23. SUMMARY OF SHIPBOARD PHYSICAL PROPERTIES OF MUDSTONES, CARBONATES, AND CLASTIC SEDIMENTS, DEEP SEA DRILLING PROJECT, LEG 72[1]

C. H. Schaftenaar, R. P. Moore, and R. L. Carlson, Department of Geophysics, Texas A&M University, College Station, Texas

INTRODUCTION

Compressional-wave velocity, wet-bulk density, and porosity were measured on sediments and rocks recovered from Deep Sea Drilling Project Holes 515B and 516F. Wet-bulk densities were measured by both gravimetric and GRAPE methods. Velocities were measured on trimmed samples with the Hamilton frame velocimeter. The shipboard measurement techniques are discussed in the explanatory notes chapter (Coulbourn, this volume) and are described in detail by Boyce (1976a). Only the shipboard measurements are reported here. The results of shore-based laboratory studies of the physical properties of the carbonates and basalts from Hole 516F can be found in Carlson and others (this volume) and Gebhard and Carlson (this volume). Mechanical properties of the sediments are discussed in Walton and others (this volume) and Faas and Crocket (this volume).

The physical properties of 55 mudstone samples recovered from Hole 515B between sub-bottom depths of 256 and 635 m are summarized in Table 1. Extensive physical property measurements were made at Hole 516F on samples from sub-bottom depths between 172 and 1231 m, including 319 carbonates, 5 volcanic ashes and sandstones, and 1 mudstone. The physical properties are listed in Table 2.

DENSITY-POROSITY RELATIONS

Wet-bulk densities (ϱ_b) of mudstones, carbonates, and clastic sediments were estimated by gravimetric (immersion) and 2-minute GRAPE methods as described by Boyce (1976a,b). "Gravimetric" porosities (ϕ) were calculated from the gravimetric densities, water contents (W_c), and pore-fluid density ($\varrho_f = 1.025$ g/cm^3) of the sediments:

$$\phi = \varrho_b W_c / \varrho_f$$

GRAPE porosities were calculated from estimated bulk densities by assuming a mean-grain density (ϱ_g) of 2.71 g/cm^3.

For suites of samples having the same mean-grain density, fractional porosity and wet-bulk density are linearly related:

$$\varrho_b = \varrho_g - \phi(\varrho_g - \varrho_f).$$

Thus, both mean-grain and pore-fluid density can be estimated by linear regression if independent measurements of bulk density and fractional porosity have been made.

Gravimetric and GRAPE densities are plotted against gravimetric porosities of mudstones from Hole 515B in Figures 1 and 2, respectively. The implied pore-fluid density ($\varrho_f = a + b$; see Table 3) of the mudstones is 0.86 g/cm^3 when estimated from the GRAPE density data and 0.92 g/cm^3 when estimated from gravimetric densities. These values are too low for fully saturated sediments, suggesting that these sediments may have been slightly undersaturated at the time of measurement (i.e., the gravimetric porosities calculated by $\phi = \varrho_b W_c / \varrho_f$ are low because the water content, W_c, was underestimated). Undersaturation could occur because of sample volume expansion upon release of overburden pressure and the subsequent uptake of air into the pore spaces or because of slight drying of the samples before measurement.

The mean-grain densities ϱ_g (parameter a in Table 3) of the mudstones are estimated to be 2.86 g/cm^3 from the gravimetric density data and 2.81 g/cm^3 from the GRAPE densities. Grain densities of clayey silts and silty clays, measured by the pycnometer method, have been reported to be as high as 2.79 g/cm^3 (Bachman and Hamilton, 1976). However, the grain density estimated for the mudstones from Hole 515B may be too large because there are two distinct groups of mudstone samples that have different apparent grain densities. Samples with porosities above 60% are siliceous mudstones that contain about 15% siliceous biogenic material. In contrast, the samples with porosities less than 55% generally contain no siliceous biogenic material but do contain small amounts of assorted heavy minerals. Thus, it is likely that the higher-porosity, siliceous mudstones have a relatively low mean-grain density, whereas the lower porosity mudstones have a relatively higher mean-grain density. Therefore, the high grain densities and low pore-fluid densities estimated by linear regression for the complete data set could be an artifact of fitting the regression line through two groups of samples with different grain densities (i.e., the two groups should lie on separate $\varrho - \phi$ curves because they have different mean-grain densities).

Theoretical wet-bulk density–porosity relationships for completely saturated sediments with a pore-fluid density of 1.025 g/cm^3 are shown for comparison with the measured values from Hole 515B and the regression

[1] Barker, P. F., Carlson, R. L., Johnson, D. A., et al., *Init. Repts. DSDP*, 72: Washington (U.S. Govt. Printing Office).

Table 1. Summary of physical properties for Hole 515B.

Core/Section (interval in cm)		Interval	Depth	Gravimetric Density (g/cc)	Gravimetric Porosity (%)	GRAPE Density (g/cc)	GRAPE Porosity (%)	Horiz. Velocity (km/s)	Vert. Velocity (km/s)	Average Velocity (km/s)	Anisotropy (%)
18	1	31- 34	256.7	1.50[a]	70.9[a]	1.15[a]	92.5	1.61	1.59	1.60	1.1
19	3	108-111	271.5	1.49	70.8	1.45	74.5	1.62	1.58	1.61	2.1
20	6	34- 37	284.8	1.51	70.9	1.49	72.1	1.66	1.64	1.65	0.8
21	6	95- 97	294.3	1.61	66.2	-	-	-	-	-	-
22	1	51- 54	294.9	1.53	68.0	1.52	70.5	1.63	1.65	1.64	-0.7
23	6	126-129	313.3	1.56	66.9	1.52	70.2	1.64	1.61	1.63	1.5
25	6	82- 83	331.9	1.56	67.1	1.51	71.0	1.66	1.61	1.64	2.8
26	2	82- 85	336.2	1.52	69.5	1.51	71.2	1.66	1.61	1.64	2.9
27	5	108-110	350.5	1.49	69.8	1.48	73.0	1.62	1.58	1.61	2.6
28	4	93- 95	358.3	1.54	68.5	1.52	70.4	1.68	1.68	1.68	0.5
29	5	136-138	369.8	1.54	68.4	1.49	72.0	1.68	1.63	1.67	3.2
30	6	125-127	379.2	1.52	68.5	1.44	75.4	1.64	1.65	1.64	-1.0
31	2	120-123	382.6	1.52	67.5	1.49	72.1	1.67	1.64	1.66	1.7
32	5	34- 37	395.8	1.56	65.4	1.54	69.4	1.68	1.68	1.68	0.2
33	2	20- 24	400.6	1.58	65.8	1.57	67.3	1.74	1.69	1.72	2.8
34	3	87- 92	412.3	1.60	65.1	1.57	67.7	1.78	1.73	1.76	2.8
34	6	4- 7	416.0	1.63	62.9	1.64	63.4	1.83	1.78	1.81	2.8
34	6	9- 16	416.0	-	-	-	-	1.82	-	-	-
35	4	42- 45	422.8	1.60	66.3	1.56	67.8	1.77	1.72	1.75	3.1
35	6	106-114	426.5	-	-	-	-	1.78	-	-	-
36	3	100-104	431.4	1.58	70.8	1.54	69.6	1.74	1.67	1.72	3.8
37	6	43- 46	444.9	1.59	64.9	1.54	69.3	1.74	1.72	1.73	1.4
38	1	10- 18	446.6	-	-	-	-	1.73	1.66	1.71	4.2
38	6	138-142	455.3	1.59	66.4	1.57	67.4	1.76	1.70	1.74	3.7
39	6	98-103	464.4	1.61	66.2	1.57	67.8	1.74	1.67	1.72	3.8
40	1	53- 61	466.0	-	-	-	-	1.73	-	-	-
40	5	48- 52	471.9	1.54	66.8	1.54	69.4	1.71	1.66	1.70	3.2
41	6	92- 96	483.3	1.52	65.2	1.47	73.2	1.73	1.68	1.72	3.3
43	6	121-126	502.6	1.57	65.1	1.60	65.7	1.75	1.69	1.73	3.7
44	1	0- 10	503.5	-	-	-	-	1.74	-	-	-
44	3	138-142	507.8	1.56	66.6	1.51	71.1	1.78	1.70	1.75	4.5
45	3	88- 92	516.8	1.83	55.8	-	-	1.81	1.73	1.78	4.4
46	5	10- 14	528.5	1.81	52.9	1.83	52.0	1.84	1.74	1.81	5.9
47	4	109-112	537.5	1.87	52.8	1.81	53.1	1.85	1.77	1.83	4.7
48	1	30- 33	541.7	2.04	51.7	1.87	49.4	1.90	1.78	1.86	6.7
48	4	75- 77	546.7	-	-	-	-	1.95	-	-	-
49	4	50- 53	555.9	1.93	50.7	1.86	50.0	1.90	1.80	1.87	5.3
50	3	79- 82	564.2	1.90	50.3	1.87	49.3	1.88	1.77	1.85	6.0
51	1	7- 14	570.0	-	-	-	-	1.90	-	-	-
51	4	2- 6	574.5	1.91	49.8	1.88	48.9	1.89	-	-	-
52	1	10- 14	579.5	1.89	50.1	1.83	51.7	1.82	1.77	1.81	3.2
53	1	12- 19	589.1	-	-	-	-	2.02	-	-	-
53	6	130-135	597.7	1.88	50.0	1.82	52.6	1.89	1.78	1.86	5.9
54	1	120-122	599.6	1.84	49.5	1.83	52.1	1.95	1.83	1.91	6.5
55	CC		607.8	-	-	-	-	2.04	-	-	-
55	4	15- 19	612.6	1.94	47.9	1.92	46.8	1.87	1.88	1.87	-0.4
56	2	81- 89	619.8	-	-	-	-	1.91	-	-	-
56	2	90- 93	619.8	2.03	41.0	2.04	39.2	-	1.92	-	-
56	3	127-129	621.7	-	-	-	-	1.98	-	-	-
56	4	128-130	623.2	-	-	-	-	1.89	-	-	-
56	5	105-107	624.5	-	-	-	-	1.96	-	-	-
56	6	131-133	626.2	-	-	-	-	1.94	-	-	-
57	1	116-118	628.1	2.01	41.3	1.98	43.2	2.06	1.99	2.04	3.6
57	3	95- 97	630.9	-	-	1.93	46.0	2.14	-	-	-
57	5	125-127	634.2	-	-	1.86	50.0	2.06	-	-	-

[a] These data were not used in the regressions shown in Figures 1 and 2 and listed in Table 3.

Table 2. Summary of physical properties for Hole 516F.

Core/Section (interval in cm)		Interval	Depth	Gravimetric Density (g/cc)	Gravimetric Porosity (%)	GRAPE Density (g/cc)	GRAPE Porosity (%)	Horiz. Velocity (km/s)	Vert. Velocity (km/s)	Average Velocity (km/s)	Anisotropy (%)
1	2	92- 94	172.5	-	-	-	-	-	-	-	-
1	2	95- 97	171.6	-	-	-	-	1.64	-	-	-
1	2	100-102	171.6	-	-	-	-	-	-	-	-
1	2	103-105	171.6	-	-	-	-	-	-	-	-
2	7	21- 23	187.8	1.73	57.2	1.73	58.4	1.77	1.78	1.77	-0.4
5	6	107-109	215.7	1.81	52.4	1.76	56.4	1.82	1.74	1.79	4.8
6	1	90- 93	217.5	1.81	52.2	1.76	56.1	1.73	1.67	1.71	3.4
7	3	33- 35	229.4	1.80	52.3	1.80	53.9	1.72	1.76	1.74	-2.4
8	6	76- 80	243.9	1.77	54.0	1.72	58.5	1.68	1.66	1.67	1.7
9	4	72- 74	250.3	1.75	53.3	1.69	60.7	1.70	1.75	1.71	-2.9
10	4	1- 5	259.1	1.75	54.9	1.70	59.8	1.71	1.69	1.70	1.3
11	1	0- 11	264.1	-	-	-	-	1.72	-	-	-
11	3	80- 83	267.9	1.82	52.3	1.76	56.5	1.78	1.75	1.77	1.2
12	1	12- 15	273.7	1.90[a]	54.5	1.77	55.7	1.73	1.72	1.73	1.0
16	1	0- 5	311.6	1.87	47.8	1.84	51.8	1.82	1.73	1.79	5.4
17	CC		324.2	-	-	-	-	1.71	-	-	-
18	CC		331.9	1.91	47.7	1.84	51.4	1.75	1.77	1.76	-1.2
19	2	75- 84	342.4	2.02[a]	49.2	1.95	44.9	1.88	1.83	1.86	2.5
19	2	117-120	342.8	-	-	1.89	48.5	2.07	-	-	-
20	1	11- 13	349.7	1.96	44.1	1.95	45.4	1.89	-	-	-
21	1	29- 31	359.4	1.95	44.7	1.93	46.3	1.94	-	-	-
22	1	5- 7	368.7	1.95	45.6	-	-	-	-	-	-
22	1	7- 14	368.7	-	-	1.91	47.2	2.04	-	-	-
23	2	12- 15	379.7	1.95	44.8	1.96	44.5	1.91	1.88	1.90	1.6
24	1	17- 26	387.8	-	-	-	-	1.88	-	-	-
24	1	49- 52	388.1	1.98	43.5	2.00	42.0	1.94	1.87	1.91	3.7
25	1	15- 17	397.3	2.01	45.1	1.96	44.3	1.77	1.78	1.77	-0.4
25	3	44- 53	400.6	-	-	1.98	43.2	1.87	-	-	-
26	1	17- 25	406.8	-	-	2.02	40.8	1.97	-	-	-
26	5	124-127	413.9	2.02	41.8	2.03	40.6	1.89	1.84	1.87	2.6
27	1	5- 8	416.2	1.96	48.3	1.91	47.6	1.79	1.77	1.79	1.0
27	4	34- 37	421.0	1.95	45.0	1.95	45.4	1.89	1.82	1.87	3.5
28	2	73- 79	427.9	1.87	48.5	1.70[a]	59.8	1.76	1.72	1.75	2.2
29	1	41- 51	435.6	-	-	-	-	1.91	-	-	-
29	5	90- 95	442.0	2.22[a]	52.2	1.91	47.6	1.88	1.84	1.87	2.3
30	2	142-145	447.5	2.08[a]	46.2	1.91	47.2	1.91	1.88	1.90	1.9
30	6	38- 42	452.5	1.96	44.7	1.92	46.9	1.93	1.85	1.90	3.9
31	1	31- 34	454.4	1.96	45.0	2.00	42.3	1.81	1.80	1.80	0.6
31	4	77- 81	459.4	2.02	41.0	2.03	40.1	1.97	1.87	1.94	5.5
32	1	15- 25	463.8	-	-	-	-	1.96	-	-	-
32	6	40- 45	471.5	1.99	43.3	1.99	42.8	2.03	1.96	2.01	3.3
33	1	57- 61	473.7	1.95	44.7	1.94	45.4	1.85	1.82	1.84	1.7
33	6	43- 48	481.1	1.98	43.1	1.93	46.5	1.94	1.89	1.92	2.7
34	1	25- 35	482.9	-	-	-	-	1.85	-	-	-
34	3	45- 49	486.1	2.13	38.8	2.10	36.2	2.14	2.03	2.11	5.4
35	1	128-132	493.4	2.06	37.9	2.02	41.1	1.90	1.94	1.91	-2.2
35	4	57- 61	497.2	1.99	43.0	1.91	47.6	1.89	1.84	1.87	3.0
36	1	33- 37	502.0	1.94	45.4	1.89	48.9	1.91	1.79	1.87	6.4
36	2	54- 65	503.7	-	-	-	-	2.01	-	-	-
37	1	28- 33	511.4	1.92	46.1	1.91	47.6	1.79	1.75	1.78	2.6
37	3	114-118	515.3	2.07	38.3	2.09	36.6	2.05	1.91	2.00	7.1
38	1	65- 69	521.3	1.94	42.9	1.93	46.1	1.78	1.70	1.76	4.8
39	1	78- 82	530.9	2.07	38.7	2.04	39.8	2.06	1.93	2.02	6.6
40	1	2- 4	539.6	1.96	42.3	1.96	44.6	1.88	1.85	1.87	1.9
41	1	85- 93	550.0	-	-	1.99	42.8	2.02	-	-	-
42	1	13- 15	558.7	2.02	40.0	1.97	43.7	1.93	1.97	1.94	-2.0
43	1	6- 8	568.2	2.00	42.0	-	-	1.87	1.87	1.87	-0.1
44	1	4- 6	577.7	1.97	43.0	1.94	45.6	1.85	1.91	1.87	-3.1
45	1	6- 16	587.2	-	-	1.96	44.4	1.92	-	-	-

Table 2. (Continued).

Core/Section (interval in cm)		Interval	Depth	Gravimetric Density (g/cc)	Gravimetric Porosity (%)	GRAPE Density (g/cc)	GRAPE Porosity (%)	Horiz. Velocity (km/s)	Vert. Velocity (km/s)	Average Velocity (km/s)	Anisotropy (%)
45	1	20- 22	587.3	1.96	43.5	-	-	-	-	-	-
48	1	133-136	617.0	2.02	39.5	1.97	44.0	2.05	1.99	2.03	3.2
48	1	139-145	617.0	-	-	2.05	39.4	2.12	-	-	-
49	1	3- 6	625.2	2.02	40.0	2.04	39.7	2.23	2.11	2.19	5.5
50	1	100-110	635.6	-	-	2.05	39.3	2.11	-	-	-
50	2	54- 57	636.7	2.03	36.7	2.04	40.0	2.35	2.27	2.33	3.7
51	1	100-104	645.1	2.01	39.9	1.99	42.9	2.11	2.03	2.09	3.9
51	3	2- 4	647.1	2.06	37.5	2.03	40.6	-	-	-	-
51	5	21- 26	650.4	2.08	35.5	2.07	38.0	2.35	2.11	2.27	10.4
52	1	29- 35	653.9	2.02	39.5	2.01	41.8	1.93	1.90	1.92	1.6
52	3	14- 17	656.8	2.06	37.8	2.08	37.1	-	-	-	-
52	5	29- 34	659.9	2.15	32.5	2.13	34.4	2.30	2.22	2.27	3.3
52	3	5- 14	656.7	-	-	-	-	2.07	-	-	-
53	1	16- 20	663.3	2.06	37.1	2.06	38.6	2.18	2.14	2.16	1.6
53	3	42- 51	666.6	-	-	-	-	2.44	-	-	-
53	3	109-111	667.2	2.16	33.6	2.15	33.0	-	-	-	-
53	5	75- 79	669.9	2.18	31.3	2.16	32.8	2.53	2.42	2.49	4.4
54	1	46- 50	673.1	2.16	31.4	2.13	34.5	2.48	2.39	2.45	3.8
54	3	32- 34	675.9	2.20	31.1	2.14	33.8	-	-	-	-
54	4	36- 41	677.5	2.18	31.9	2.20	30.5	2.55	2.39	2.50	6.3
54	6	99-102	681.1	2.10	34.3	2.12	35.2	-	-	-	-
55	1	53- 58	682.7	2.18	32.7	2.20	30.1	2.49	2.30	2.42	8.0
55	2	43- 53	684.1	-	-	-	-	2.54	-	-	-
56	1	62- 67	692.3	2.15	32.4	2.16	32.5	2.32	2.27	2.30	2.3
56	3	9- 12	694.7	2.16	33.6	2.20	30.5	-	-	-	-
56	4	43- 47	696.6	2.16	33.2	2.15	33.3	2.42	2.24	2.36	8.0
56	6	55- 57	699.7	2.15	31.6	2.16	32.7	-	-	-	-
58	1	19- 22	710.8	2.19	30.4	2.20	30.1	2.43	2.39	2.41	1.6
58	1	78- 88	711.4	-	-	2.22	29.2	2.68	-	-	-
58	2	118-121	713.3	2.22	28.7	2.25	27.4	2.57	2.55	2.56	0.7
58	3	55- 58	714.1	2.22	29.4	2.24	27.9	2.63	2.52	2.59	4.5
59	1	4- 7	716.7	2.26	27.3	2.23	28.2	2.48	2.49	2.48	-0.6
60	2	88- 91	722.4	2.23	25.2	-	-	2.94	2.95	2.94	-0.3
60	4	112-122	725.6	2.23	30.2	2.24	28.1	2.86	-	-	-
60	CC		729.0	2.26	22.8	2.28	25.5	3.11	-	-	-
61	1	88- 91	730.0	-	-	2.24	28.0	2.96	-	-	-
61	2	0- 10	730.7	-	-	2.14	34.1	2.88	-	-	-
61	1	81- 83	729.9	2.21	25.2	2.19	31.0	-	-	-	-
61	2	0- 5	730.6	2.17	27.1	-	-	-	2.54	-	-
61	3	76- 80	732.9	2.28[a]	19.8	2.21[a]	29.4	3.32	3.18	3.27	4.2
61	5	31- 35	735.4	2.13	32.1	2.11	35.3	2.97	2.92	2.95	1.6
62	1	70- 75	738.8	2.26	26.5	2.26	26.7	2.79	2.73	2.77	2.1
62	2	48- 56	740.1	-	-	-	-	2.80	-	-	-
62	3	56- 61	741.7	2.19	31.7	2.16	32.9	2.71	2.62	2.68	3.2
62	4	21- 23	742.8	2.26	28.5	2.21	29.7	-	-	-	-
63	1	72- 74	747.8	2.25	28.6	2.25	27.5	2.72	2.54	2.66	6.8
63	2	70- 73	749.3	2.31	25.5	2.33	22.3	-	-	-	-
63	3	86- 88	751.0	2.28	25.0	2.30	24.1	2.87	-	-	-
63	5	56- 58	753.7	2.29	25.6	2.23	28.2	-	-	-	-
63	6	7- 10	754.7	2.29	24.5	2.27	26.0	2.83	2.77	2.81	2.0
64	1	105-108	757.2	2.29	24.6	2.26	26.7	2.91	2.67	2.83	8.3
64	2	36- 38	758.0	2.27	27.4	2.18	31.5	-	-	-	-
64	3	77- 80	759.9	2.34	24.8	2.37	20.2	2.65	2.72	2.67	-2.6
64	3	108-118	760.1	-	-	-	-	3.37	-	-	-
64	4	69- 72	761.3	2.29	28.8	2.33	22.8	2.64	-	-	-
64	5	139-143	763.5	2.34	21.8	2.36	21.0	3.03	2.88	2.98	5.1
65	1	81- 86	765.9	2.24	27.6	2.33	22.3	2.80	2.71	2.77	3.4
65	2	93- 95	767.5	2.28	25.1	2.35	21.2	-	-	-	-
66	1	118-121	775.3	2.24	28.4	2.29	24.8	-	-	-	-

Table 2. (Continued).

Core/Section (interval in cm)		Interval	Depth	Gravimetric Density (g/cc)	Gravimetric Porosity (%)	GRAPE Density (g/cc)	GRAPE Porosity (%)	Horiz. Velocity (km/s)	Vert. Velocity (km/s)	Average Velocity (km/s)	Anisotropy (%)
66	1	122-132	775.4	-	-	-	-	2.86	-	-	-
66	2	103-106	776.6	2.28	25.4	2.30	24.4	2.86	2.71	2.81	5.3
66	3	100-103	778.1	2.27	26.6	2.28	25.8	-	-	-	-
66	4	66- 69	779.3	2.26	27.0	2.20	30.4	2.88	2.68	2.81	7.1
67	2	118-120	784.3	2.24	28.8	2.24	27.9	2.79	2.67	2.75	4.5
68	1	136-139	787.5	2.43	19.1	2.43	16.8	3.42	3.39	3.41	0.8
68	2	125-128	788.9s	2.03[a]	45.9	2.05[a]	38.9	2.12	2.03	2.09	4.3
68	4	9- 19	790.8	2.29	24.0	2.31	24.0	3.21	-	-	-
69	1	47- 50	792.6	2.29	25.5	2.30	24.3	-	2.63	-	-
69	2	130-132	794.9	2.30	26.3	2.35	21.4	2.79	2.73	2.77	1.9
70	1	22- 32	796.4	2.28	26.2	2.29	24.9	2.96	-	-	-
70	1	61- 64	796.7	2.28	26.7	2.32	23.3	2.77	2.61	2.71	5.6
71	1	113-117	802.3	2.29	25.6	2.25	27.3	2.72	2.51	2.65	7.9
71	2	70- 72	803.3	2.32	22.4	2.32	23.2	2.98	2.85	2.94	4.3
71	3	86- 89	805.0	2.33	23.4	2.35	21.3	2.96	2.69	2.87	9.4
71	4	85- 87	806.5	2.32	23.6	2.30	24.6	-	-	-	-
71	4	88- 91	808.0	2.35	21.1	2.32	22.9	3.11	2.94	3.05	5.6
72	1	48- 50	810.6	2.33	22.7	2.28	25.3	2.96	2.86	2.92	3.4
72	2	4- 14	811.7	-	-	-	-	3.14	-	-	-
72	2	55- 57	812.2	-	-	2.27	26.4	2.34	-	-	-
72	3	61- 65	813.7	2.32	22.5	2.32	23.4	3.02	2.84	2.96	5.9
72	4	43- 46	815.0v	2.35	21.6	2.57[a]	8.1	-	-	-	-
73	1	65- 68	815.3	2.38	17.2	2.39	19.2	3.40	3.28	3.36	3.6
73	2	117-120	817.3	2.36	20.3	2.36	21.0	3.20	-	-	-
73	3	120-123	818.8	2.32	23.3	2.31	23.6	2.97	2.81	2.92	5.4
73	4	57- 60	819.7	2.31	23.2	2.34	22.1	2.99	-	-	-
73	5	68- 70	821.3	-	-	-	-	3.06	2.82	2.98	8.1
74	1	117-119	824.8	2.36	21.1	2.30	24.3	3.11	2.93	3.05	6.1
74	2	111-113	826.2	2.33	20.6	2.35	21.3	3.11	-	-	-
74	3	81- 83	827.4	2.30	22.9	2.31	24.0	3.07	2.71	2.95	12.1
74	4	140-143	829.5	2.34	22.6	2.28	25.8	3.11	-	-	-
74	5	40- 42	830.0	2.31	21.4	2.30	24.2	3.12	2.91	3.05	6.7
74	6	68- 70	831.8	2.27	25.7	2.21	29.4	2.82	-	-	-
75	1	89- 91	833.5	2.50[a]	21.4	2.47[a]	14.1	3.08	3.02	3.06	1.9
75	2	108-111	835.2	2.29	24.5	2.28	25.5	2.92	2.76	2.87	5.8
75	4	110-120	838.3	2.14[a]	16.3	2.39	18.7	3.36	-	-	-
75	5	3- 6	838.7s	2.06[a]	44.9	2.15[a]	33.0	2.35	2.27	2.32	3.7
75	5	84- 86	839.5	2.78[a]	14.9	2.82[a]	-	3.83	3.99	3.88	-4.3
75	6	143-145	841.6	2.26	27.7	2.28	25.8	2.86	2.68	2.80	6.2
76	2	123-126	844.4m	2.14[a]	33.8	2.12[a]	35.3	2.46	2.34	2.42	5.3
76	4	116-126	847.4s	1.94[a]	49.1	1.96[a]	44.3	2.20	2.12	2.17	3.7
77	1	16- 25	850.8s	-	-	1.99	42.5	2.27	2.15	2.23	5.2
77	2	93- 95	853.1	1.94	47.0	1.96	44.4	2.26	2.18	2.24	3.6
77	4	73- 75	855.9	2.31	21.4	2.34	22.0	3.04	2.97	3.02	2.6
78	1	71- 74	860.3	2.32	20.5	2.31	23.8	3.13	2.92	3.06	7.0
78	2	133-136	862.5	2.51	16.8	2.49	12.9	3.42	3.35	3.40	2.3
78	4	1- 11	864.2	-	-	2.29	24.8	2.80	-	-	-
78	4	120-123	865.3	2.39	19.8	2.39	18.9	3.60	3.54	3.58	1.7
79	1	30- 32	868.9	2.28	25.9	2.22	29.2	2.74	2.70	2.72	1.4
79	2	29- 31	870.4	2.34	23.3	2.33	22.5	2.87	2.71	2.82	5.8
79	3	100-102	872.6	2.34	22.1	2.32	23.2	3.06	3.02	3.05	1.4
79	4	93- 95	874.1	2.38	20.8	2.42	17.2	3.12	3.03	3.09	2.7
79	2	103- 93	871.0	-	-	2.32	22.9	3.14	-	-	-
79	5	70- 73	875.3	2.00	35.9	2.01	41.7	2.67	2.55	2.63	4.7
80	1	113-115	878.8	2.17	29.4	2.27	26.0	3.17	2.95	3.09	7.2
80	2	108-110	880.2	2.22	25.0	2.18	31.5	3.37	3.41	3.39	-1.0
80	2	32- 45	879.5	-	-	2.23	28.3	3.25	-	-	-
81	1	104-106	887.7	2.11	35.7	2.13	34.6	2.18	2.18	2.18	-0.0
81	2	106-108	889.7	2.08	37.0	2.09	36.6	2.45	2.35	2.42	4.1

Table 2. (Continued).

Core/Section (interval in cm)		Interval	Depth	Gravimetric Density (g/cc)	Gravimetric Porosity (%)	GRAPE Density (g/cc)	GRAPE Porosity (%)	Horiz. Velocity (km/s)	Vert. Velocity (km/s)	Average Velocity (km/s)	Anisotropy (%)
83	1	90- 93	901.5	2.23	28.4	2.23	28.6	2.69	2.69	2.69	0.0
83	2	80- 82	902.9	2.20	29.7	2.16	32.5	2.55	2.38	2.49	7.2
83	4	22- 24	905.3	2.18	31.4	2.20	30.6	2.45	2.33	2.41	4.8
83	5	29- 31	906.9	2.16	31.9	2.11	35.3	2.33	-	-	-
83	6	41- 43	908.5	2.16	32.2	2.19	30.9	2.39	2.33	2.37	2.7
84	1	46- 48	910.6	2.19	30.5	2.18	31.7	2.44	2.35	2.41	3.9
84	2	62- 64	912.2	2.20	29.9	2.27	26.4	2.51	2.38	2.47	5.2
84	3	35- 37	913.5	2.18	31.2	2.17	31.9	2.49	2.41	2.46	3.5
84	4	21- 23	914.8	2.20	30.1	2.18	31.7	2.54	2.48	2.52	2.1
84	5	135-137	917.5	2.20	30.0	2.17	32.2	2.63	2.57	2.61	2.4
84	6	20- 30	917.9	-	-	2.22	28.9	2.67	-	-	-
85	1	29- 32	919.9	2.12	34.4	2.10	36.0	2.34	2.31	2.33	1.3
85	2	28- 38	921.4	-	-	2.13	34.3	2.26	-	-	-
86	1	55- 58	929.7	2.26	27.1	2.22	28.8	2.54	2.39	2.49	6.2
86	2	44- 54	931.1	-	-	2.24	28.1	2.58	-	-	-
86	3	128-130	933.4	2.21	29.9	2.21	29.5	2.06	2.40	2.17	-15.6
86	5	7- 9	935.2	2.19	31.0	2.15	33.5	2.41	2.33	2.38	3.3
86	7	17- 19	938.3	2.17	31.8	2.09	36.6	2.27	2.21	2.25	3.0
87	1	54- 57	939.2	2.17	32.2	2.21	29.7	2.43	2.32	2.39	4.5
87	2	140-143	941.5	2.12[a]	27.6	2.23	28.6	2.49	2.42	2.47	2.7
87	3	131-134	942.9	2.25	27.7	2.27	25.9	2.59	2.68	2.62	-3.4
87	4	144-147	944.6	2.21	30.1	2.21	29.9	2.49	2.42	2.47	2.9
87	5	112-121	945.8	-	-	2.21	29.4	2.66	-	-	-
87	7	0- 3	947.6	2.25	27.7	2.27	25.9	2.50	2.43	2.48	3.0
88	2	3- 6	948.1	2.18	31.5	2.18	31.5	2.36	2.37	2.36	-0.5
88	2	2- 5	949.7	2.24	27.9	2.24	27.6	2.59	2.58	2.59	0.5
89	1	42- 45	958.1	2.30	24.7	2.31	23.8	2.67	2.56	2.63	4.4
89	3	88- 91	961.5	2.32	23.5	2.69[a]	1.2	2.78	2.63	2.73	5.5
89	4	140-149	963.6	-	-	2.29	24.8	3.16	-	-	-
89	5	9- 12	963.7	2.37	20.5	2.39	19.0	3.29	3.20	3.26	2.7
90	1	5- 8	967.2	2.21	30.1	2.20	30.2	2.37	2.27	2.34	4.4
90	3	123-132	971.4	-	-	2.15	33.4	2.48	-	-	-
90	4	20- 23	971.8	2.13	34.3	2.13	34.2	2.26	2.21	2.24	2.3
90	6	3- 6	974.7	2.17	32.7	2.11	35.6	2.42	2.44	2.43	-0.7
91	2	3- 6	978.2	2.23	28.6	2.24	27.8	2.50	2.39	2.46	4.4
91	3	138-141	980.5	2.25	27.9	2.27	26.3	2.50	2.40	2.46	4.0
91	5	78- 87	983.4	-	-	2.27	26.3	2.58	-	-	-
91	5	3- 6	984.2	2.29	25.8	2.31	24.0	2.41	2.34	2.39	3.1
92	1	126-128	987.4	2.18	31.3	2.17	32.3	2.45	2.30	2.40	6.1
92	2	145-147	989.1	2.19	31.4	2.13	34.4	2.25	2.17	2.22	3.6
92	3	94- 96	990.1	2.24	28.2	2.23	28.3	2.41	2.35	2.39	2.6
92	4	21- 31	990.9	-	-	2.35	21.5	2.59	-	-	-
93	1	129-131	996.9	2.27	25.6	2.23	28.3	2.58	2.45	2.54	5.2
93	2	129-131	998.4	2.22	29.5	2.21	29.8	2.42	2.32	2.38	3.9
93	3	124-126	999.9	2.22	28.6	2.24	28.1	2.47	2.35	2.43	4.8
93	4	126-135	1001.4	-	-	2.35	21.4	2.79	-	-	-
93	5	130-132	1002.9	2.33	23.7	2.34	22.2	2.71	2.51	2.64	7.6
94	1	119-121	1006.3	2.34	23.4	2.30	24.3	2.72	2.58	2.68	5.2
94	3	38- 40	1008.5	2.35	22.6	2.29	25.2	2.72	2.52	2.65	7.6
94	4	141-143	1011.0	2.37	21.2	2.39	18.8	2.87	2.66	2.80	7.7
94	6	2- 12	1012.7	-	-	2.32	23.1	2.83	-	-	-
95	1	63- 65	1015.2	2.37	23.7	2.37	20.1	2.62	2.48	2.58	5.3
95	3	12- 14	1017.7	2.36	23.3	2.34	22.2	2.64	2.47	2.58	6.7
95	4	6- 16	1019.2	-	-	2.35	21.5	2.60	-	-	-
95	5	17- 20	1020.8	2.36	21.8	2.36	20.6	2.64	2.53	2.60	4.0
96	1	29- 38	1023.9	-	-	2.36	20.5	2.75	-	-	-
96	2	35- 37	1025.5	2.34	21.9	2.32	23.3	2.80	2.68	2.76	4.6
96	3	25- 27	1026.9	2.34	22.6	2.38	19.9	2.81	2.67	2.76	5.2
97	1	36- 39	1030.0	2.31	24.1	2.34	21.9	2.68	2.55	2.63	4.9

Table 2. (Continued).

Core/Section (interval in cm)		Interval	Depth	Gravimetric Density (g/cc)	Gravimetric Porosity (%)	GRAPE Density (g/cc)	GRAPE Porosity (%)	Horiz. Velocity (km/s)	Vert. Velocity (km/s)	Average Velocity (km/s)	Anisotropy (%)
97	1	39- 47	1030.1	-	-	2.32	23.5	2.73	-	-	-
97	2	77- 80	1031.9	2.31	25.0	2.31	24.0	2.76	2.60	2.71	6.1
97	3	16- 19	1032.8	2.30	25.2	2.32	23.3	2.77	2.58	2.71	7.2
98	1	34- 43	1033.0	-	-	2.30	24.3	2.83	-	-	-
98	1	100-103	1033.6	2.31	24.7	2.34	21.7	2.74	2.53	2.67	7.8
98	4	4- 7	1037.5	2.29	24.7	2.30	24.1	2.70	2.57	2.66	4.9
98	5	92- 95	1039.6	2.30	23.6	2.34	22.3	2.79	2.64	2.74	5.6
100	1	96- 98	1045.1	2.34	23.8	2.34	22.2	2.70	2.51	2.63	7.2
100	2	94- 96	1046.6	2.36	23.4	2.32	23.4	2.79	2.55	2.71	8.6
100	3	44- 53	1047.6	-	-	2.37	20.0	2.84	-	-	-
100	4	95- 97	1049.6	2.34	23.3	2.29	24.9	2.75	2.57	2.69	6.5
101	1	123-125	1051.9	2.34	23.6	2.34	22.0	2.68	2.52	2.63	6.3
101	2	95-105	1053.1	-	-	2.29	24.7	2.71	-	-	-
102	1	80- 82	1056.4	2.34	23.7	2.50[a]	12.6	2.67	2.52	2.62	5.6
102	2	121-131	1058.4	-	-	2.33	22.7	2.70	-	-	-
102	3	92- 94	1059.5	2.33	24.4	2.35	21.5	2.66	2.41	2.57	9.7
103	1	40- 42	1060.0	2.32	25.2	2.32	23.2	2.68	2.49	2.62	7.3
103	2	18- 20	1061.3	2.34	23.5	2.33	22.6	2.75	2.49	2.66	9.8
103	3	30- 39	1062.5	-	-	2.30	24.1	2.77	-	-	-
104	1	40- 42	1069.0	2.34	23.6	2.38	19.7	2.65	2.42	2.57	8.6
104	3	31- 40	1072.0	-	-	2.34	22.1	2.86	-	-	-
104	5	85- 88	1075.5	2.36	22.6	2.39	19.2	2.79	2.57	2.71	8.1
105	1	107-110	1078.7	2.32	24.4	2.33	22.8	2.87	2.66	2.80	7.3
105	3	128-131	1081.9	2.37	21.9	2.38	19.9	2.83	2.54	2.73	10.8
105	4	104-107	1083.2	2.34	24.0	2.38	19.8	2.71	2.39	2.60	12.1
105	5	0- 10	1083.6	-	-	2.30	24.3	2.82	-	-	-
105	6	3- 7	1085.2	2.33	23.1	2.37	20.4	2.90	2.64	2.81	9.3
106	1	26- 28	1086.9	2.38	21.5	2.39	18.8	2.89	2.56	2.78	11.7
106	2	28- 30	1088.4	2.37	21.6	2.38	19.7	2.88	2.56	2.78	11.5
106	3	26- 36	1089.9	-	-	2.24	27.9	2.77	-	-	-
106	4	31- 33	1091.4	2.29	26.0	2.28	25.4	2.68	2.43	2.60	9.6
106	5	56- 58	1093.2	2.39	20.1	2.41	17.9	2.93	2.55	2.80	13.5
106	7	33- 35	1095.9	2.26	27.0	2.28	25.8	2.37	2.34	2.36	1.1
107	1	139-141	1097.0	2.35	22.1	2.31	23.7	2.85	2.59	2.77	9.4
107	3	17- 19	1098.8	2.34	23.1	2.36	20.6	2.78	2.50	2.68	10.2
107	4	125-134	1101.4	-	-	2.31	24.0	2.71	-	-	-
107	6	7- 9	1103.2	2.34	22.4	2.32	23.1	2.73	2.52	2.66	8.0
108	1	138-140	1106.0	2.26	27.0	2.29	25.2	2.63	2.48	2.58	5.7
108	3	114-124	1108.8	-	-	2.31	23.9	2.81	-	-	-
108	4	79- 81	1109.9	2.29	24.3	2.31	23.9	2.76	2.52	2.68	9.1
109	1	137-139	1110.5	2.32	23.4	2.58[a]	26.9	2.74	2.51	2.66	8.5
109	2	141-143	1112.0	2.28	25.9	2.28	25.3	2.76	2.57	2.69	7.1
109	3	107-116	1113.2	-	-	2.35	21.1	2.90	-	-	-
109	4	122-124	1114.8	-	-	-	-	2.57	-	-	-
109	5	40- 42	1115.5	2.30	24.6	2.24	27.7	2.89	2.62	2.80	9.6
110	1	89- 92	1119.0	2.30	24.4	2.29	24.7	2.79	2.59	2.72	7.3
110	2	103-106	1120.7	2.34	22.0	2.38	19.4	2.88	2.65	2.80	8.2
110	4	12- 15	1122.8	2.36	22.5	2.40	18.7	2.63	2.42	2.56	8.0
110	5	52- 62	1124.7	-	-	-	-	2.81	-	-	-
110	6	127-130	1126.9	2.36	21.6	2.35	21.2	2.80	2.63	2.74	6.1
112	1	56- 59	1136.7	2.44	17.6	2.42	17.5	3.22	3.30	3.25	-2.6
112	2	10- 13	1137.7	2.43	17.1	2.46	15.1	3.34	3.28	3.32	2.0
112	4	16- 19	1140.8	2.41	18.7	2.43	16.4	3.25	3.14	3.21	3.7
112	5	6- 9	1142.2	2.43	17.4	2.52[a]	11.4	3.31	3.17	3.26	4.0
112	6	12- 21	1143.8	-	-	2.40	18.3	3.51	-	-	-
113	2	3- 6	1146.7	2.42	17.6	2.43	16.7	3.26	3.10	3.20	4.9
113	4	30- 33	1149.9	2.37	20.8	2.38	19.4	3.14	2.97	3.08	5.5
113	5	78- 87	1152.0	2.32	23.2	2.31	23.6	3.15	-	-	-
113	7	4- 7	1154.2	2.34	22.6	2.35	21.2	3.07	2.92	3.02	5.0

Table 2. (Continued).

Core/Section (interval in cm)		Interval	Depth	Gravimetric Density (g/cc)	Gravimetric Porosity (%)	GRAPE Density (g/cc)	GRAPE Porosity (%)	Horiz. Velocity (km/s)	Vert. Velocity (km/s)	Average Velocity (km/s)	Anisotropy (%)
114	1	26- 36	1154.4	-	-	2.35	21.5	3.41	-	-	-
114	2	143-145	1157.0	2.33	22.9	2.27	26.3	3.09	2.79	2.99	10.0
114	4	13- 15	1158.7	2.40	18.2	2.41	18.0	3.45	3.20	3.37	7.3
114	6	26- 28	1161.9	2.42	16.8	2.35	21.4	3.23	3.07	3.17	4.8
115	1	113-115	1164.2	2.41	17.2	2.40	18.2	3.36	3.06	3.26	9.4
115	2	39- 49	1165.0	-	-	2.36	20.9	3.41	-	-	-
115	3	72- 74	1166.8	2.40	17.8	2.37	20.1	3.35	-	-	-
115	4	88- 90	1168.5	2.38	19.8	2.34	22.0	3.25	3.06	3.18	5.8
116	1	32- 34	1172.4	2.41	17.6	2.40	18.2	3.55	3.24	3.45	9.2
116	2	110-120	1174.8	-	-	2.35	21.5	3.31	-	-	-
116	4	21- 23	1176.8	2.45	15.2	2.45	15.7	3.81	3.63	3.75	4.7
116	6	59- 61	1180.2	2.51	12.3	2.53	10.9	3.76	3.66	3.72	2.6
117	1	40- 43	1181.5	2.48	13.5	2.46	14.9	3.57	3.28	3.47	8.4
117	3	9- 12	1184.2	2.49	13.1	2.50	12.3	3.70	3.51	3.63	5.1
117	4	115-125	1186.8	2.46	15.7	2.46	14.7	3.67	-	-	-
117	6	24- 27	1188.9	2.49	12.7	2.51	11.9	3.69	3.57	3.65	3.2
118	1	141-144	1192.5	2.51	12.5	2.49	13.1	3.71	3.43	3.62	7.6
118	2	75- 84	1193.4	-	-	2.51	12.0	3.60	-	-	-
118	3	97-100	1195.1	2.49	13.4	2.50	12.7	3.87	3.45	3.73	11.2
119	1	124-126	1195.9	2.50	12.2	2.51	11.7	3.75	3.55	3.68	5.6
119	2	127-129	1197.4	2.48	13.4	2.50	12.5	3.90	3.64	3.82	6.8
119	3	62- 71	1198.3	-	-	2.39	19.3	3.50	-	-	-
119	4	123-125	1200.4	2.48	15.1	2.49	13.0	3.42	3.16	3.33	7.8
120	1	49- 51	1204.1	2.36	21.5	2.34	21.8	2.99	2.68	2.88	10.8
120	2	33- 35	1205.5	2.27	25.2	2.24	27.9	3.02	2.56	2.87	16.0
121	1	19- 21	1212.8	2.39	18.8	2.36	20.9	3.31	3.17	3.26	4.3
122	1	77- 86	1222.4	-	-	2.45	15.2	4.36	-	-	-
122	1	146-148	1223.0	2.43	18.3	2.44	16.0	2.97	2.70	2.88	9.4
122	2	89- 91	1224.0	2.36	19.7	2.21[a]	29.9	3.55	3.13	3.41	12.2
123	1	38- 40	1231.0	2.45	19.9	2.39	18.9	4.30	4.28	4.30	0.5

[a] These data were not used in the regressions shown in Figures 3, 4, and 5 and listed in Table 3.
Mudstones and clastics are indicated as follows: s, sandstone; m, mudstone; v, volcanic ash.

lines in Figure 1 ($\varrho_{grav.}$ versus ϕ) and Figure 2 (ϱ_{GRAPE} versus ϕ). In Figure 1, the siliceous mudstones ($\phi > 60\%$) plot close to the line for the grain density of 2.6 g/cm^3, whereas the lower porosity mudstones plot closer to the line representing a grain density of 2.8 g/cm^3. In Figure 2, the siliceous mudstones also plot close to the 2.6 g/cm^3 grain density line, but the lower porosity mudstones plot closer to the theoretical relationship with a grain density of 2.7 g/cm^3. Comparison of Figures 1 and 2 also show that the GRAPE densities are systematically lower than the gravimetric density values.

The density-porosity relationships for the carbonates recovered at Hole 516F are shown in Figures 3 and 4 for the gravimetric and GRAPE densities, respectively. Neither questionable data nor data for mudstones or clastic sediments were included in the regression analysis. Comparison of the figures shows that the scatter of the GRAPE data is larger than the scatter of the corresponding gravimetric density data. Mean-grain densities (see Table 3) and pore-fluid densities estimated by linear regression from the gravimetric density data are in good agreement with the expected values for carbonates (e.g., Hamilton, 1970; Bachman and Hamilton 1976; Hamilton, 1974).

VELOCITY ANISOTROPY

Deep-sea sediments usually exhibit transverse compressional-wave velocity isotropy and velocities parallel to bedding (V_h) that are higher than velocities normal to bedding (V_v) (Boyce, 1976a; Carlson and Christensen, 1979; Bachman, 1979; Carlson et al., this volume). When both horizontal and vertical compressional-wave velocities are available, transverse isotropy was assumed and the mean velocity ($\overline{V}$) and anisotropy (A) were calculated by:

$$\overline{V} = (2V_h + V_v)/3;$$
$$A = 100\,(V_h - V_v)/\overline{V}.$$

The mean velocities and anisotropies calculated from the shipboard velocity data are shown in Tables 1 and 2.

Anisotropies of the mudstones range from −1 to almost 7%. The carbonates from Hole 516F have anisot-

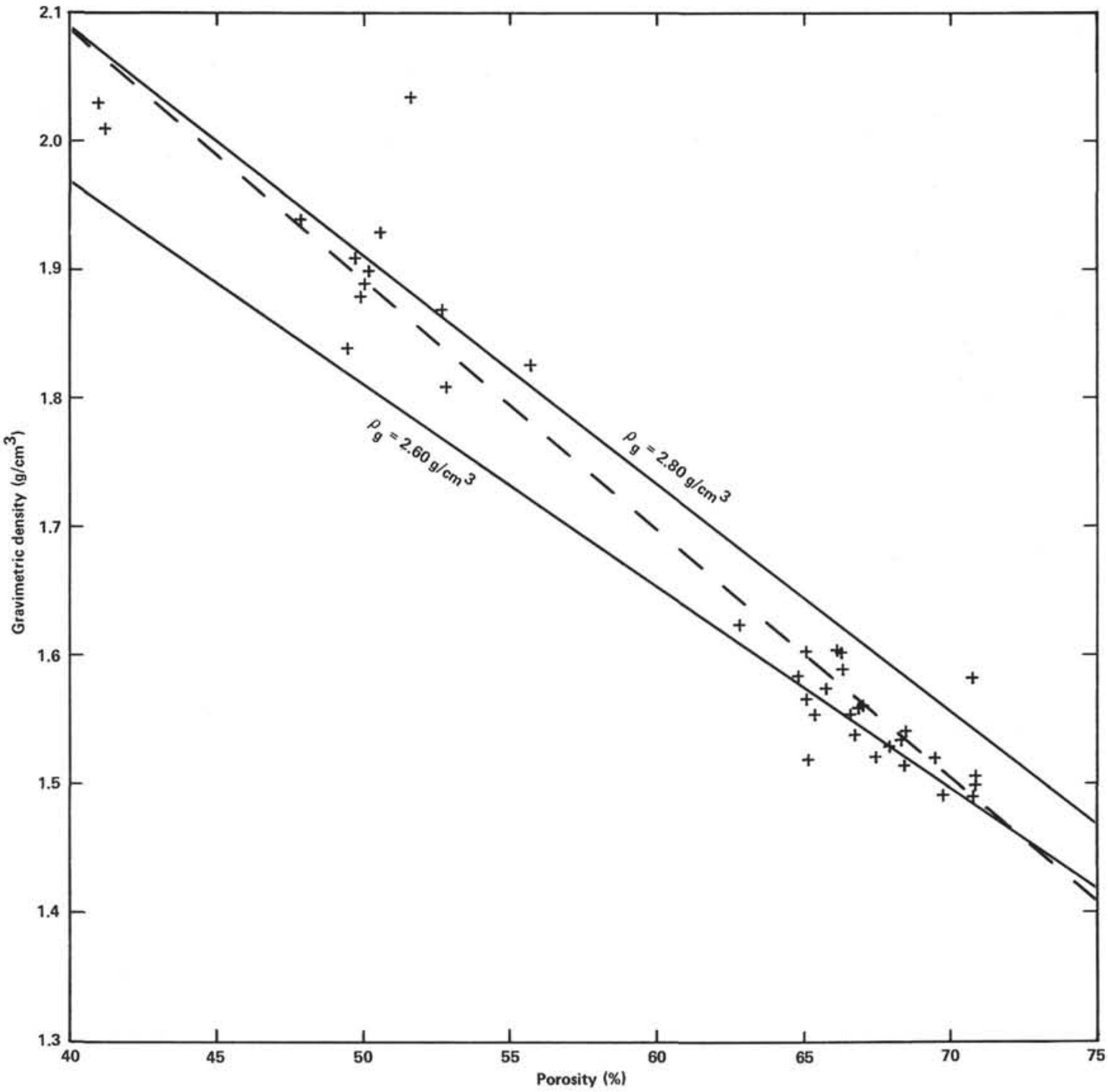

Figure 1. Hole 515B, gravimetric wet-bulk density versus gravimetric porosity. The dashed line shows the best-fitting linear relation determined by least squares (see Table 3). The solid lines show the theoretical relationships for completely saturated sediments. $\varrho_b = \varrho_f\phi + (1 - \phi)\,\varrho_g$ with a pore-fluid density of 1.025 g/cm^3 and grain densities as indicated.

ropies that, with the exception of Section 516F-86-3, range from −4.3 to 16%. An error in one or both of the velocity measurements on this section was probably the cause of the large negative anisotropy of this sample ($A = -15.6\%$). Approximately 6% of the shipboard measurements indicate a negative anisotropy (i.e., V_v higher than V_h). However, negative anisotropy is rarely observed in shore-based laboratory measurements (e.g., Carlson and Christensen, 1979; Carlson, 1982; Carlson, 1981; Carlson et al., this volume) and those that do occur are usually less negative than the uncertainty of the measurement. Most of the negative anisotropies reported are small, suggesting that errors in velocity measurements could produce them. For example, it is likely that trimmed surfaces on some samples are not parallel, in which case the measured velocity would be too low because the acoustic path is partially through water. Thus, measurements for samples that are isotropic or have a small positive anisotropy could show negative anisotropies.

VELOCITY-DENSITY RELATIONS

Figure 5 shows the average compressional-wave velocity plotted as a function of the gravimetric wet-bulk density for the carbonates from Hole 516F. The dashed line represents a nonlinear least-squares fit of ϱ_b on $\overline{V}$. Questionable density data, which are indicated in Table 2 and Figure 5, were not included in the analysis. The regression parameters are shown in Table 3. For comparison, the empirical relationships determined by Hamilton (1978) and Milholland (1980) from laboratory measurements of velocity and density of calcareous deep-sea sediments are included in Figure 5. The shipboard measurements on the carbonates from Hole 516F agree well with the empirical velocity-density curve of Hamilton

(1978) but are systematically lower than the empirical curve of Milholland (1978).

ACKNOWLEDGMENTS

This research was supported by the Office of Naval Research Contract No. 0014-80-C-0113.

REFERENCES

Bachman, R. T., 1979. Acoustic anisotropy in marine sediments and sedimentary rocks. *J. Geophys. Res.*, 84(B13):7661-7663.

Bachman, R. T., and E. L. Hamilton, 1976. Density, porosity, and grain density of samples from Deep Sea Drilling Project Site 222 (Leg 23) in the Arabian Sea. *J. Sediment. Petrol.*, 46(3):654-658.

Boyce, R. E., 1976a. Definitions and laboratory techniques of compressional sound velocity parameters and wet-water content, wet-bulk density, and porosity parameters by gravimetric and gamma ray attenuation techniques. *In* Schlanger, S. O., Jackson, E. D., et al., *Init. Repts. DSDP*, 33: Washington (U.S. Govt. Printing Office), 931-958.

_______, 1976b. Sound velocity-density parameters of sediment and rock from DSDP Drill Sites 315-318 on the Line Islands Chain, Manihiki Plateau, and Tuamoto Ridge in the Pacific Ocean. *In* Schlanger, S. O., Jackson, E. D., et al., *Init. Repts. DSDP*, 33: Washington (U.S. Govt. Printing Office), 695-728.

Carlson, R. L., 1981. Acoustic properties of limestones from the North-central Pacific, Deep Sea Drilling Project Leg 62. *In* Thiede, J., Vallier, T. L., et al., *Init. Repts. DSDP*, 62: Washington (U.S. Govt. Printing Office), 999-1004.

_______, 1982. Acoustic properties of tuffaceous and calcareous sediments, Deep Sea Drilling Project Leg 60. *In* Hussong, D. M., Uyeda, S., et al., *Init. Repts. DSDP*, 60: Washington (U.S. Govt. Printing Office), 803-804.

Carlson, R. L., and Christensen, N. I., 1979. Velocity anisotropy in semiindurated calcareous deep sea sediments. *J. Geophys. Res.*, 84(B1):205-211.

Hamilton, E. L., 1970. Sound velocity and related properties of marine sediments, North Pacific. *J. Geophys. Res.*, 75(23):4423-4446.

_______, 1974. Prediction of deep-sea sediment properties; state-of-the-art. *In* Inderbitzen, A. L. (Ed.), *Deep-Sea Sediments: Physical and Mechanical Properties:* New York (Plenum Press), pp. 1-43.

_______, 1978. Sound velocity-density relations in sea-floor sediments and rocks. *J. Acoust. Soc. Am.*, 63(2):366-377.

Milholland, P., Manghnani, M. H., Schlanger, S. O., and Sutton, G. H., 1980. Geoacoustic modeling of deep-sea carbonate sediments. *J. Acoust. Soc. Am.*, 68(5):1351-1360.

Date of Initial Receipt: August 10, 1982

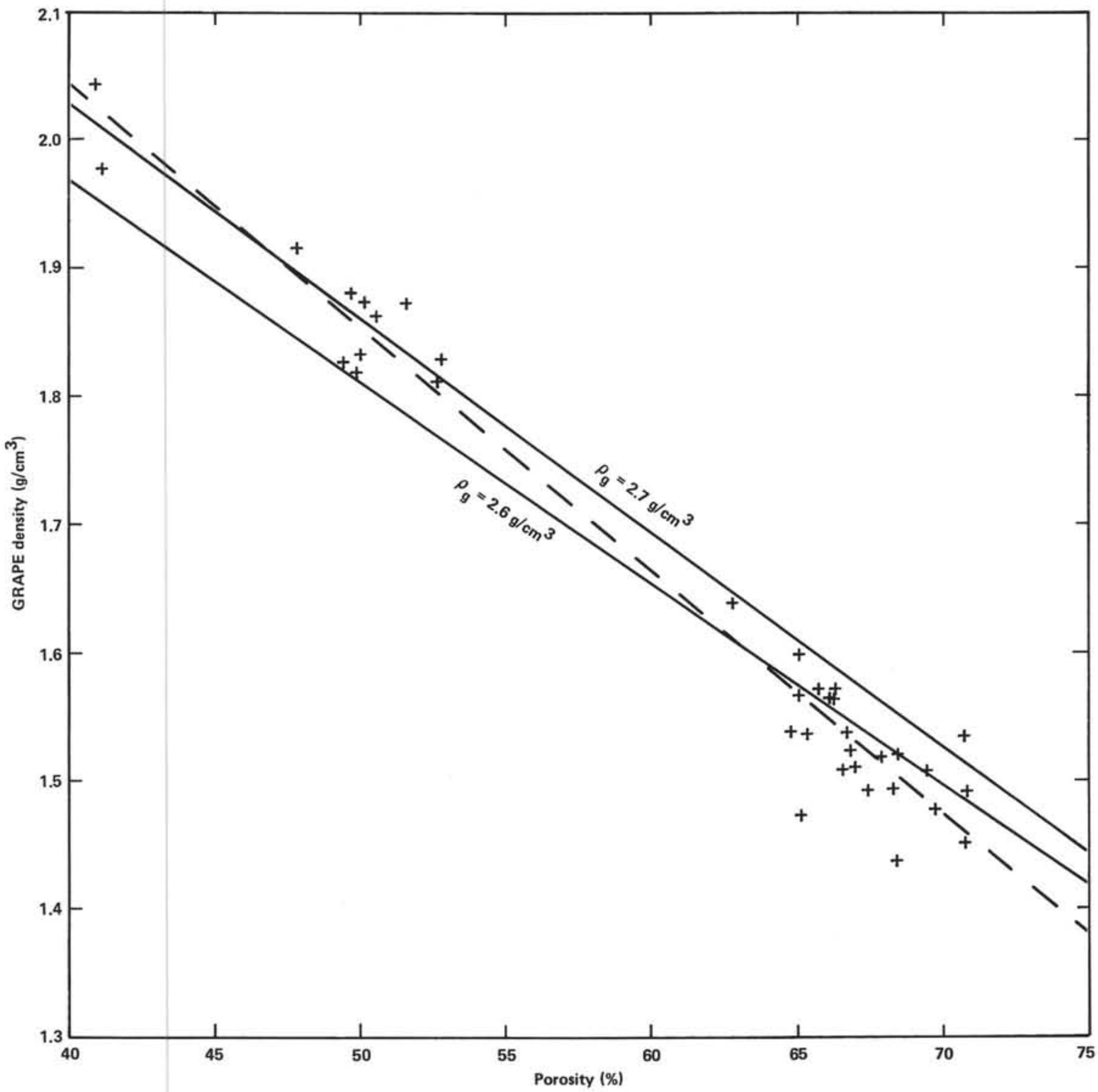

Figure 2. Hole 515B, GRAPE wet-bulk density versus gravimetric porosity. The dashed line shows the best-fitting linear relation determined by least squares (see Table 3). The solid lines show the theoretical relationships for completely saturated sediments. $\varrho_b = \varrho_f\phi + (1 - \phi)\ \varrho_g$ with a pore-fluid density of 1.025 g/cm³ and grain densities as indicated.

Table 3. Summary of regression parameters.

Hole	Figure	Relation	Parameters a	Parameters b	Parameters c	Number of samples	r
515B	1	ϱ_b (grav.) = a + b ϕ	2.86 ± 0.05	−1.94 ± 0.08		38	0.97
515B	2	ϱ_b (GRAPE) = a + b ϕ	2.81 ± 0.04	−1.90 ± 0.06		36	0.98
516F	3	ϱ_b (grav.) = a + b ϕ	2.73 ± 0.01	−1.75 ± 0.02		242	0.99
516F	4	ϱ_b (GRAPE) = a + b ϕ	2.74 ± 0.01	−1.82 ± 0.03		232	0.98
516F	5	$\varrho_b = a\,\overline{V}^b + c$	−2.15 ± 0.15	−1.74 ± 0.25	2.67 ± 0.06	205	

Note: ϱ_b is wet-bulk density; grav. is gravimetric; ϕ is porosity (%); $\overline{V}$ is mean compressional-wave velocity.

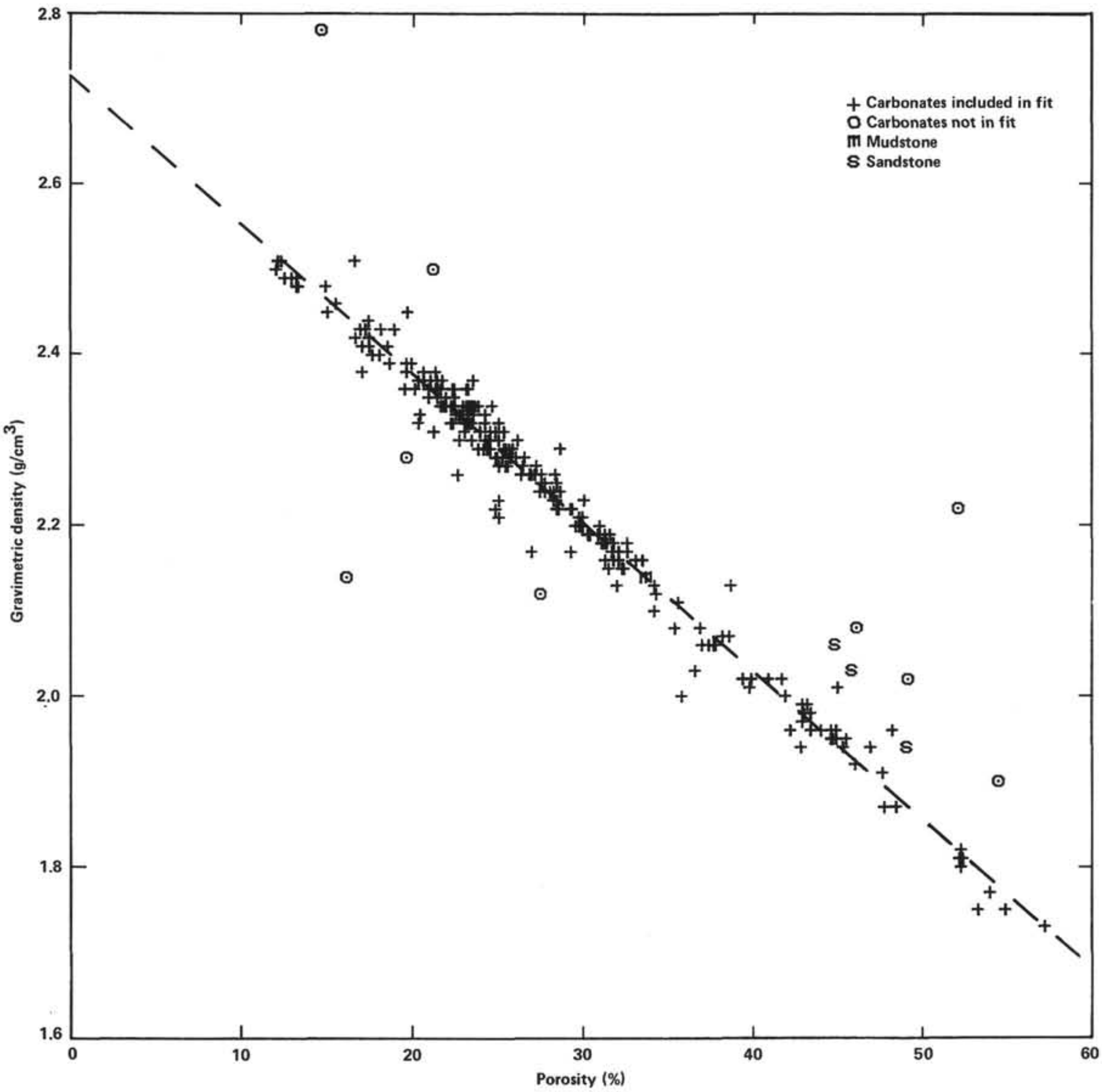

Figure 3. Hole 516F, gravimetric wet-bulk density versus gravimetric porosity. The dashed line shows the best-fitting linear relation determined by least squares (see Table 3). Clastics and indicated carbonates are not included in the linear regression.

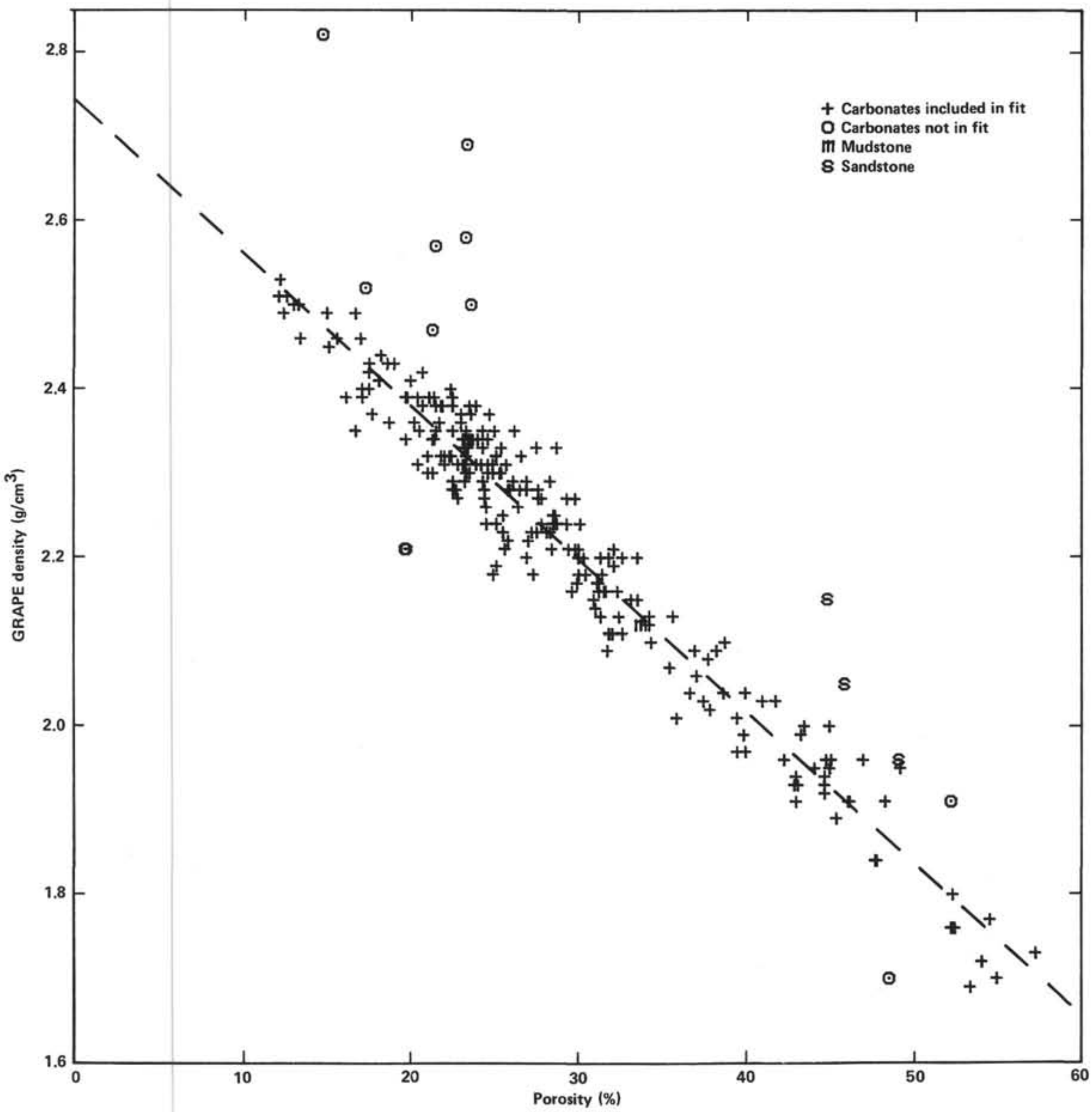

Figure 4. Hole 516F, GRAPE wet-bulk density versus gravimetric porosity. The dashed line shows the best-fitting linear relation determined by least squares (see Table 3). Clastics and indicated carbonates are not included in the linear regression.

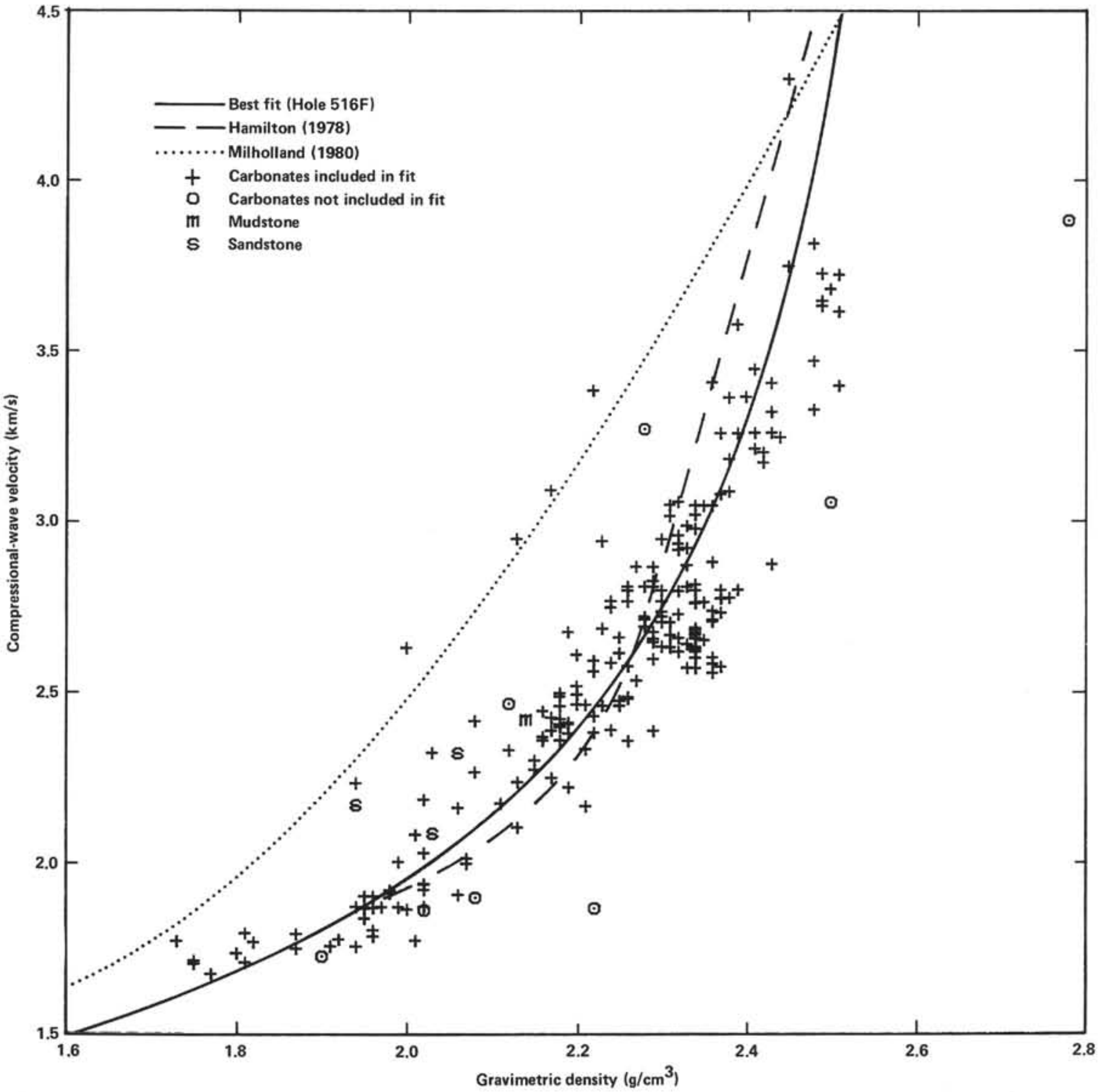

Figure 5. Hole 516F, compressional-wave velocity versus gravimetric wet-bulk density. The best-fitting relation of the form $\varrho_b = a\overline{V}^b + c$ determined by least squares (see Table 3) and the empirical relations of Hamilton (1978) and Milholland (1980) are as indicated.