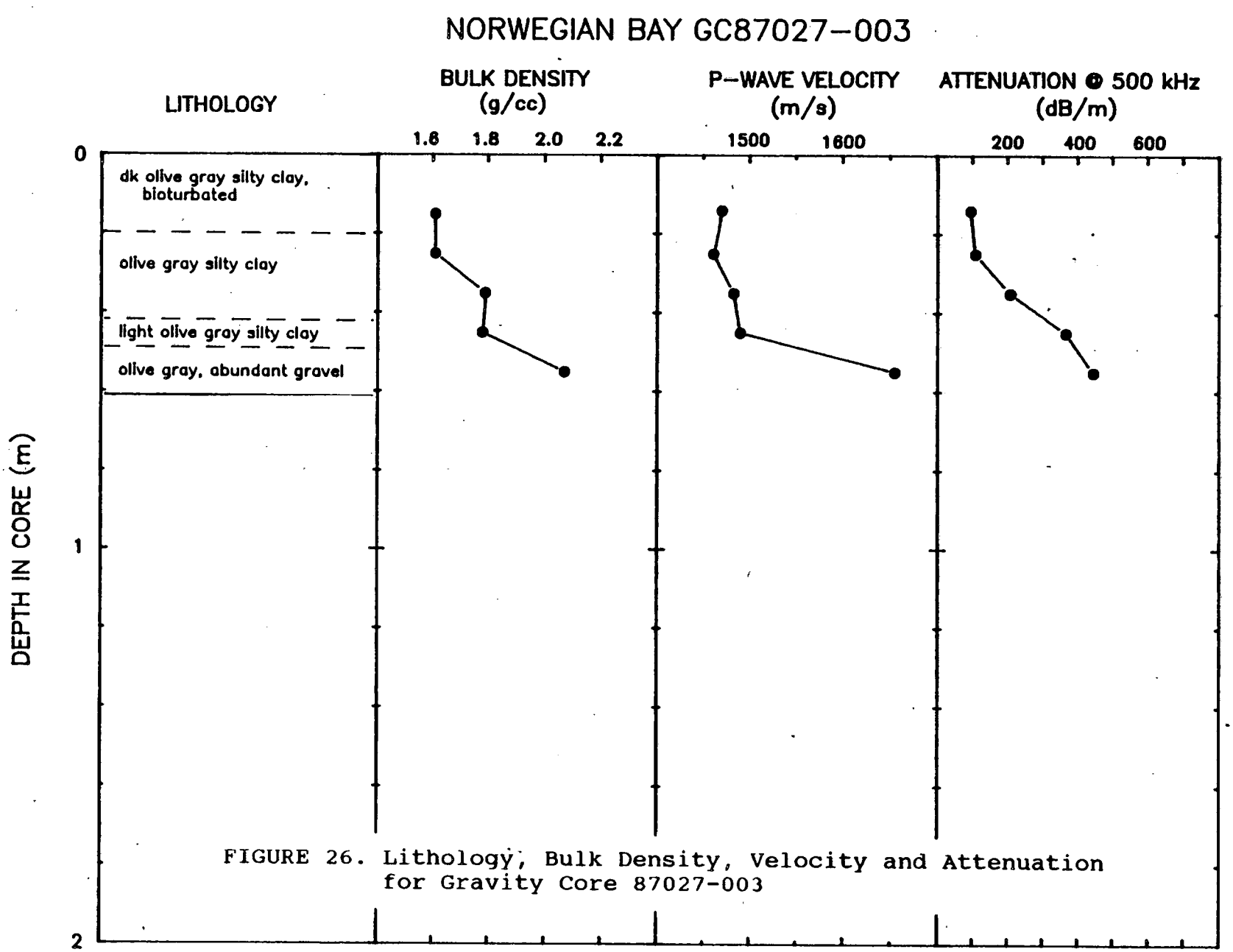

FIGURE 26. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87027-003

TABLE 24 - Physical Properties for Gravity Core 87027-004

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.02	1.98	46.0	****	****
0.12	1.99	47.1	1610.	123.

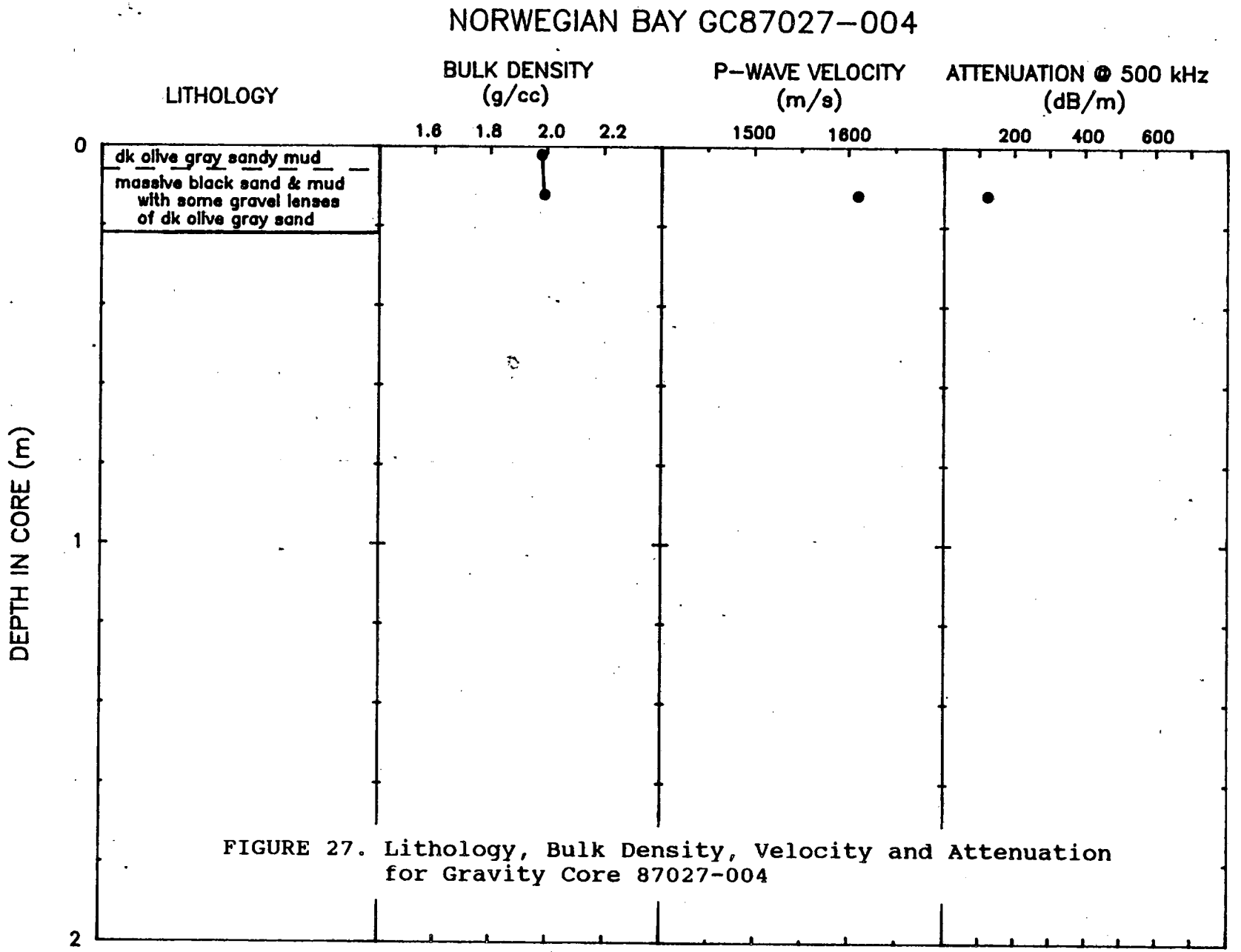

FIGURE 27. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87027-004

TABLE 25 - Physical Properties for Gravity Core 87027-006

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.06	1.70	61.2	1471.	89.
0.15	2.17	37.4	1764.	424.
0.26	2.27	30.2	1783.	225.
0.35	2.29	31.3	****	****
0.43	2.31	29.2	2073.	571.

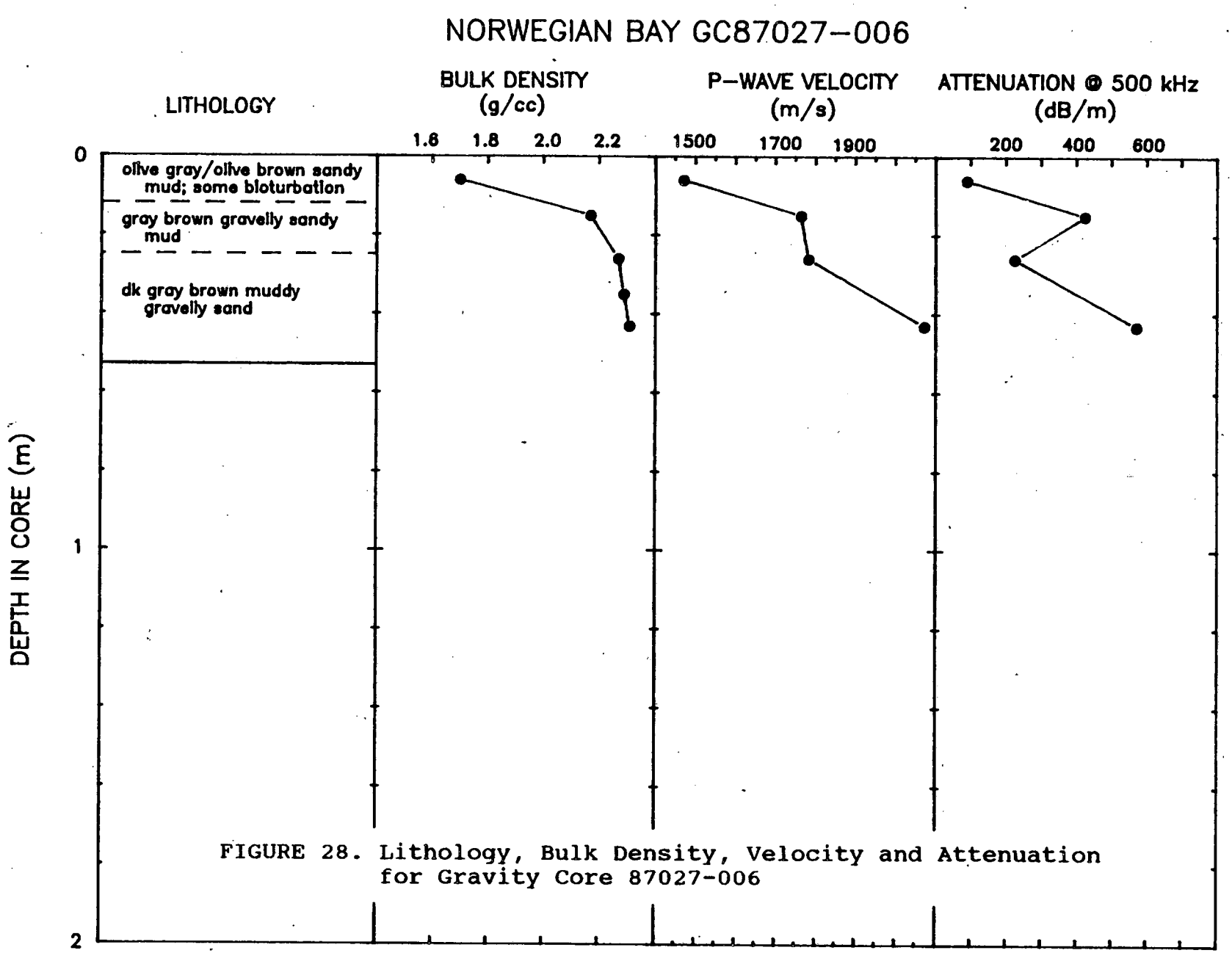

FIGURE 28. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87027-006

TABLE 26 - Physical Properties for Gravity Core 87027-008

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.07	1.64	66.0	1473.	139.
0.16	1.57	69.3	1450.	56.
0.25	1.57	70.5	1447.	78.
0.35	1.51	72.1	1448.	54.
0.45	1.59	68.6	1447.	113.
0.55	1.56	71.2	1443.	56.
0.66	1.67	65.1	1455.	126.
0.78	1.68	67.1	1439.	100.
0.85	1.73	62.1	****	****

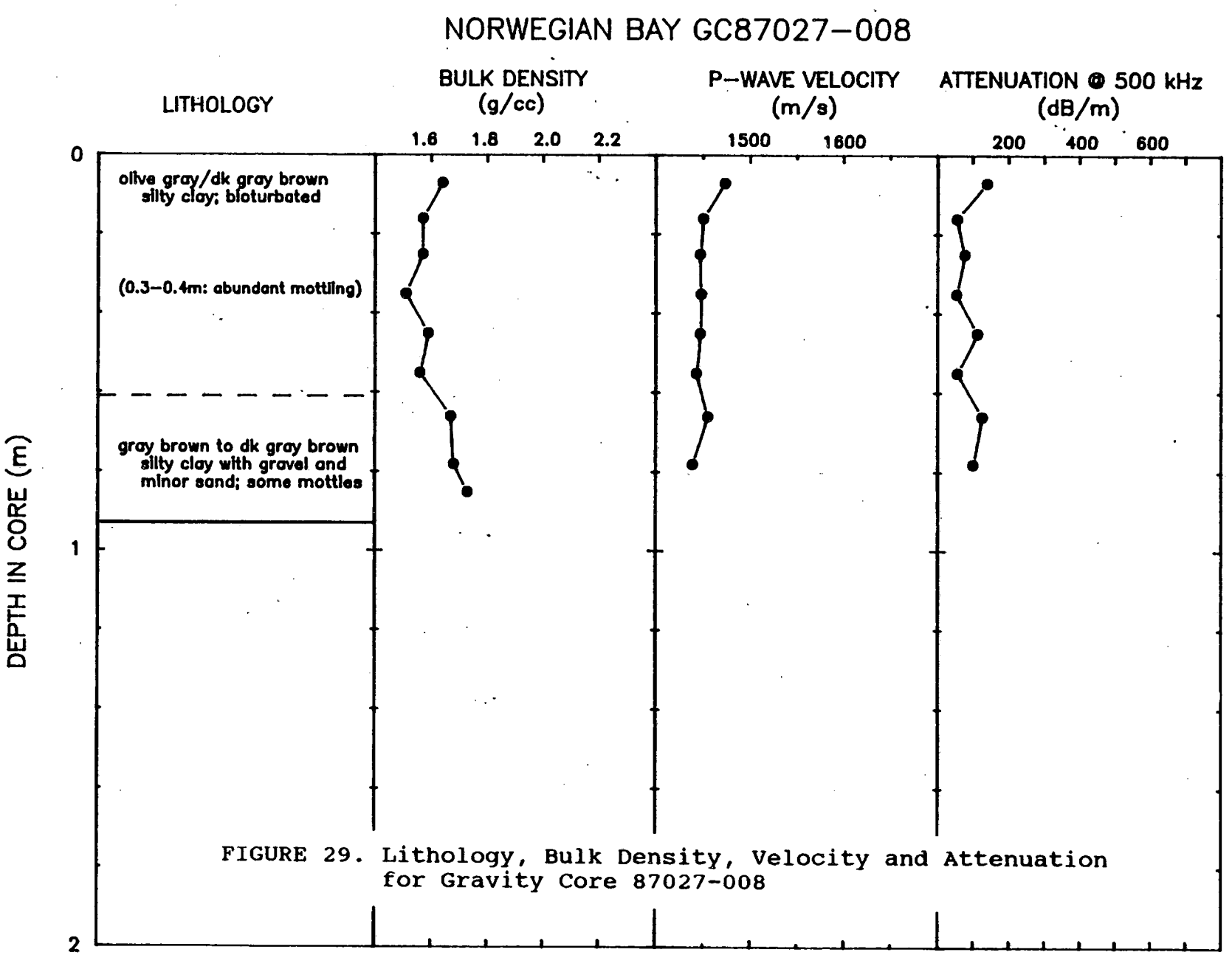

FIGURE 29. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87027-008

TABLE 27 - Physical Properties for Gravity Core 87027-009

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.12	1.76	61.8	1458.	40.
0.22	1.79	59.1	1477.	99.
0.34	2.29	29.0	1705.	210.

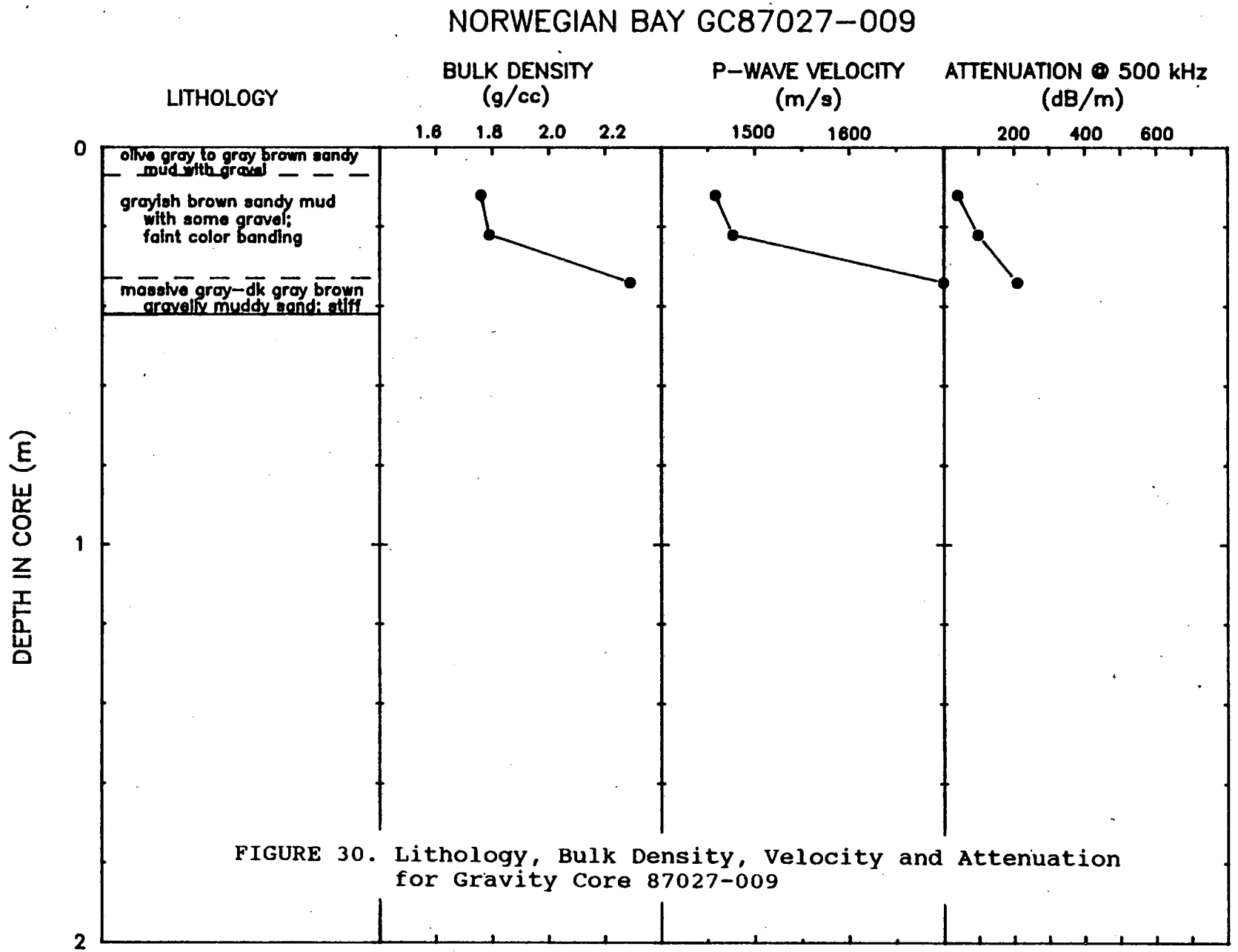

FIGURE 30. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87027-009

TABLE 28 - Physical Properties for Gravity Core 87027-010

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.10	1.59	71.6	1459.	112.
0.20	1.52	75.5	1450.	46.
0.30	1.51	74.4	1446.	89.
0.40	1.53	73.4	1455.	56.
0.50	1.55	71.9	1449.	41.
0.60	1.56	71.4	1451.	45.
0.70	1.53	73.3	1432.	160.

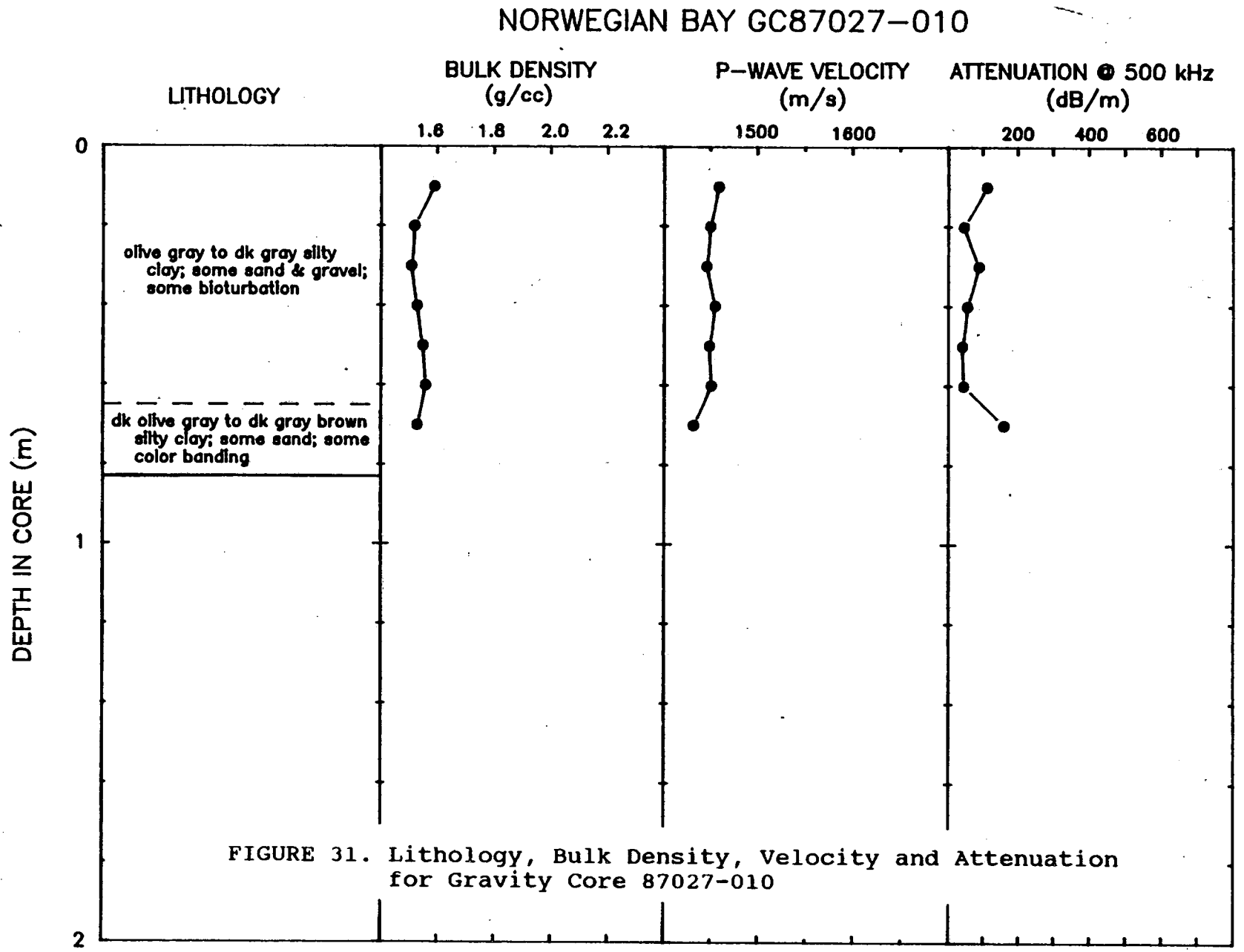

FIGURE 31. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87027-010

TABLE 29 - Physical Properties for Gravity Core 87027-011

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.10	1.61	69.7	1450.	201.
0.20	1.54	73.7	1450.	46.
0.30	1.60	70.8	1450.	49.
0.40	1.60	71.6	1452.	66.

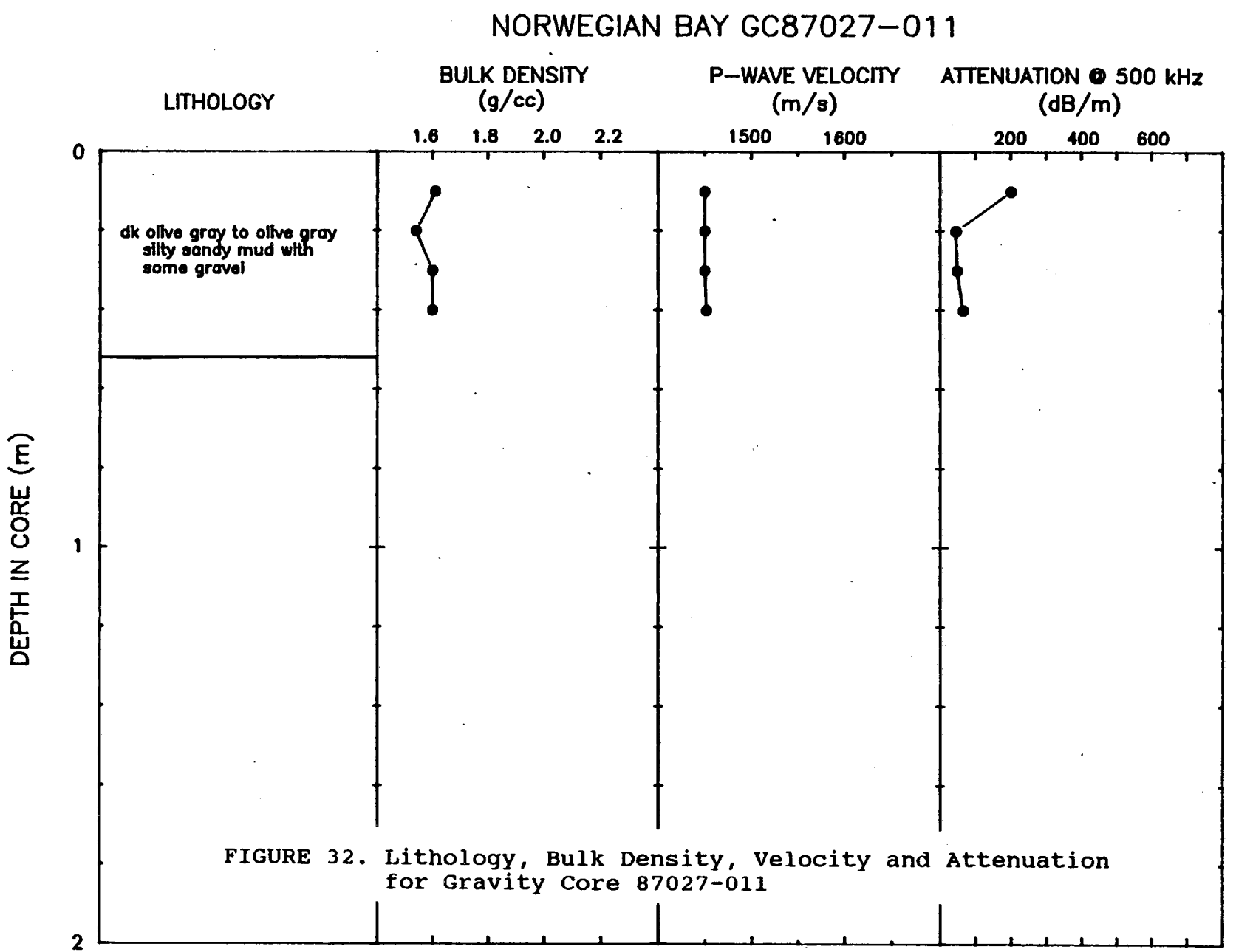

FIGURE 32. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87027-011

TABLE 30 - Physical Properties for Gravity Core 87027-014

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.08	1.49	77.3	1441.	123.
0.16	1.43	79.7	1438.	50.
0.25	1.46	78.0	1438.	70.
0.35	1.52	77.4	1436.	62.

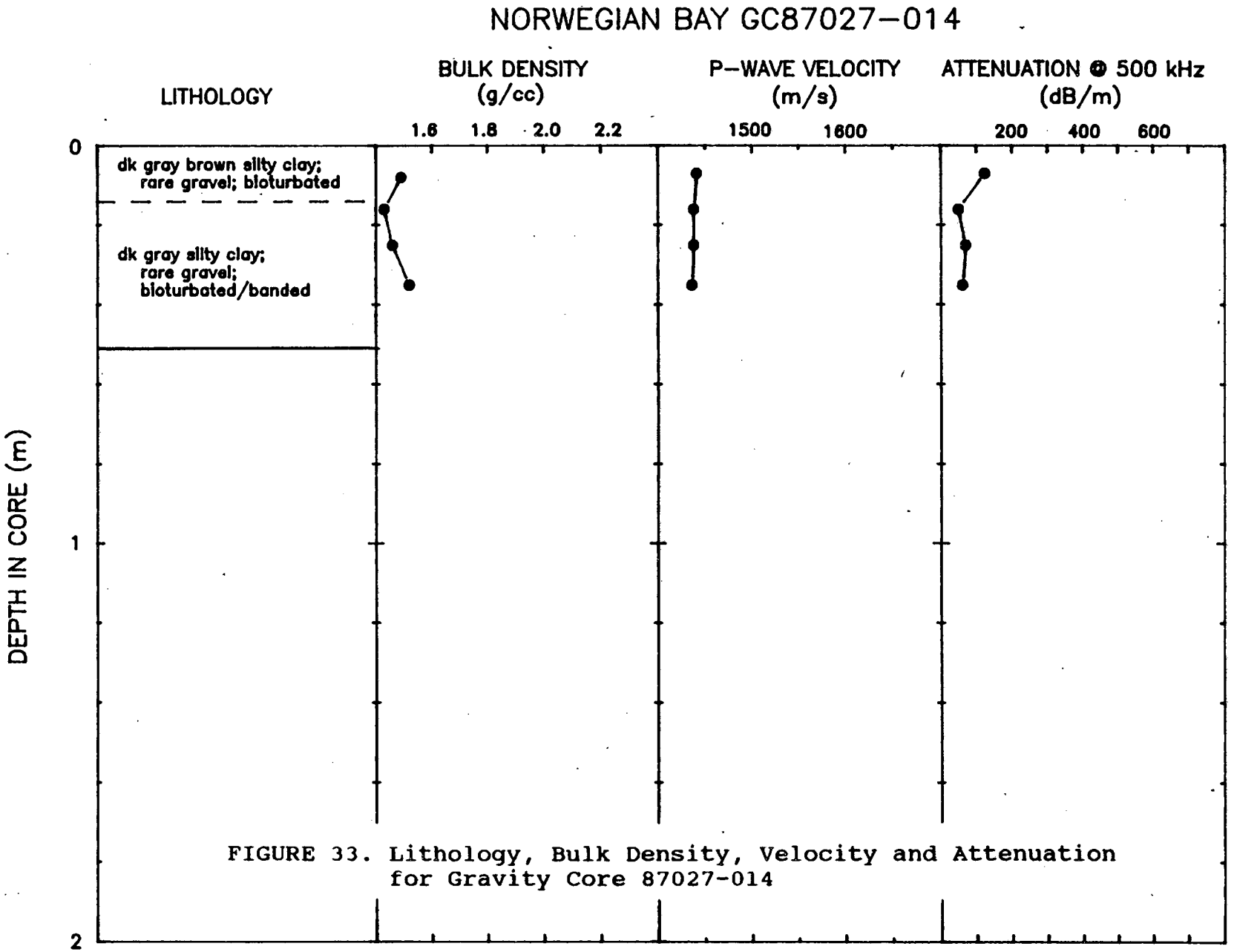

FIGURE 33. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87027-014

TABLE 31 - Physical Properties for Gravity Core 87027-015

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.10	1.94	50.0	1590.	129.
0.20	1.88	52.7	1526.	219.
0.29	1.87	52.6	1566.	111.

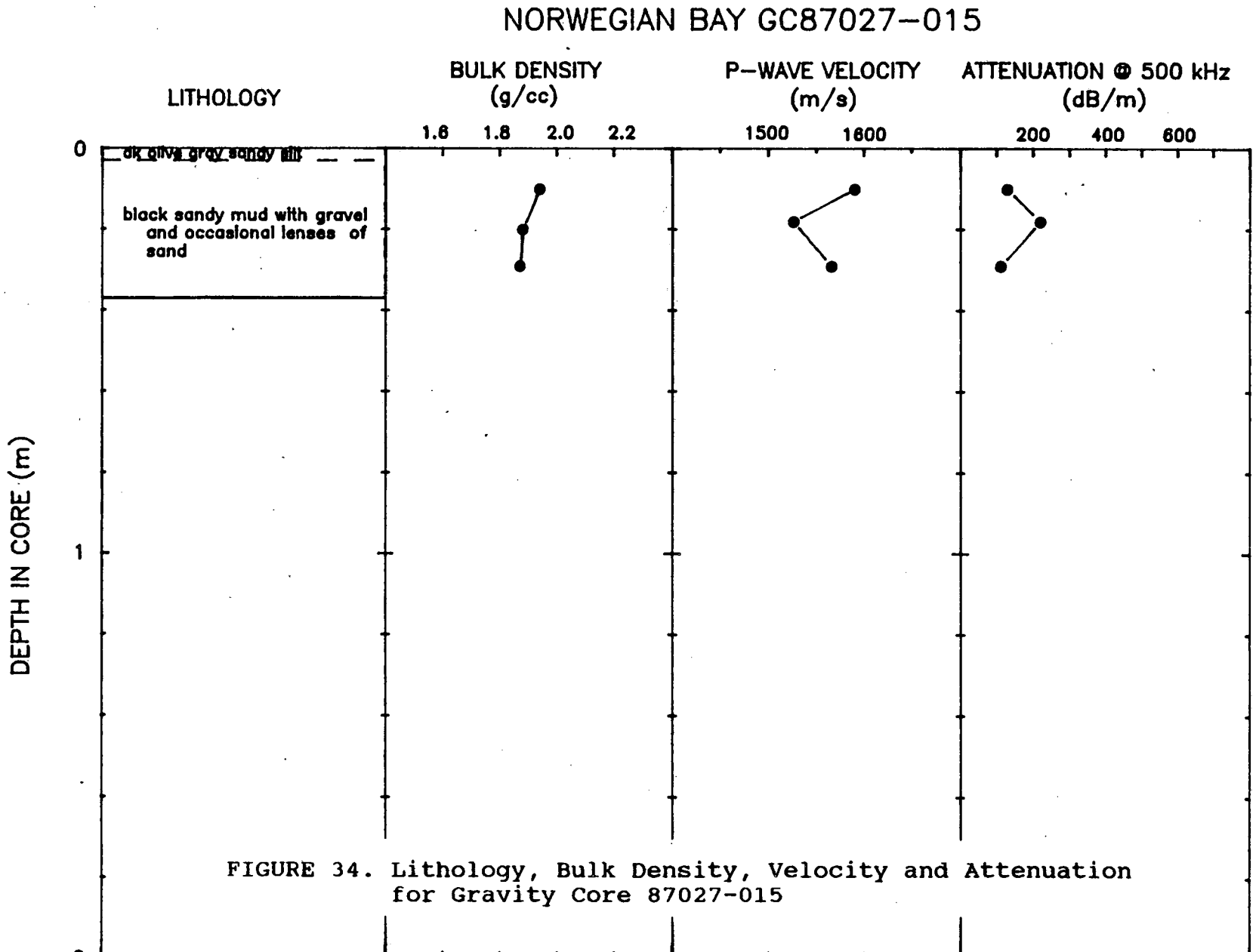

FIGURE 34. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87027-015

TABLE 32 - Physical Properties for Gravity Core 87027-016

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.20	1.97	47.4	1606.	712.
0.30	2.01	45.5	1624.	689.

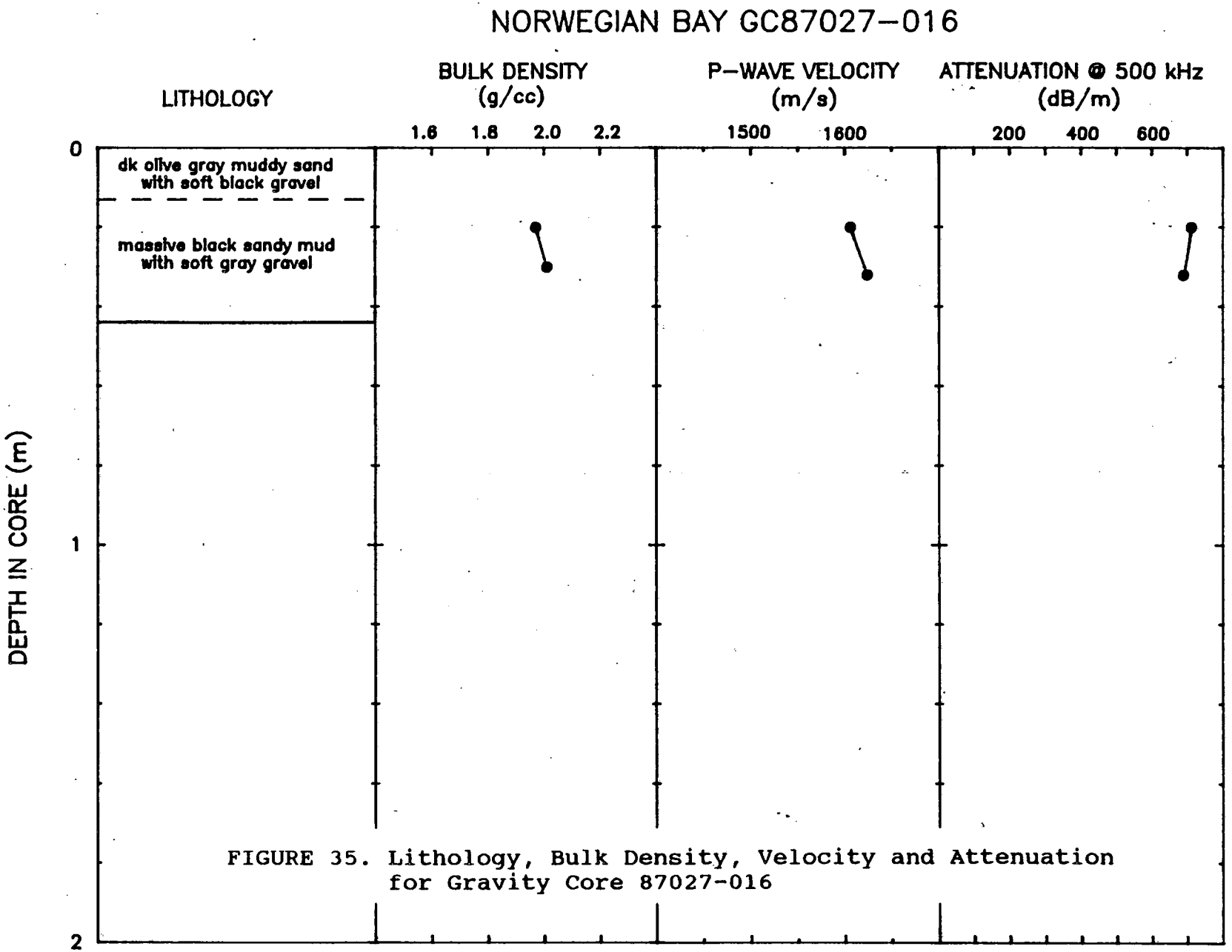

FIGURE 35. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87027-016

TABLE 33 - Physical Properties for Gravity Core 87027-026

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.07	1.51	72.3	1423.	****
0.16	1.50	74.8	1443.	93.
0.25	1.50	75.3	1442.	96.
0.35	1.51	76.4	1441.	82.
0.45	1.52	75.0	1438.	71.
0.55	1.58	72.2	1442.	57.
0.63	1.69	69.6	1450.	48.
0.75	1.50	75.2	1437.	3.
0.88	1.50	72.7	1437.	54.

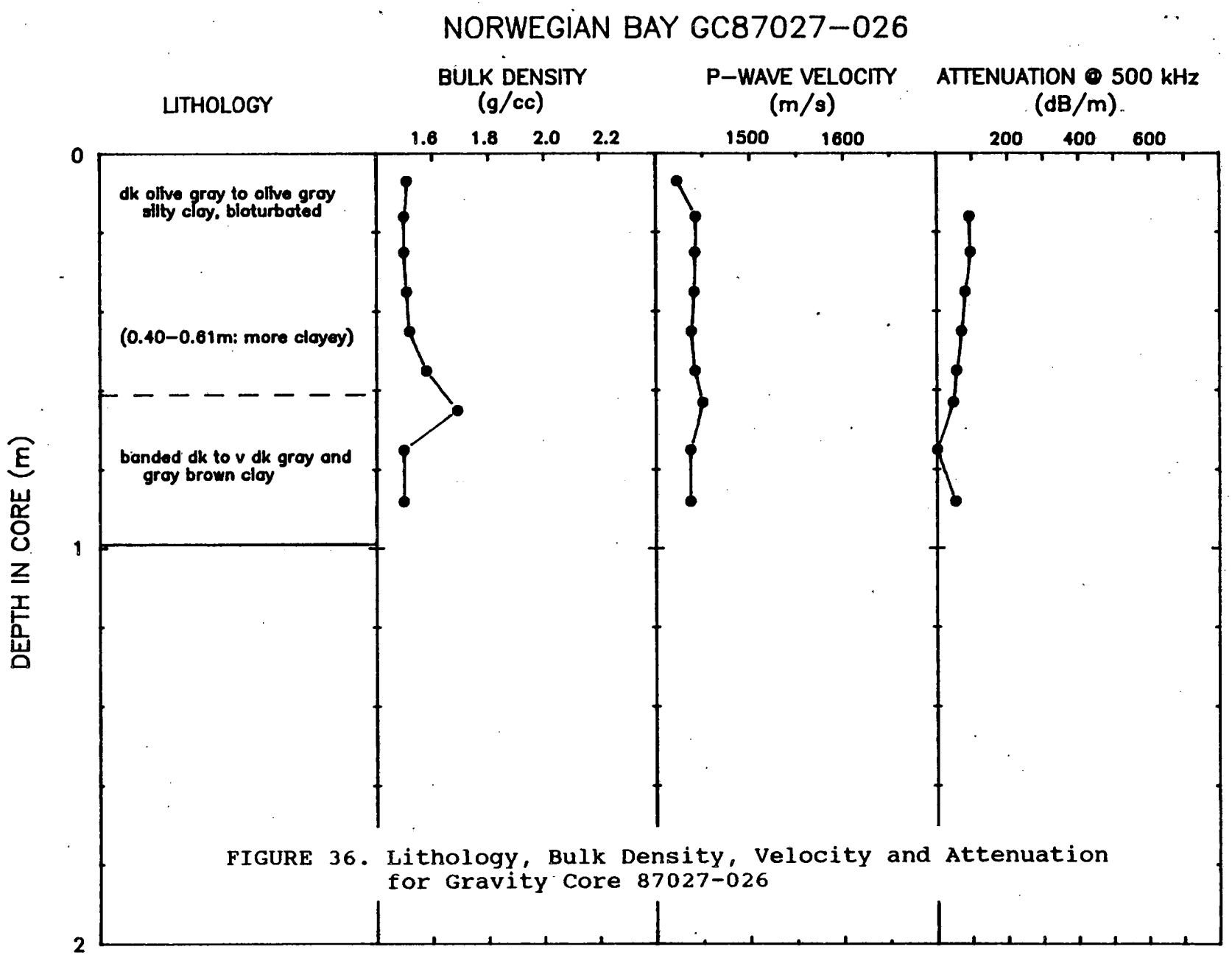

FIGURE 36. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87027-026

TABLE 34 - Physical Properties for Gravity Core 87027-027

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.07	1.49	75.2	1444.	- 2.
0.17	1.47	76.4	1447.	-15.
0.39	1.48	75.9	1446.	39.
0.50	1.46	77.7	1448.	66.
0.62	1.45	77.8	1444.	41.
0.75	1.47	77.5	1446.	36.
0.85	1.49	75.7	1445.	13.
0.95	1.48	77.1	1444.	16.
1.05	1.50	75.2	1448.	26.

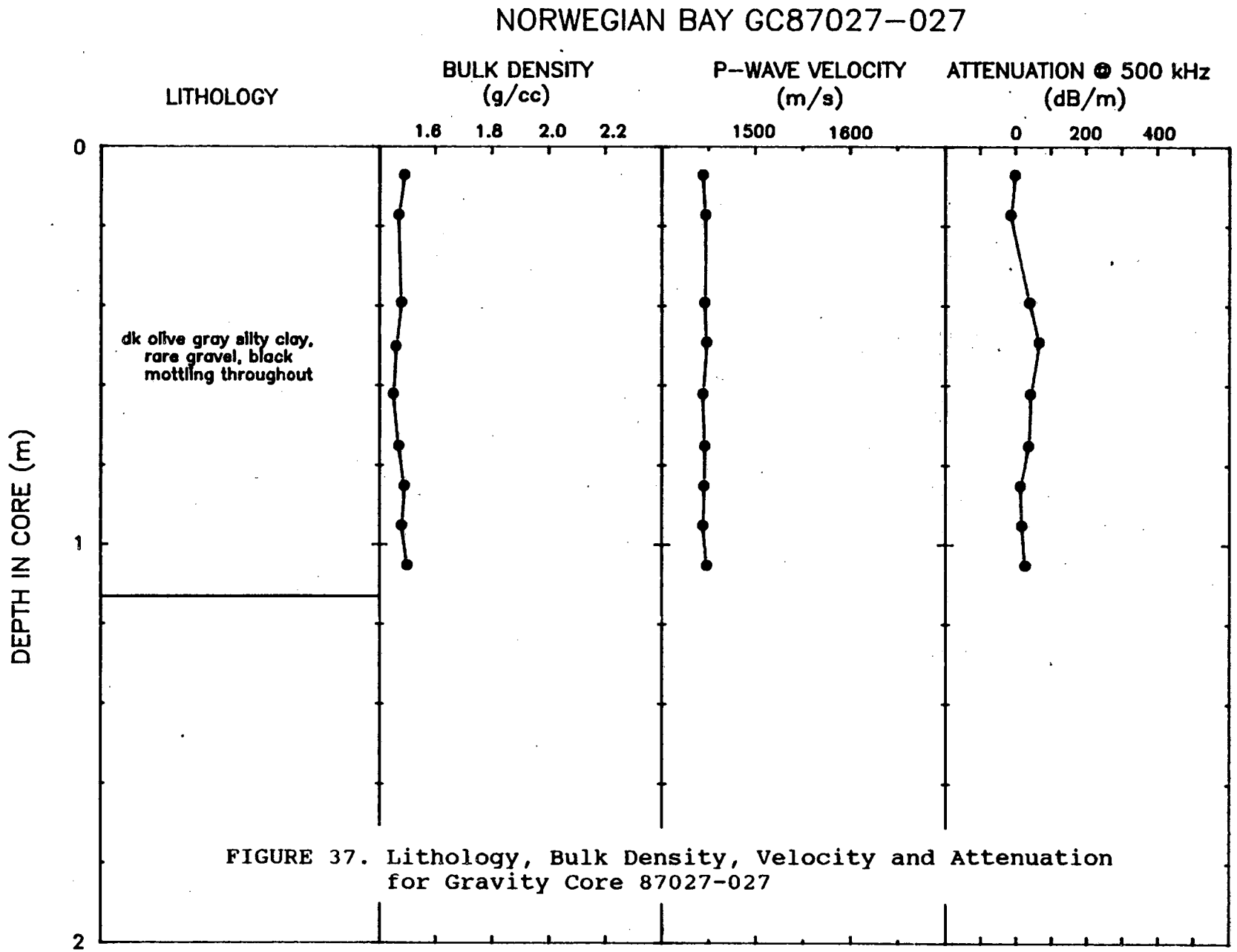

FIGURE 37. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87027-027

TABLE 35 - Physical Properties for Gravity Core 87027-029

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.10	1.60	69.0	1461.	56.
0.20	1.58	70.0	1457.	52.
0.30	1.55	72.1	1457.	62.
0.40	1.57	70.9	1459.	66.
0.50	1.64	71.4	1466.	55.
0.60	1.65	65.6	1480.	40.
0.70	1.66	****	1477.	32.
0.80	1.69	64.8	1479.	23.
0.90	1.69	64.2	1486.	42.

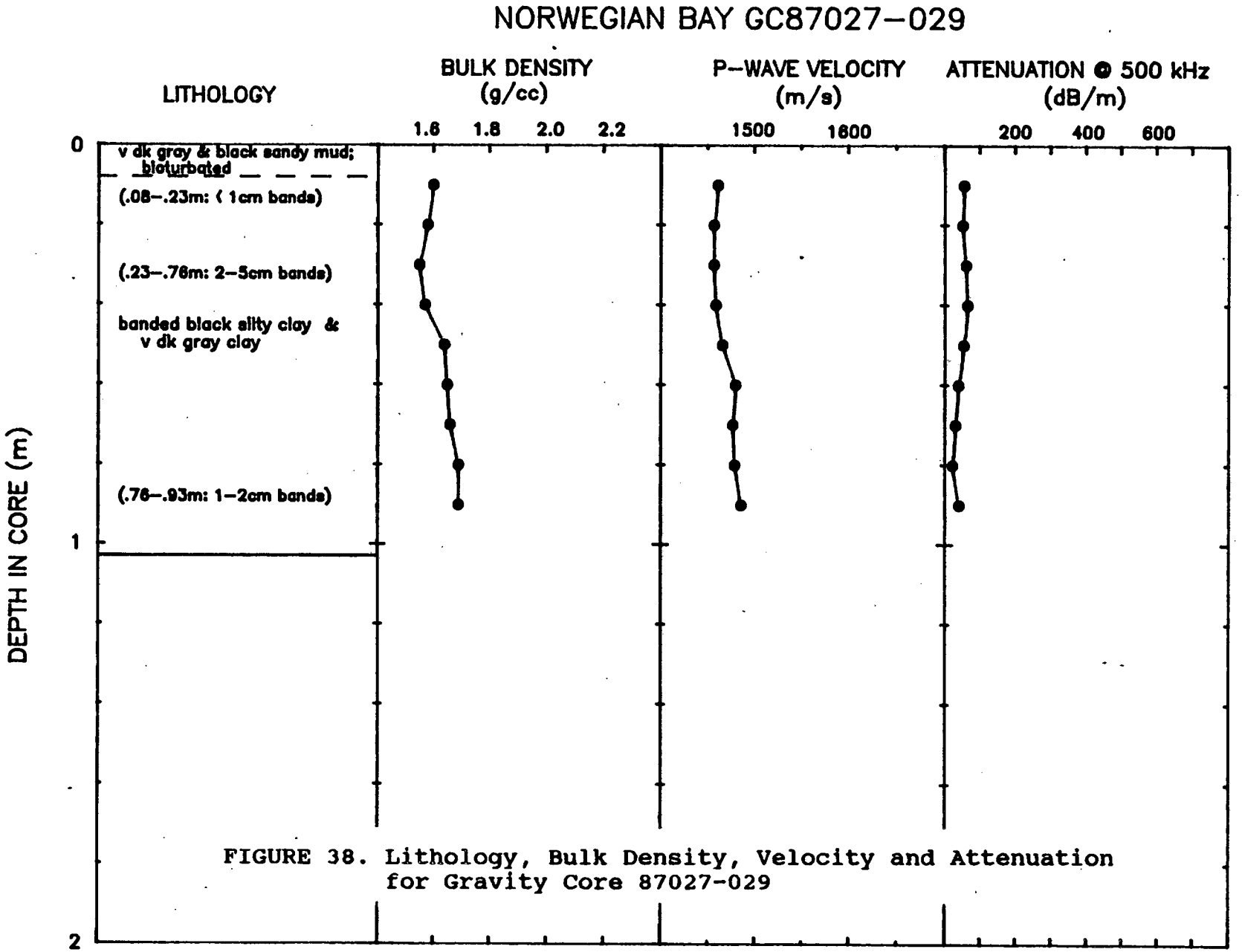

FIGURE 38. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87027-029

TABLE 36 - Physical Properties for Gravity Core 87027-032

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.07	1.59	68.0	1469.	51.
0.16	1.57	69.7	****	****
0.25	1.55	70.7	1453.	- 8.
0.35	1.55	71.7	1457.	35.
0.45	1.60	70.3	****	****
0.57	1.58	70.7	1456.	138.

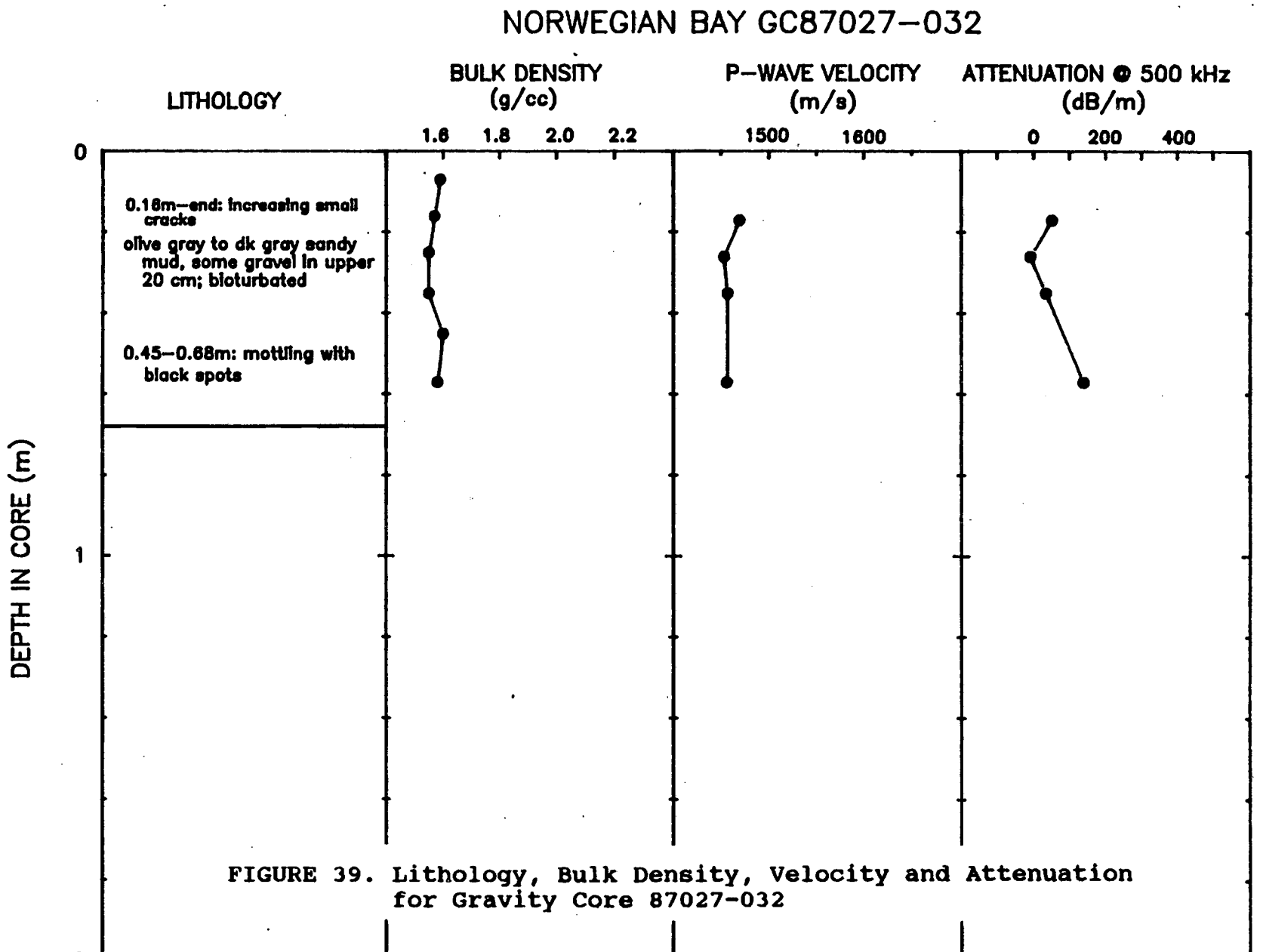

FIGURE 39. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87027-032

TABLE 37 - Physical Properties for Gravity Core 87027-033

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.10	1.87	51.0	1556.	35.
0.20	1.88	52.3	1558.	73.
0.30	1.86	54.4	1547.	63.

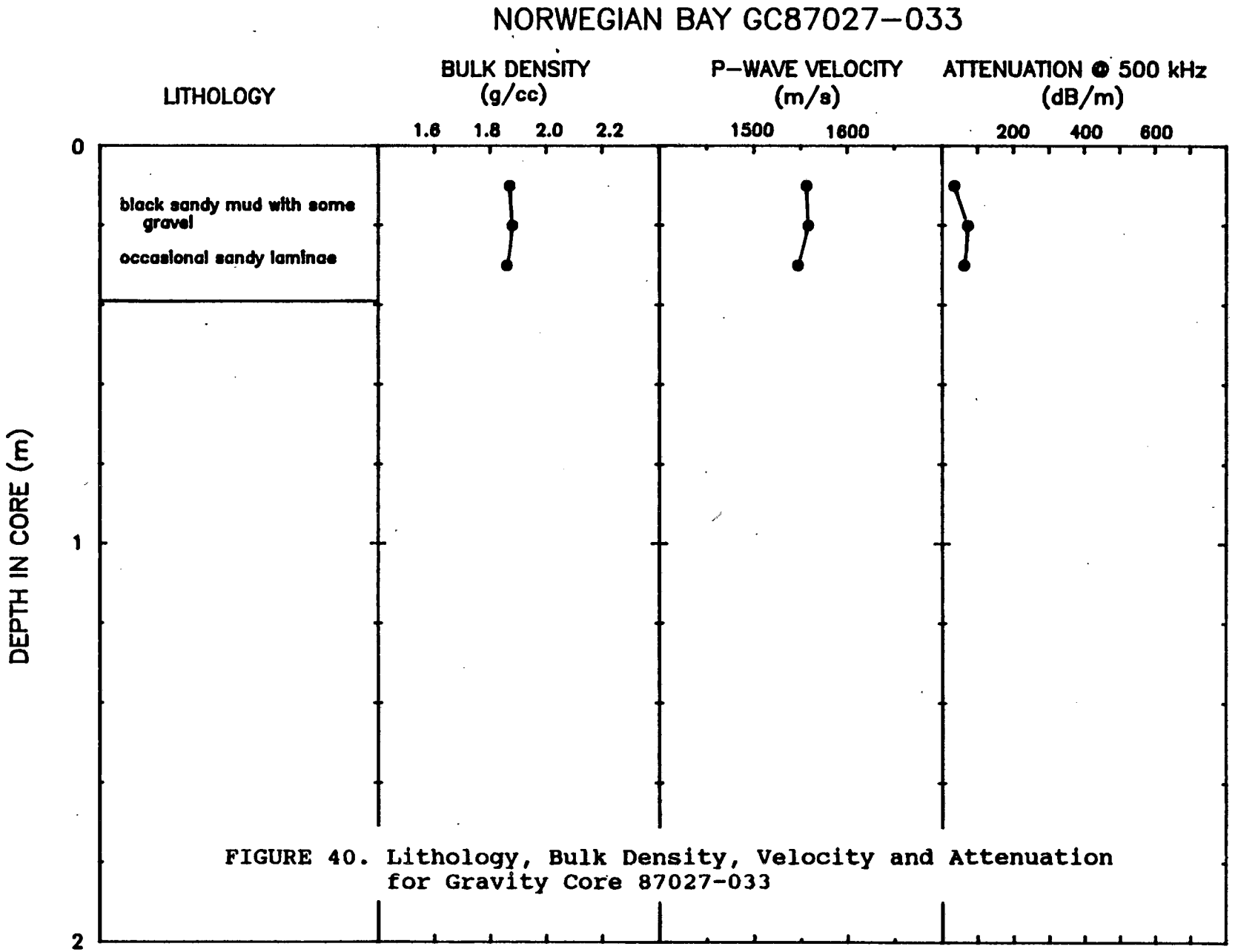

FIGURE 40. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87027-033

TABLE 38 - Physical Properties for Gravity Core 87027-034

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.06	1.79	57.7	1588.	236.
0.14	1.76	59.3	1520.	188.

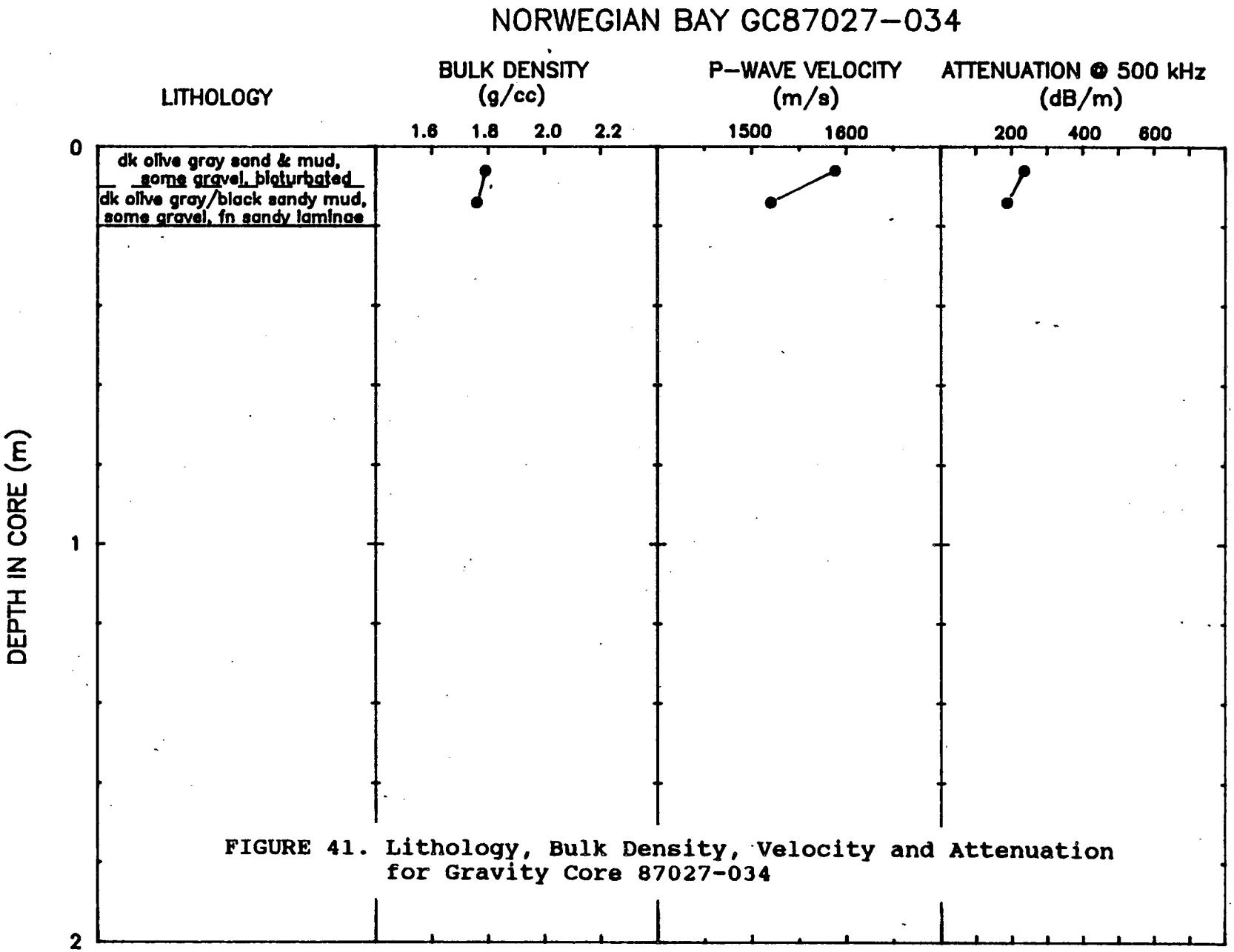

FIGURE 41. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87027-034

TABLE 39 - Physical Properties for Gravity Core 87027-043

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.10	1.93	49.3	1597.	110.
0.27	1.94	48.6	1636.	130.

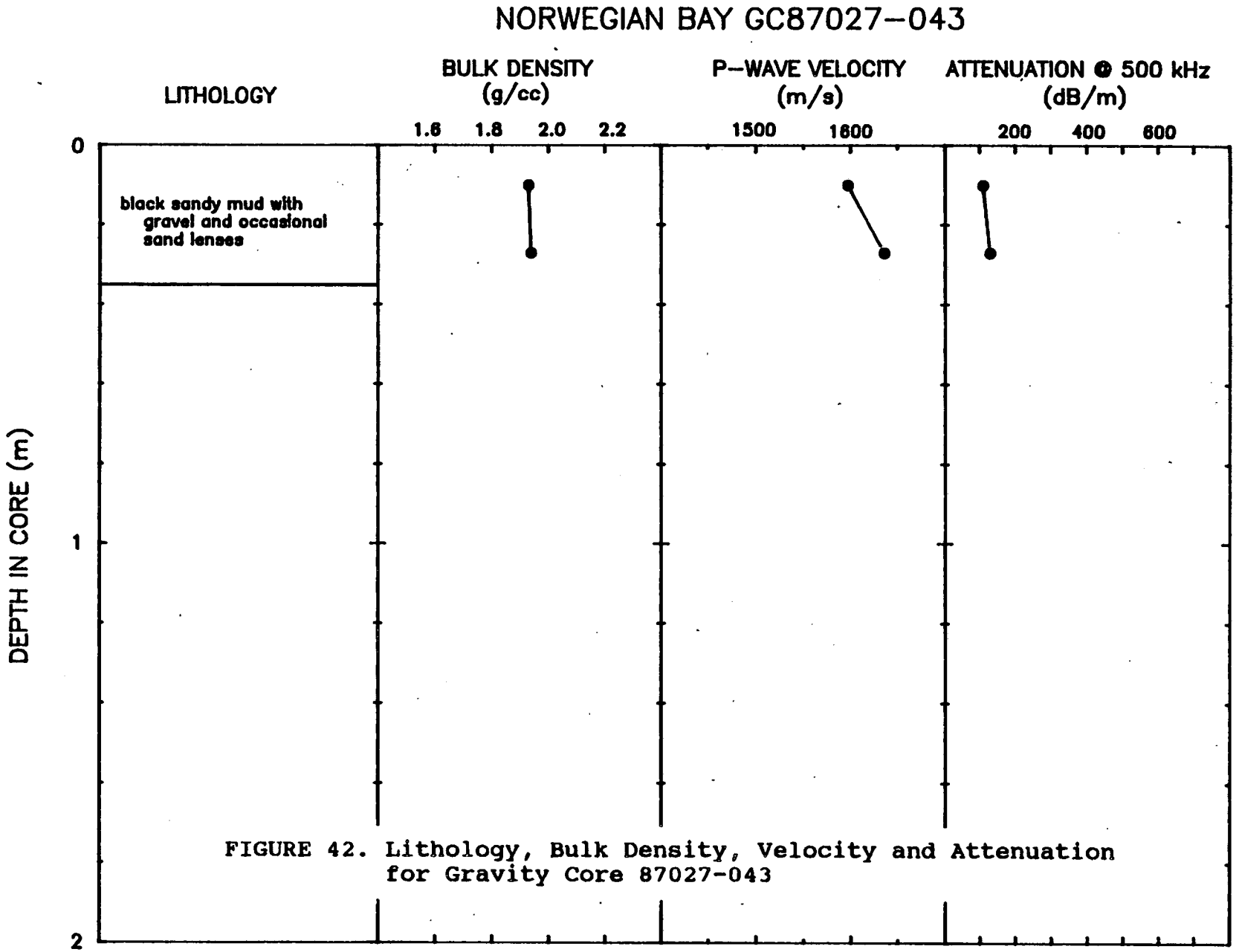

FIGURE 42. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87027-043

TABLE 40 - Physical Properties for Piston Core 87028-001

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitud. Velocity (m/s)	Transvrs. Velocity (m/s)	Long. Att. @ 500kHz (dB/m)	Trn. Att. @ 500kHz (dB/m)
0.22	1.55	72.7	****	****	****	****
0.40	2.00	47.2	****	****	****	****
0.58	2.09	41.5	****	****	****	****
0.91	1.92	53.9	****	****	****	****
1.90	1.94	50.1	1549.	1548.	117.	110.
2.10	1.97	49.2	1568.	1577.	139.	218.
2.40	1.94	52.7	1543.	1599.	102.	318.
2.70	1.92	53.3	1539.	1534.	114.	102.
2.90	1.97	46.8	1579.	1592.	205.	236.
3.10	1.96	48.2	1566.	1594.	112.	260.
3.30	1.98	48.2	1584.	1576.	127.	163.
3.50	2.00	46.6	1614.	1611.	257.	327.
3.70	1.89	51.9	1538.	1548.	131.	127.
3.81	1.85	55.3	****	****	****	****
3.90	****	****	1526.	1525.	78.	181.
4.08	****	****	1543.	1541.	129.	185.
4.50	1.88	53.9	1553.	1519.	157.	76.
4.70	2.00	45.0	1607.	1612.	506.	554.
4.97	1.96	48.0	1627.	1626.	509.	723.
5.13	1.82	57.5	1533.	1590.	387.	768.
5.30	1.86	55.6	1606.	1566.	445.	490.
5.50	1.99	46.2	1683.	1684.	671.	710.
5.70	2.29	28.7	1852.	1874.	854.	1500.
5.99	2.14	38.9	1725.	1838.	733.	764.
6.57	2.24	32.5	1847.	1895.	556.	905.
6.90	2.02	45.3	1761.	1689.	866.	929.
7.01	2.25	31.5	1866.	1854.	599.	886.

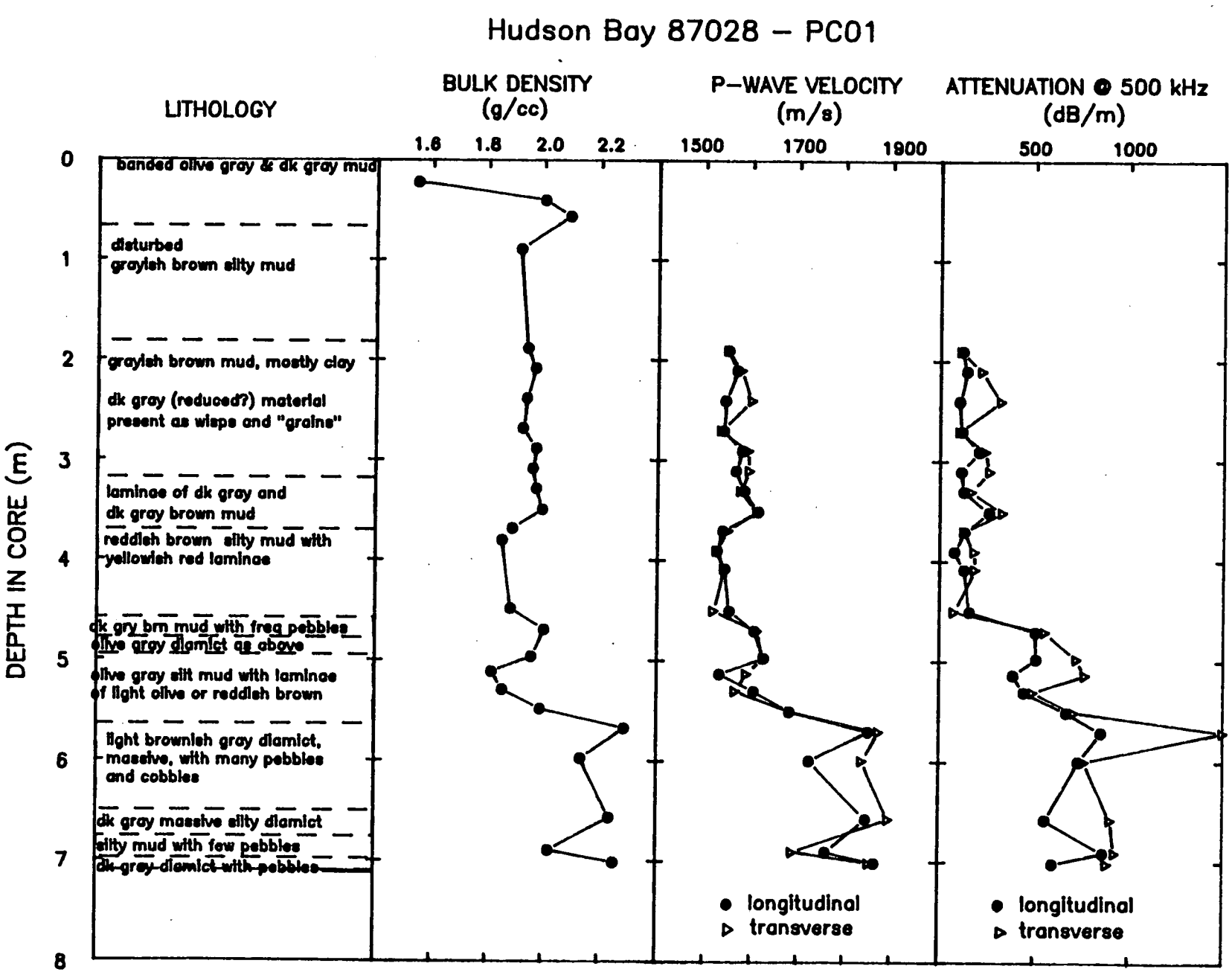

FIGURE 43. Lithology, Bulk Density, Velocity and Attenuation for Piston Core 87028-001

TABLE 41 - Physical Properties for Piston Core 87028-004

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitud. Velocity (m/s)	Transvrs. Velocity (m/s)	Long. Att. @ 500kHz (dB/m)	Trn. Att. @ 500kHz (dB/m)
0.25	****	****	1619.	1622.	250.	161.
0.45	1.88	54.1	****	****	****	****
0.64	1.93	51.3	****	****	****	****
0.79	****	****	1537.	1515.	85.	85.
0.89	1.91	50.9	****	****	****	****
1.07	2.00	46.3	****	****	****	****
1.15	1.95	50.1	****	****	****	****
1.23	****	****	1512.	1552.	62.	187.
2.62	1.78	59.5	1532.	1565.	137.	242.
2.87	1.88	52.7	1607.	1513.	180.	-69.
3.11	2.00	46.3	1677.	1631.	156.	227.
3.29	2.30	29.0	****	****	****	****
3.42	2.18	36.8	1785.	1786.	304.	287.
3.60	2.10	29.4	1757.	1830.	270.	584.
4.03	2.18	36.8	1748.	1805.	309.	271.
4.25	2.12	38.7	1675.	1737.	397.	390.
4.50	2.22	31.8	1837.	1868.	411.	381.
4.75	2.20	33.7	1764.	1806.	458.	352.
5.13	2.32	28.5	****	****	****	****

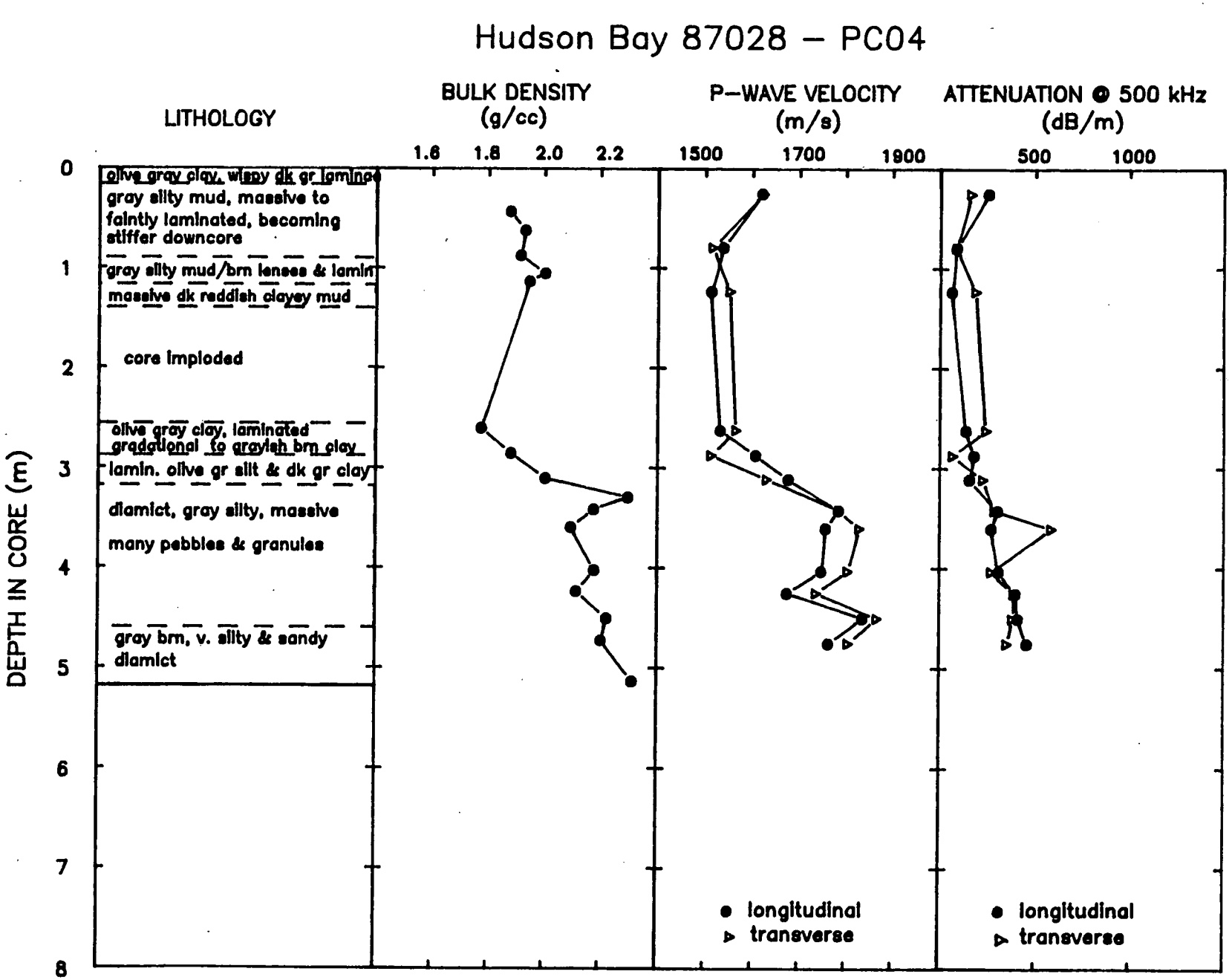

FIGURE 44. Lithology, Bulk Density, Velocity and Attenuation for Piston Core 87028-004

TABLE 42 - Physical Properties for Piston Core 87028-015

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitud. Velocity (m/s)	Transvrs. Velocity (m/s)	Long. Att. @ 500kHz (dB/m)	Trn. Att. @ 500kHz (dB/m)
0.45	2.28	29.2	****	****	****	****
0.63	2.30	29.0	1943.	1905.	511.	465.
1.07	2.31	28.5	1921.	1945.	525.	359.
1.32	2.29	27.9	2030.	****	501.	****

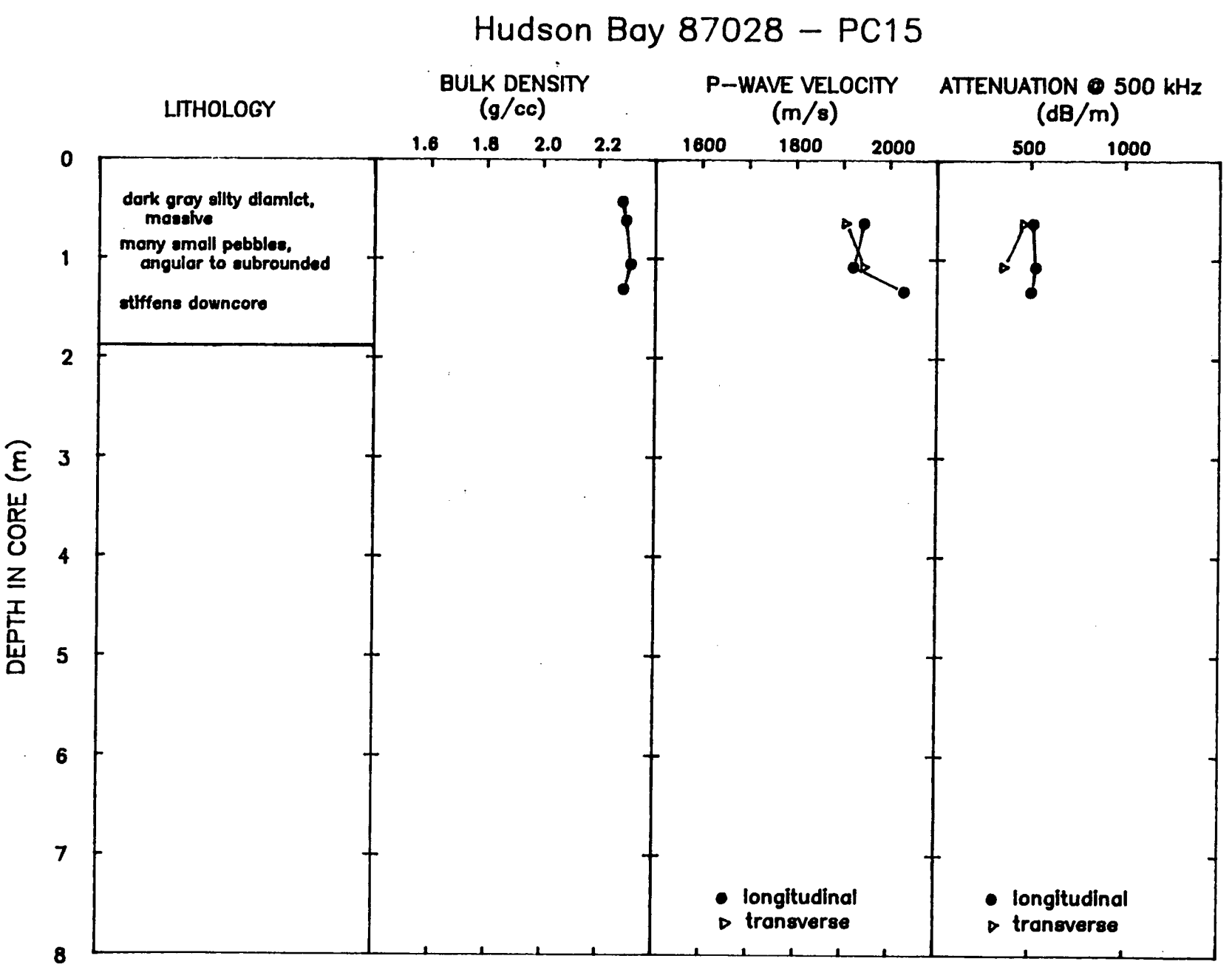

FIGURE 45. Lithology, Bulk Density, Velocity and Attenuation for Piston Core 87028-015

TABLE 43 - Physical Properties for Trigger Core 87028-015

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitud. Velocity (m/s)	Transvrs. Velocity (m/s)	Long. Att. @ 500kHz (dB/m)	Trn. Att. @ 500kHz (dB/m)
0.16	****	****	1455.	1461.	154.	132.
0.19	1.48	76.2	****	****	****	****
0.63	1.58	69.4	****	****	****	****
0.71	****	****	1461.	1459.	108.	119.
0.92	1.69	64.3	****	****	****	****
1.11	1.80	59.7	1531.	1502.	174.	128.
1.24	2.02	46.7	****	****	****	****

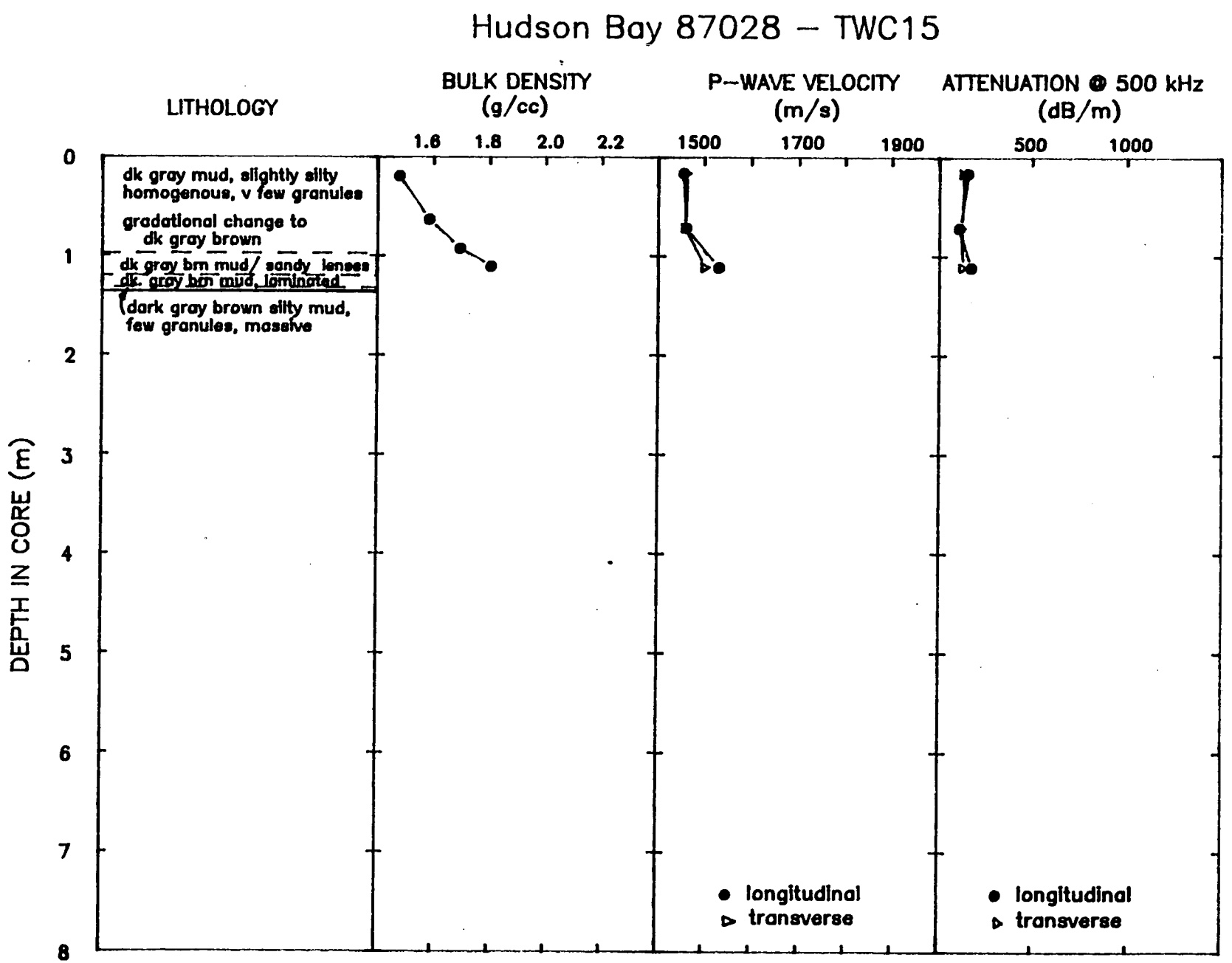

FIGURE 46. Lithology, Bulk Density, Velocity and Attenuation for Trigger Core 87028-015

TABLE 44 - Physical Properties for Gravity Core 87028-029

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitud. Velocity (m/s)	Transvrs. Velocity (m/s)	Long. Att. @ 500kHz (dB/m)	Trn. Att. @ 500kHz (dB/m)
0.13	1.48	78.6	****	****	****	****
0.24	1.47	78.8	****	****	****	****
0.34	****	****	1447.	1445.	88.	92.
0.55	1.46	79.8	****	****	****	****
0.75	1.52	76.4	****	****	****	****
0.90	1.64	69.5	1471.	1466.	108.	120.

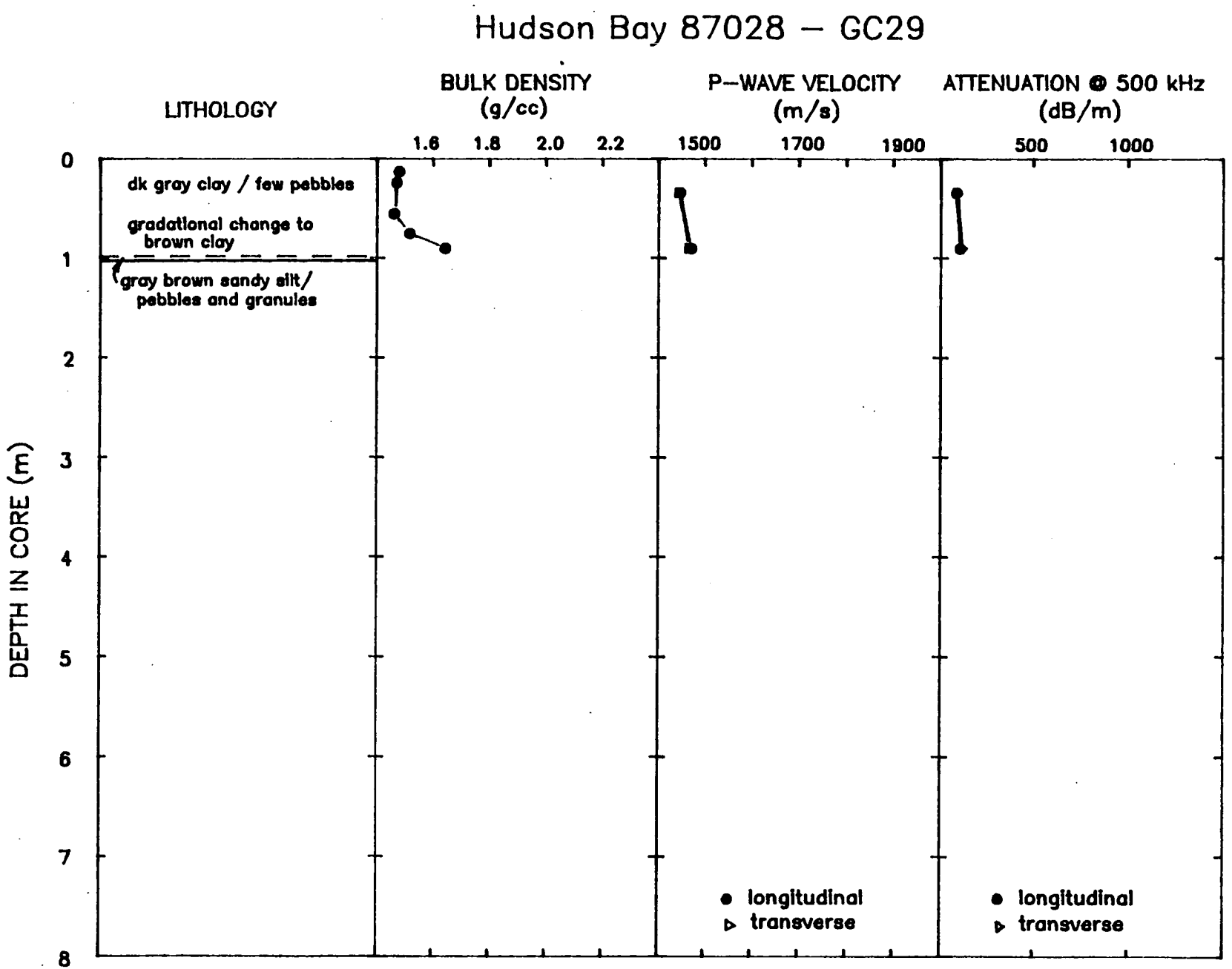

FIGURE 47. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87028-029

TABLE 45 - Physical Properties for Gravity Core 87028-035

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitud. Velocity (m/s)	Transvrs. Velocity (m/s)	Long. Att. @ 500kHz (dB/m)	Trn. Att. @ 500kHz (dB/m)
0.11	1.86	55.3	1541.	1569.	184.	235.
0.21	1.96	50.8	1639.	1623.	476.	565.
0.31	1.92	53.6	1562.	1586.	260.	190.
0.50	1.96	50.4	1581.	1593.	130.	152.
0.68	2.10	40.9	1947.	2108.	386.	367.
0.85	2.09	42.1	1674.	1661.	197.	251.
1.11	2.13	39.8	1745.	1744.	200.	202.
1.30	2.11	40.8	1681.	1681.	206.	315.
1.51	2.12	38.5	1814.	1975.	285.	395.
1.64	****	****	****	****	760.	1291.
1.82	2.18	36.3	1752.	1748.	192.	183.

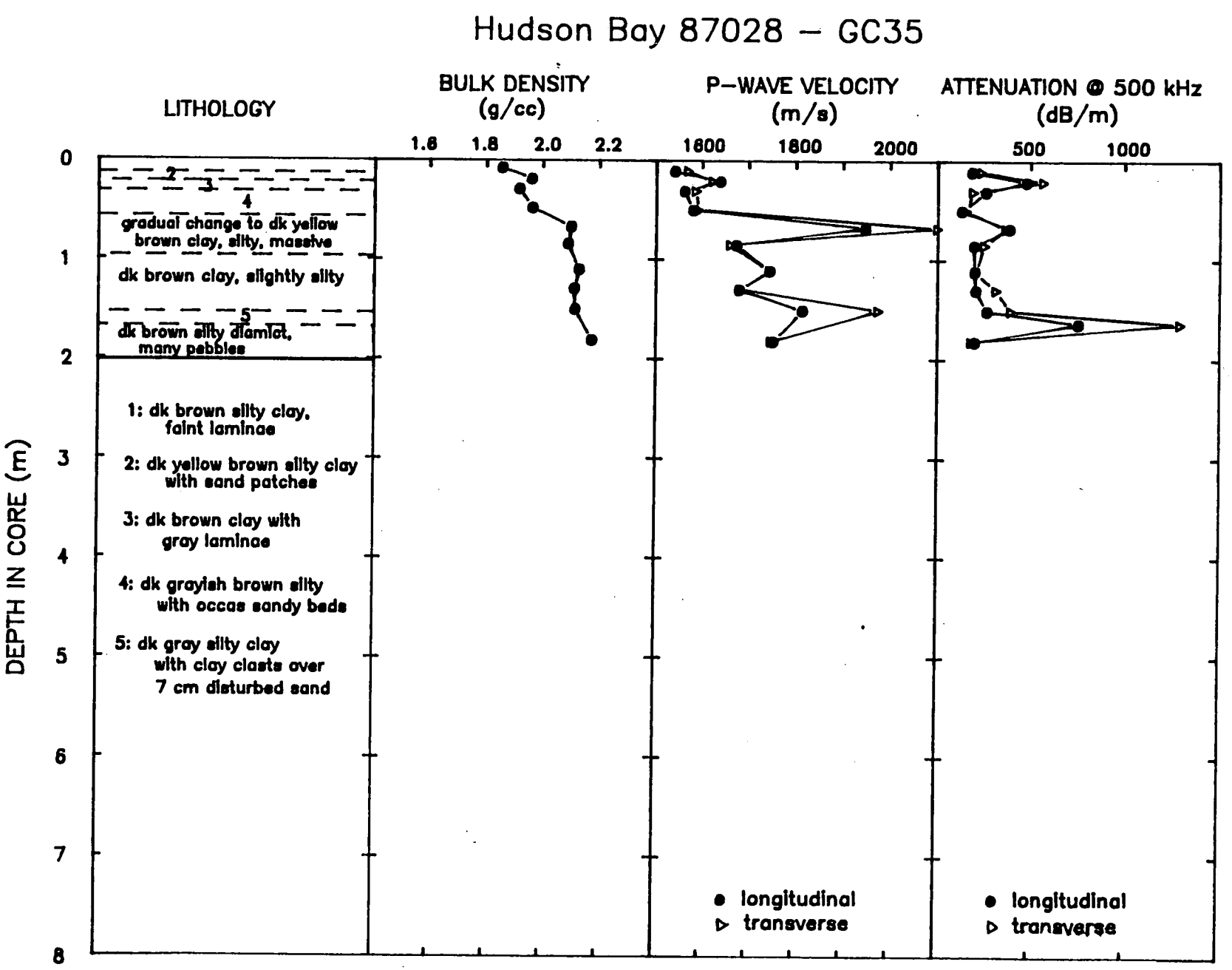

FIGURE 48. Lithology, Bulk Density, Velocity and Attenuation for Gravity Core 87028-035

TABLE 46 - Physical Properties for Piston Core 87028-043

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitud. Velocity (m/s)	Transvrs. Velocity (m/s)	Long. Att. @ 500kHz (dB/m)	Trn. Att. @ 500kHz (dB/m)
0.20	1.60	71.6	1458.	1463.	52.	100.
0.32	1.56	73.7	****	****	****	****
0.46	1.54	73.6	1453.	1454.	51.	65.
0.63	1.54	74.7	****	****	****	****
0.86	1.51	76.4	1446.	1449.	59.	88.
1.05	1.53	75.1	1447.	1451.	39.	80.
1.21	****	****	1446.	1448.	59.	76.
1.25	1.50	76.6	****	****	****	****
1.35	1.53	75.6	1452.	1451.	34.	95.
1.50	1.54	75.1	1448.	1451.	46.	70.
1.64	1.53	74.8	1451.	1453.	49.	76.
1.90	1.58	72.2	1452.	1456.	46.	62.
2.02	1.70	66.2	****	****	****	****
2.07	****	****	1497.	1551.	142.	623.
2.25	1.57	74.0	1450.	1450.	62.	77.
2.41	1.53	76.3	1438.	1438.	25.	70.
2.55	1.58	71.0	1452.	1455.	17.	45.
2.70	1.73	62.9	****	****	****	****
2.85	1.63	69.3	1478.	1470.	102.	287.
3.00	1.63	69.6	1481.	1485.	121.	80.
3.16	****	****	1476.	1478.	169.	114.
3.31	1.68	65.7	1476.	1506.	- 18.	140.
3.53	1.78	60.4	1502.	1521.	122.	128.
3.82	2.02	45.7	1628.	1637.	210.	244.
4.08	2.04	43.9	1579.	1708.	182.	456.
4.30	2.07	42.1	1618.	1678.	161.	334.
4.45	****	****	1442.	****	884.	****
4.52	2.01	47.4	****	****	****	****
4.79	2.02	47.1	1617.	1632.	335.	298.

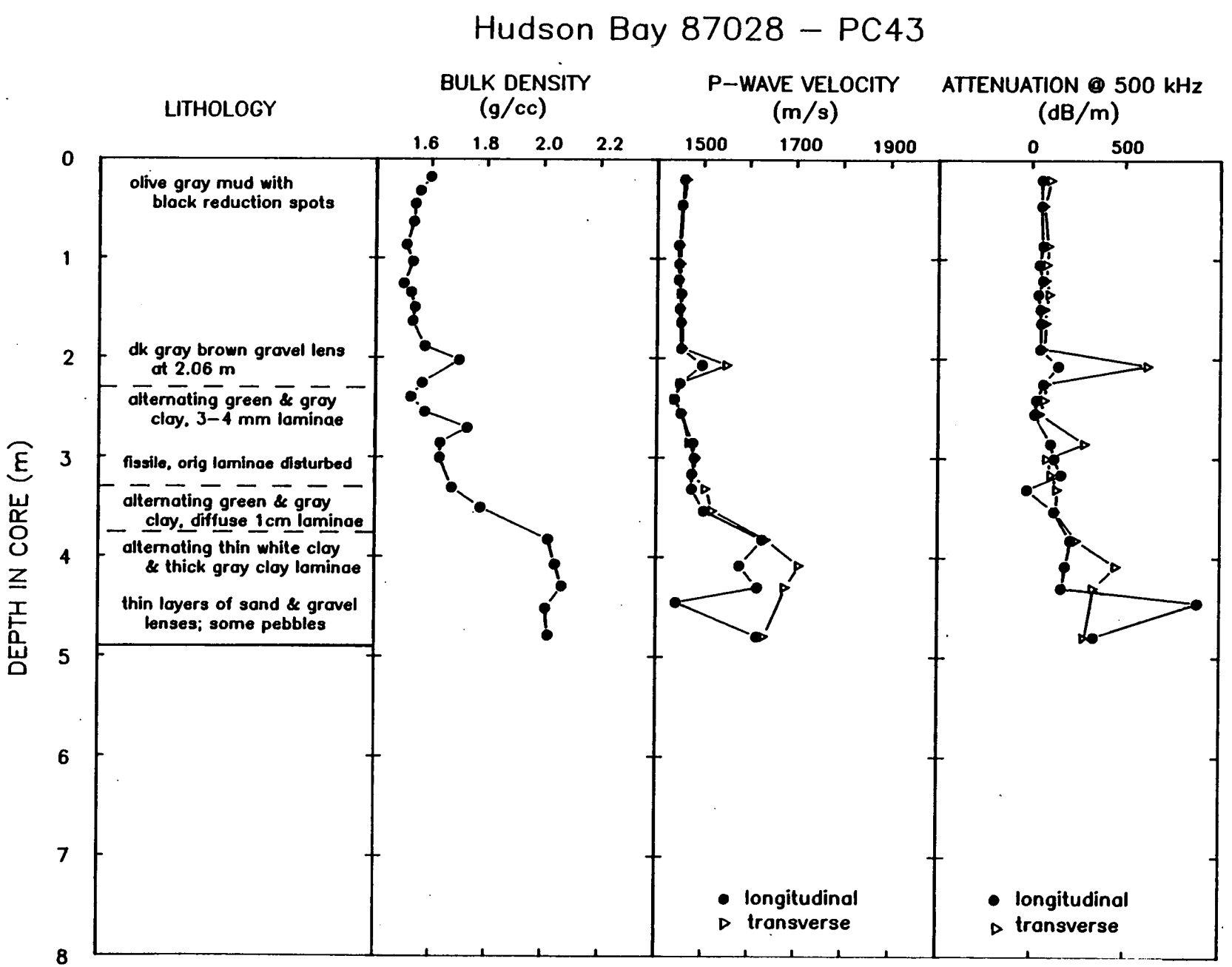

FIGURE 49. Lithology, Bulk Density, Velocity and Attenuation for Piston Core 87028-043

TABLE 47 - Physical Properties for Piston Core 87028-047

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitud. Velocity (m/s)	Transvrs. Velocity (m/s)	Long. Att. @ 500kHz (dB/m)	Trn. Att. @ 500kHz (dB/m)
1.70	1.58	69.5	1452.	1469.	220.	350.
1.89	1.66	65.5	1477.	1485.	100.	76.
2.05	1.73	61.9	1518.	1542.	191.	212.
2.22	1.59	70.5	1456.	1458.	64.	65.
2.38	1.50	75.7	1443.	1439.	112.	20.
2.54	1.61	68.4	1468.	1473.	43.	67.
2.70	****	****	1444.	1446.	236.	125.

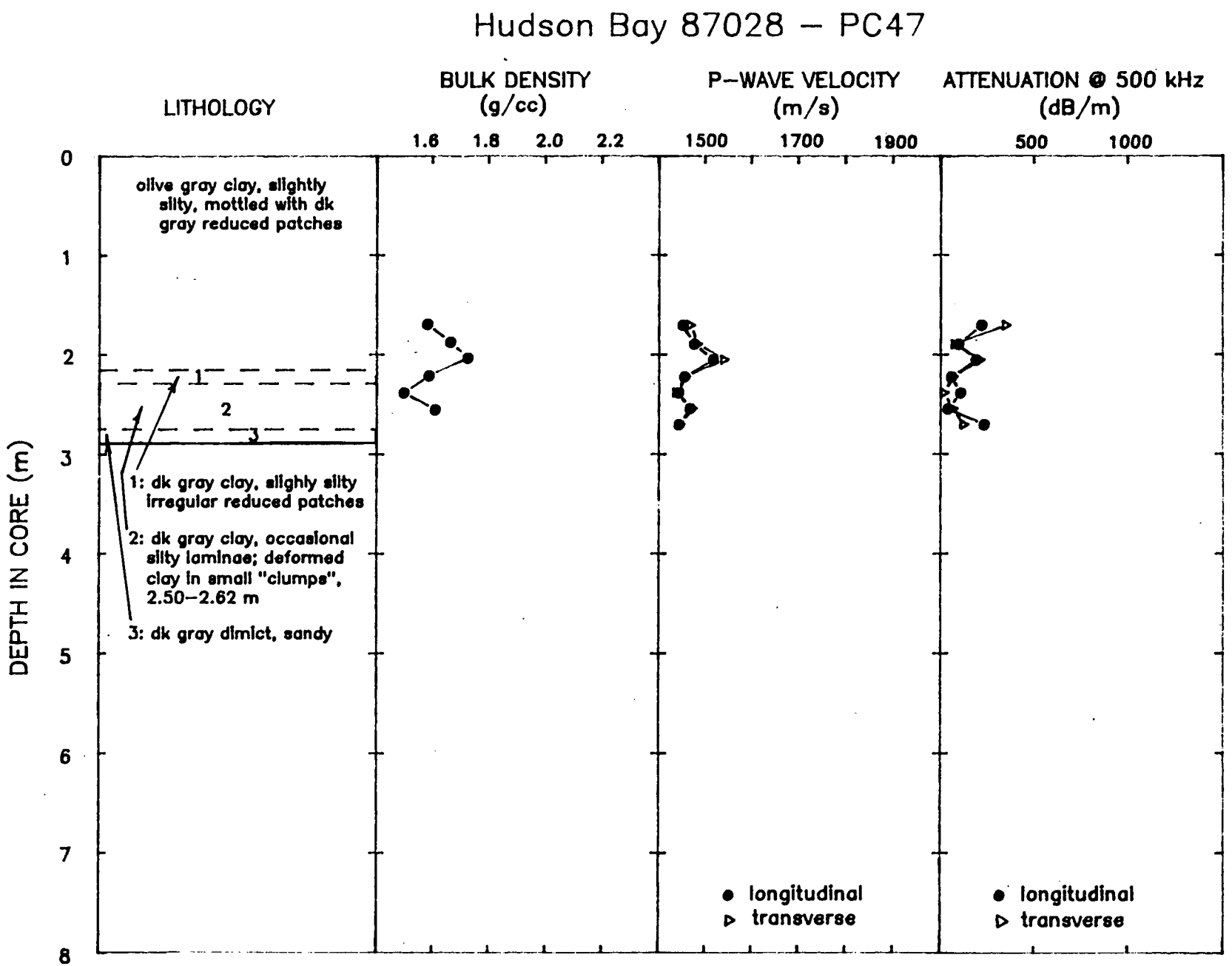

FIGURE 50. Lithology, Bulk Density, Velocity and Attenuation for Piston Core 87027-047

TABLE 48 - Physical Properties for Piston Core 87028-048

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitud. Velocity (m/s)	Transvrs. Velocity (m/s)	Long. Att. @ 500kHz (dB/m)	Trn. Att. @ 500kHz (dB/m)
0.10	1.75	61.2	****	****	****	****
0.35	1.75	62.0	****	****	****	****
0.60	1.72	60.5	****	****	****	****
0.85	1.74	60.9	****	****	****	****
1.06	1.52	74.5	1476.	1464.	106.	111.
1.24	1.23	66.4	1453.	1450.	125.	74.
1.43	1.43	71.5	1448.	1454.	119.	94.
1.66	1.62	69.2	1491.	1486.	133.	151.
1.79	1.78	57.4	1540.	1524.	206.	187.
2.00	2.04	43.9	1636.	1616.	261.	391.

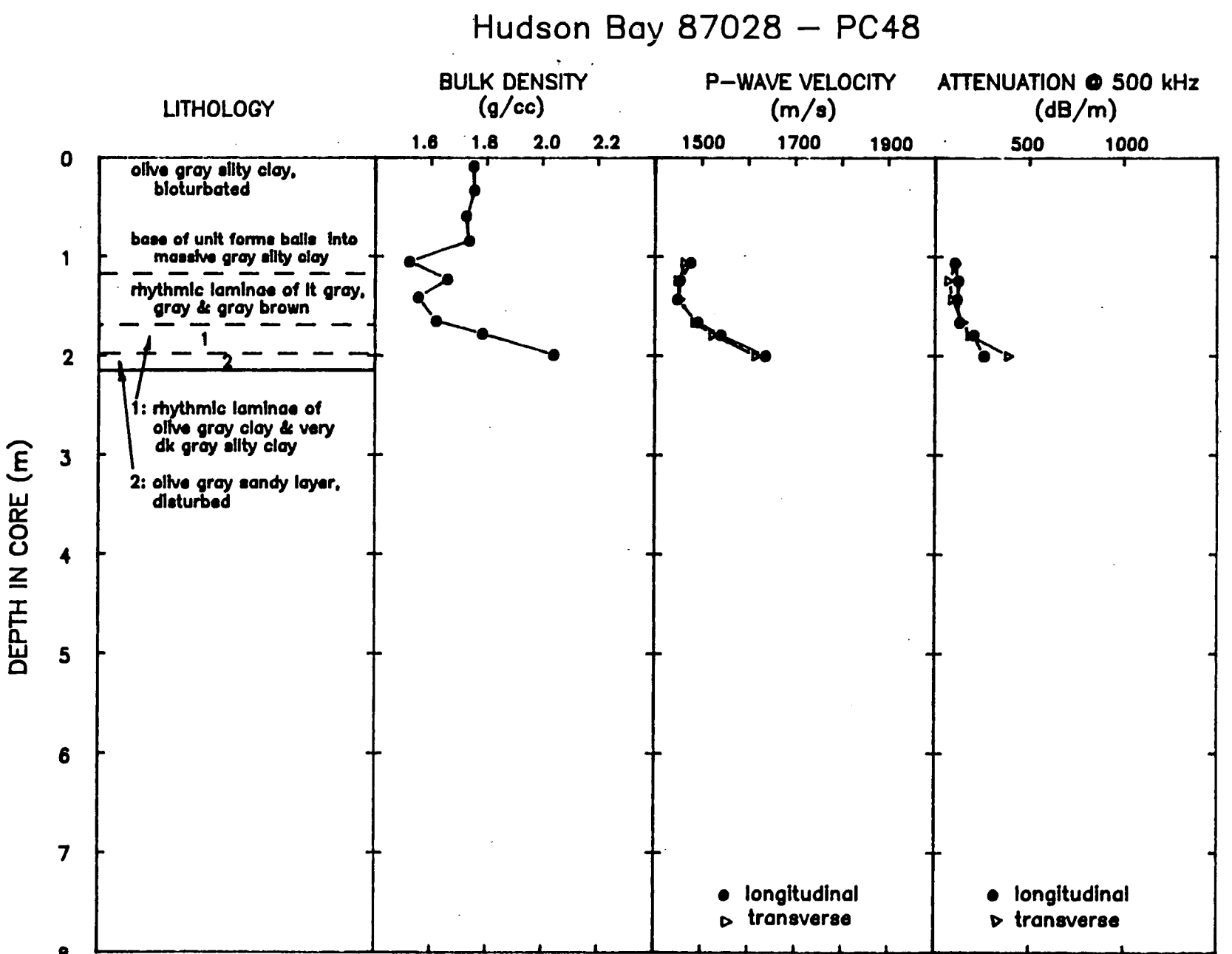

FIGURE 51. Lithology, Bulk Density, Velocity and Attenuation for Piston Core 87027-048

TABLE 49 - Physical Properties for Piston Core 87028-068

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitud. Velocity (m/s)	Transvrs. Velocity (m/s)	Long. Att. @ 500kHz (dB/m)	Trn. Att. @ 500kHz (dB/m)
0.02	1.63	67.1	****	****	****	****
0.20	1.64	66.8	1472.	1480.	95.	101.
0.40	1.64	69.0	1472.	1475.	107.	87.
0.60	1.66	67.9	1474.	1472.	88.	86.
0.80	1.67	67.4	1473.	1476.	113.	105.
1.00	1.66	67.1	1480.	1477.	121.	132.
1.19	1.67	67.4	1474.	1477.	82.	112.
1.50	1.66	67.4	1472.	1476.	107.	106.
1.70	1.66	67.9	1475.	1475.	76.	102.
1.90	1.66	66.7	1476.	1475.	75.	99.
2.10	1.66	67.7	1475.	1477.	85.	115.
2.30	1.65	67.4	1475.	1479.	89.	140.
2.50	1.67	67.1	1476.	1476.	76.	155.
2.68	1.65	66.0	1479.	1476.	94.	173.
3.33	1.64	67.7	****	****	****	****
3.55	1.65	67.3	****	****	****	****
3.78	1.64	67.0	1472.	1464.	159.	312.
3.96	1.63	66.9	1472.	1476.	101.	152.
4.13	1.66	66.7	1474.	1463.	82.	220.
4.32	****	****	1467.	1463.	185.	370.
4.50	1.65	68.2	1459.	1466.	402.	479.
4.82	1.64	67.4	1453.	1465.	370.	430.
4.98	1.62	68.1	1461.	1457.	294.	410.
5.23	1.64	67.2	1477.	1468.	98.	347.
5.40	1.60	70.0	1466.	1450.	120.	615.
5.57	1.61	69.5	1466.	1457.	103.	570.
5.73	1.60	69.6	1452.	1450.	326.	823.
5.88	1.63	68.2	1460.	1450.	106.	926.

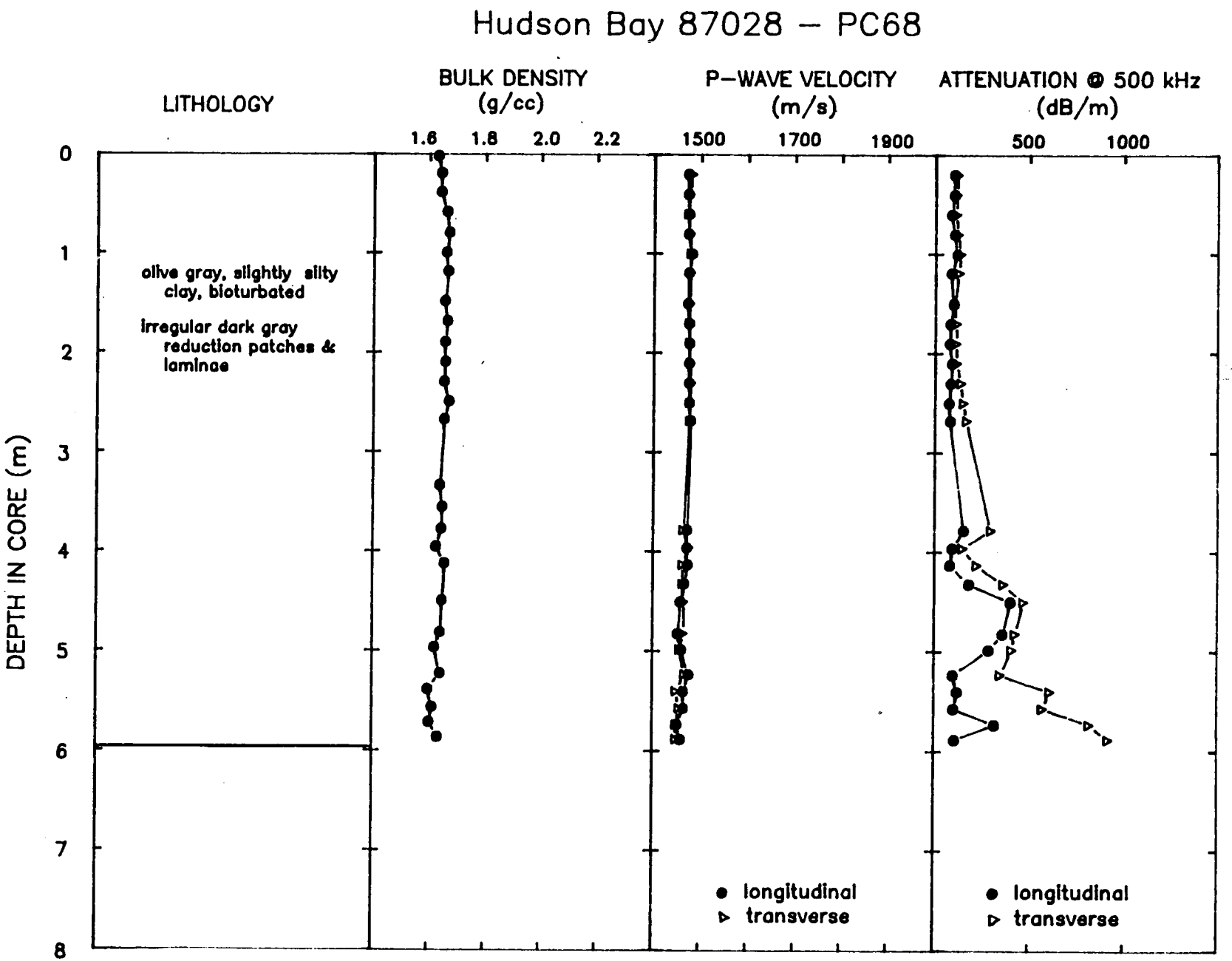

FIGURE 52. Lithology, Bulk Density, Velocity and Attenuation for Piston Core 87027-068

TABLE 50 - Physical Properties for Piston Core 87028-069

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitud. Velocity (m/s)	Transvrs. Velocity (m/s)	Long. Att. @ 500kHz (dB/m)	Trn. Att. @ 500kHz (dB/m)
0.15	1.60	71.2	****	****	****	****
0.35	1.58	71.5	****	****	****	****
0.55	1.56	72.9	****	****	****	****
0.80	1.54	73.2	****	****	****	****
1.04	1.53	75.6	****	****	****	****
1.30	1.55	73.3	****	****	****	****
1.55	1.54	74.3	****	****	****	****
1.80	1.53	74.0	****	****	****	****
2.05	1.55	73.4	****	****	****	****
2.30	1.54	74.9	****	****	****	****
2.56	1.55	73.8	****	****	****	****
2.80	1.56	72.5	****	****	****	****
3.05	1.57	73.9	****	****	****	****
3.30	1.53	73.8	****	****	****	****
3.55	1.54	74.8	****	****	****	****
3.85	1.54	74.9	****	****	****	****
4.10	1.55	74.6	****	****	****	****
4.14	1.52	74.8	****	****	****	****
4.60	1.56	74.2	****	****	****	****
4.85	1.56	73.8	****	****	****	****
5.10	1.62	71.3	****	****	****	****
5.47	1.71	64.3	1500.	1495.	145.	144.
5.60	1.74	****	1575.	1495.	164.	118.
5.82	1.77	61.3	1592.	1771.	221.	485.
5.98	1.54	75.9	1445.	1443.	141.	57.
6.11	1.67	66.0	1489.	1467.	62.	72.
6.35	1.78	****	1515.	1474.	88.	64.
6.53	1.81	57.9	1521.	1535.	71.	131.
6.70	1.86	56.1	1507.	1648.	277.	732.
6.86	1.65	67.4	1476.	1450.	390.	589.
7.05	1.61	70.1	1459.	1468.	368.	623.

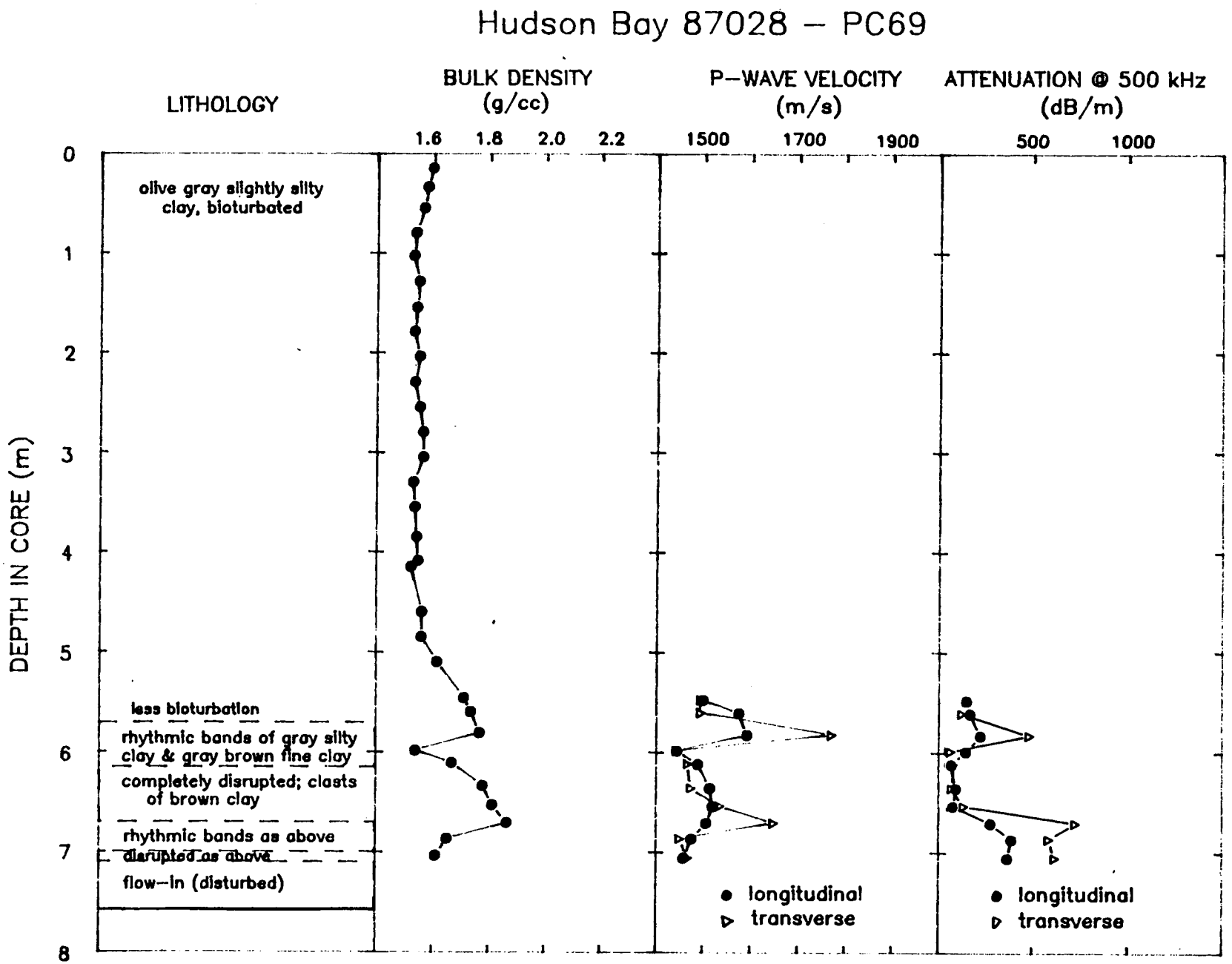

FIGURE 53. Lithology, Bulk Density, Velocity and Attenuation for Piston Core 87027-069

TABLE 51 - Physical Properties for Piston Core 87028-070

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitud. Velocity (m/s)	Transvrs. Velocity (m/s)	Long. Att. @ 500kHz (dB/m)	Trn. Att. @ 500kHz (dB/m)
0.10	1.75	59.6	1522.	1516.	????	????
0.28	1.80	55.8	1536.	1535.	216.	228.
0.45	1.80	57.4	1515.	1501.	139.	98.
0.60	1.84	53.3	1554.	1557.	239.	245.
0.79	1.84	55.8	1528.	1539.	171.	180.
0.95	1.84	54.5	1541.	1534.	182.	484.

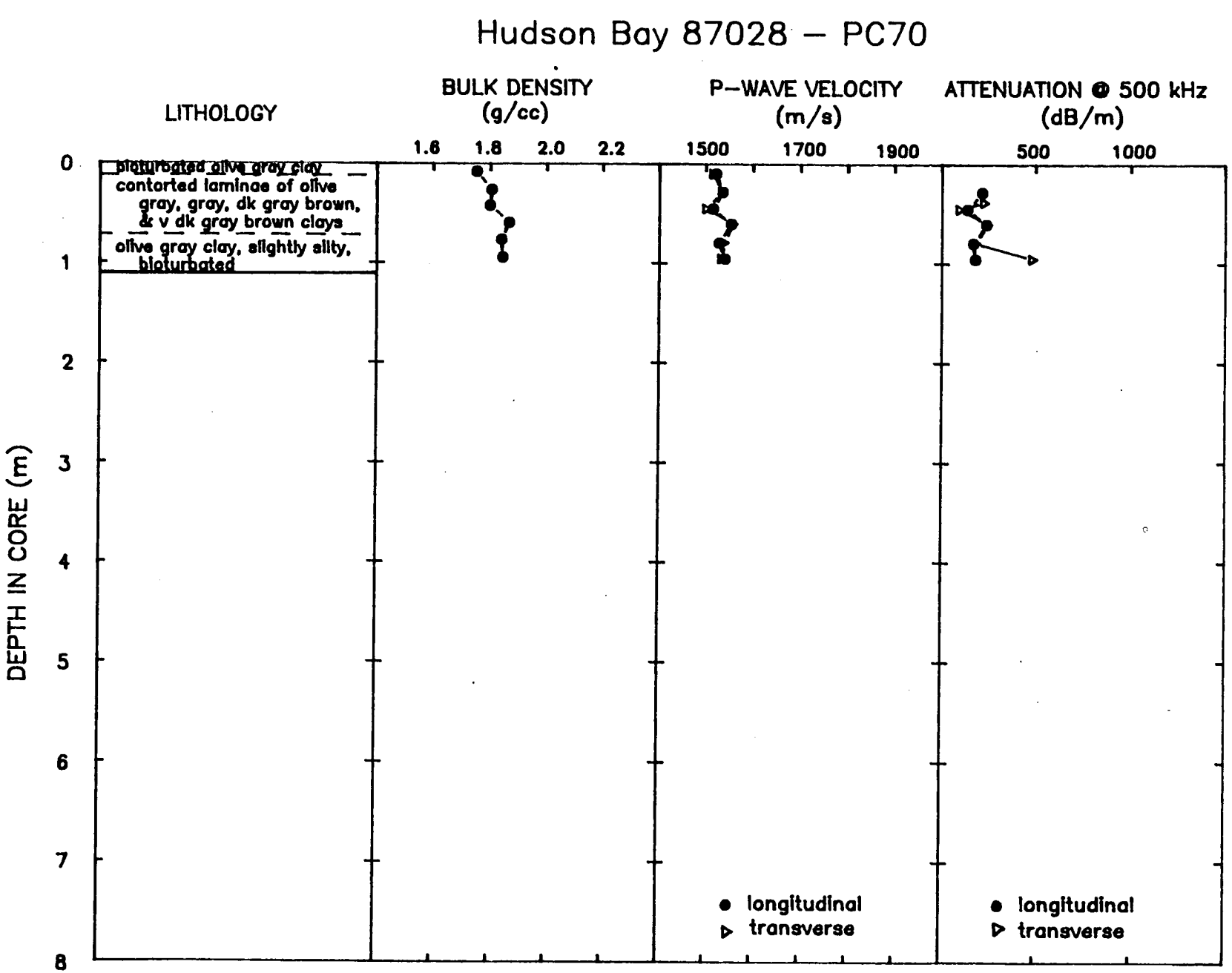

FIGURE 54. Lithology, Bulk Density, Velocity and Attenuation for Piston Core 87027-070

TABLE 52 - Physical Properties for Piston Core 87028-074

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitud. Velocity (m/s)	Transvrs. Velocity (m/s)	Long. Att. @ 500kHz (dB/m)	Trn. Att. @ 500kHz (dB/m)
0.03	1.69	65.7	****	****	****	****
0.20	1.69	66.1	1518.	1472.	130.	70.
0.36	1.59	71.5	1603.	1507.	242.	83.
0.55	2.20	34.8	1804.	1817.	356.	473.
0.71	2.16	37.6	1751.	1767.	332.	242.
1.00	2.18	35.6	1823.	1891.	358.	445.
1.18	2.18	35.4	1786.	1857.	358.	402.
1.34	2.19	35.7	1948.	1945.	447.	553.

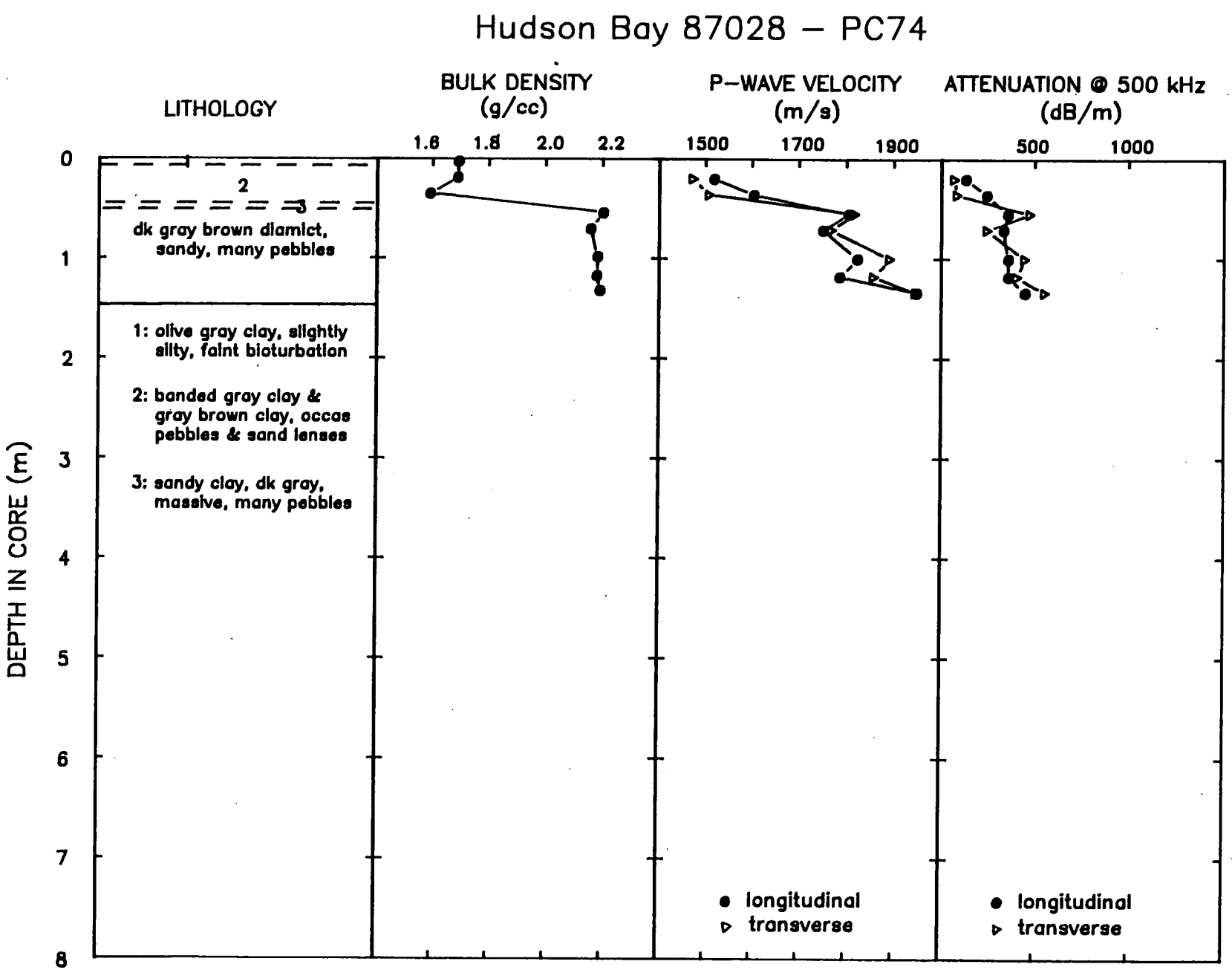

FIGURE 55. Lithology, Bulk Density, Velocity and Attenuation for Piston Core 87027-074

TABLE 53 - Physical Properties for Piston Core 87028-090

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitud. Velocity (m/s)	Transvrs. Velocity (m/s)	Long. Att. @ 500kHz (dB/m)	Trn. Att. @ 500kHz (dB/m)
0.14	1.61	70.1	****	****	****	****
0.23	1.61	72.1	****	****	****	****
0.32	1.60	71.2	1458.	1462.	78.	81.
0.52	1.58	70.9	****	****	****	****
0.75	1.60	71.4	1456.	1462.	68.	65.
0.95	1.60	70.9	1456.	1461.	67.	53.
1.15	1.60	71.5	1456.	1459.	70.	63.
1.35	1.58	70.8	1456.	1461.	69.	83.
1.55	1.63	69.2	1461.	1467.	53.	60.
1.80	1.62	70.2	1459.	1461.	56.	95.
2.16	1.60	71.5	1455.	1461.	49.	133.
2.35	1.60	69.5	1458.	1461.	57.	133.
2.55	1.66	67.9	1465.	1470.	55.	98.
2.75	1.66	68.0	1464.	1466.	36.	92.
3.10	1.70	65.7	1465.	1474.	48.	88.
3.32	1.72	63.3	1466.	1479.	43.	78.
3.65	****	****	****	****	1182.	175.
3.77	1.73	63.4	1472.	1487.	54.	66.
4.05	2.06	43.0	****	****	1109.	1572.

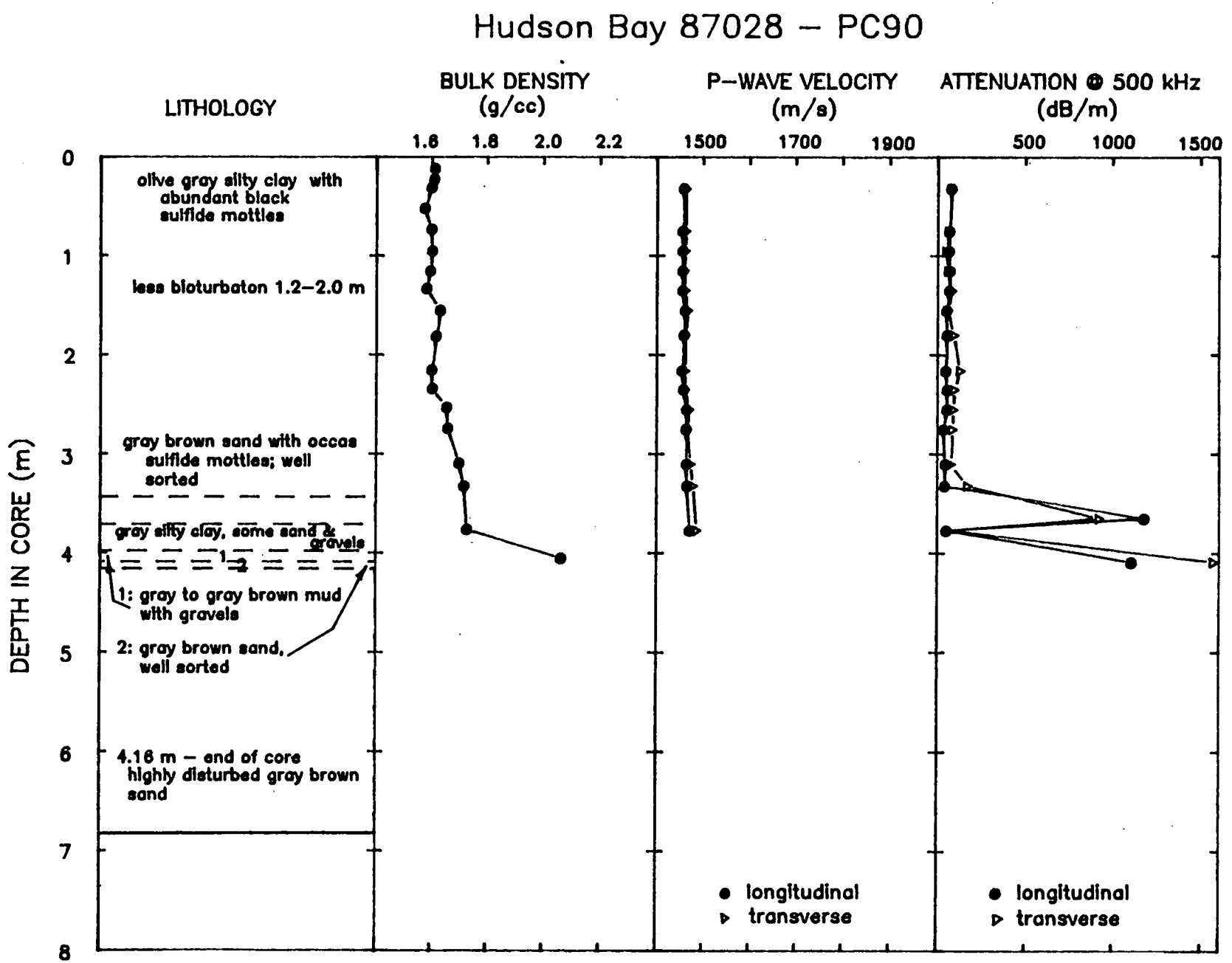

FIGURE 56. Lithology, Bulk Density, Velocity and Attenuation for Piston Core 87027-090

TABLE 54a - Physical Properties for DREP Core

Subbottom Depth (m)	Bulk Density (g/cc)	Porosity (%)	Longitudinal Velocity (m/s)	Attenuation @ 500 kHz (dB/m)
0.06	2.14	40.7	1794.	483.
0.14	2.13	38.4	1683.	214.

TABLE 54b - Grain Size Data for DREP Core

Subbottom Depth Interval (m)	% Gravel	% Sand	% Silt	% Clay
0.00-0.01	--	5	48	47
0.01-0.02	12	20	48	20
0.08-0.09	22	38	22	18
0.09-0.10	7	57	18	19
0.10-0.11	3	62	16	19
0.17-0.18	tr	55	34	11
0.19-0.21	1	50	37	12

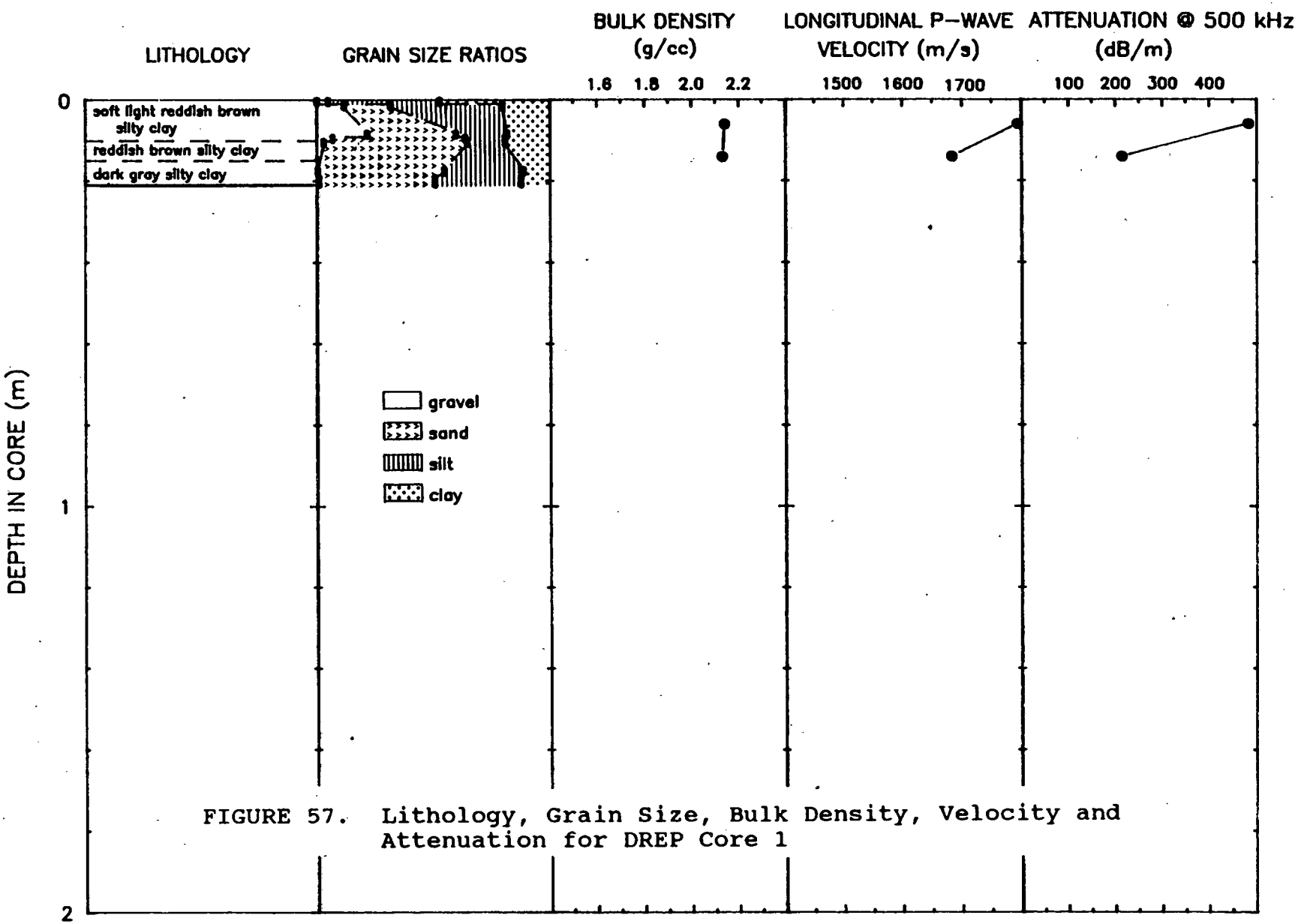

FIGURE 57. Lithology, Grain Size, Bulk Density, Velocity and Attenuation for DREP Core 1

REPORT NO: DREP CONTRACTORS REPORT

TITLE: MEASUREMENT OF GEOPHYSICAL PROPERTIES OF ARCTIC SEDIMENT CORES

AUTHOR: LARRY A MAYER AND JANICE MASTERS

DATED: MARCH 1989

SECURITY GRADING: UNCLASSIFIED

3 - DSIS
Circulate to:
DRDM
DIUP

1 DREA

1 Atlantic Geoscience Centre,
Geological Survey of Canada,
Bedford Institute of Oceanography,
P.O. Box 1006,
Dartmouth, N.S.,
B2Y 4A2.
Attn: Ron Macnab

1 Terrain Sciences Division,
Geological Survey of Canada,
601 Booth St.,
Ottawa, K1A 0E8,
Attn: J. A. Hunter.

5 DREP

UNCLASSIFIED

SECURITY CLASSIFICATION OF FORM
(highest classification of Title, Abstract, Keywords)

DOCUMENT CONTROL DATA

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (the name and address of the organization preparing the document. Organizations for whom the document was prepared, e.g. Establishment sponsoring a contractor's report, or tasking agency, are entered in section 8.)

Dept. of Oceanography,
Dalhousie University,
Halifax, Nova Scotia.

2. SECURITY CLASSIFICATION (overall security classification of the document including special warning terms if applicable)

unclassified

3. TITLE (the complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S,C,R or U) in parentheses after the title.)

Measurement of Geophysical Properties of Arctic Sediment Cores.

4. AUTHORS (Last name, first name, middle initial)

Mayer, L.A. and Marsters, J.

5. DATE OF PUBLICATION (month and year of publication of document)

March 1989

6a. NO. OF PAGES (total containing information. Include Annexes, Appendices, etc.)

120

6b. NO. OF REFS (total cited in document)

7. DESCRIPTIVE NOTES (the category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

Contractors Report

8. SPONSORING ACTIVITY (the name of the department project office or laboratory sponsoring the research and development. Include the address.)

Defence Research Establishment Pacific

9a. PROJECT OR GRANT NO. (if appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant)

9b. CONTRACT NO. (if appropriate, the applicable number under which the document was written)

W7708-7-9408/01-SB

10a. ORIGINATOR'S DOCUMENT NUMBER (the official document number by which the document is identified by the originating activity. This number must be unique to this document.)

CRS-89-19

10b. OTHER DOCUMENT NOS. (Any other numbers which may be assigned this document either by the originator or by the sponsor)

11. DOCUMENT AVAILABILITY (any limitations on further dissemination of the document, other than those imposed by security classification)

(XX) Unlimited distribution
( ) Distribution limited to defence departments and defence contractors; further distribution only as approved
( ) Distribution limited to defence departments and Canadian defence contractors; further distribution only as approved
( ) Distribution limited to government departments and agencies; further distribution only as approved
( ) Distribution limited to defence departments; further distribution only as approved
( ) Other (please specify):

12. DOCUMENT ANNOUNCEMENT (any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availabilty (11). However, where further distribution (beyond the audience specified in 11) is possible, a wider announcement audience may be selected.)

unlimited

UNCLASSIFIED

SECURITY CLASSIFICATION OF FORM

DCD03 2/06/87

13. ABSTRACT (a brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both offical languages unless the text is bilingual).

//In support of research conducted at DREP the physical and acoustic properties of a number of Arctic cores were measured by scientists at Dalhousie University. This report represents the preliminary presentation of the results of these measurements.//

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus. e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus-identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

Ice measurements
Arctic