23. GRAIN-SIZE DISTRIBUTION OF SEDIMENTS FROM THE EASTERN INDIAN OCEAN: DEEP SEA DRILLING PROJECT, LEG 27

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ABSTRACT

Grain size of 172 unconsolidated sediment samples from five DSDP sites in the eastern Indian Ocean was determined by sieve and pipette techniques. Folk and Ward (1957) statistical parameters were calculated for all samples by computer.

On the basis of grain-size parameters, the sediments can be divided into two broad groups: Mesozoic clays and Cenozoic calcareous oozes. Mesozoic sediments have a mean size of 10.07ϕ and are very poorly sorted (2.58ϕ), coarse skewed (-0.14), and mesokurtic (K'_G = 0.47). Cenozoic sediments have a mean size of 7.67ϕ and are very poorly sorted (3.19ϕ), fine skewed (+0.18), and mesokurtic (K'_G = 0.47).

INTRODUCTION

Although grain size is one of the fundamental properties of deep-sea sediments and sedimentary rocks (Griffiths, 1967; Blatt et al., 1972), little detailed work on grain-size distribution or statistical parameters has previously been done on samples obtained by the Deep Sea Drilling Project. Sand-silt-clay percentages are routinely determined for all Initial Reports of the Deep Sea Drilling Project, but only Lisitzin et al. (1971) for Leg 6 and Boyce (1972) for Leg 11 have performed complete grain-size analyses at 1ϕ unit intervals. However, neither investigator computed statistical parameters of grain-size distribution. Beall et al. (1973) did detailed sieve analyses on the sand and coarse silt fractions for Leg 10 sediments, but did not consider the rest of the silt or clay fractions.

By comparison, grain-size data for different types of Recent deep-sea sediments have been reported by a number of workers (e.g., Barth et al., 1939; Sverdrup et al., 1942; Kuenen and Neeb, 1943; Revelle, 1944; Shukri and Higazy, 1944; Kuenen, 1950; Correns, 1955; van Andel, 1964; van Andel and Veevers, 1967; Kukal, 1971; and Lisitzin, 1972). Unfortunately, most of these data are presented in the form of histograms and usually no statistical parameters are computed; or if they are, the outmoded quartile measures of Trask (1932) have been generally used. Thus, much of the grain-size data from these studies cannot be compared with modern statistical data obtained from ancient deep-sea sediments except in a very general sense. Furthermore, data from the modern sediments are of little value for trying to recognize environments and conditions of deposition in older deep-sea deposits.

This paper presents detailed grain-size information on Mesozoic and Cenozoic deep-sea sediments cored at five sites in the eastern Indian Ocean (Figure 1). Our chief objective is to provide basic size-distribution data for different lithologic units cored at these sites. These data, along with petrologic data, are utilized in Chapter 48 (this volume), for deducing environments of deposition and physical mechanisms of sedimentation. The information may also be useful for relating size distribution to physical properties of the sediments, such as porosity, bulk density, sonic transmissability, tensile strength, etc.

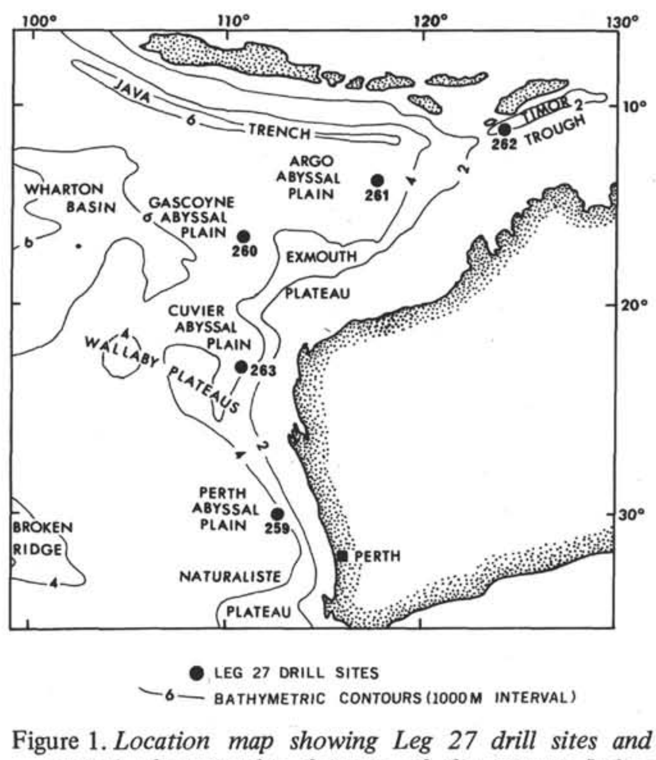

Figure 1. *Location map showing Leg 27 drill sites and general physiographic features of the eastern Indian Ocean.*

METHODS

Unconsolidated sediment samples (172) were selected for grain-size analysis. Sample locations are shown in Figure 2. Size analyses on lithified or semilithified sediments were not performed because the rigorous treatment necessary for disaggregation leads to an erroneous picture of the grain-size distribution (Folk, 1968; Gealy, 1971). Thus, size data presented here are biased in favor of unconsolidated sedimentary units.

Water-soluble salts were removed from all samples by dialysis (Müller, 1967). Each sample was placed in a dialyzer bag and put in a large container of circulating distilled water for 2 days. Samples were then dispersed by soaking for 24 hr in 200 ml of distilled water to which 50 ml of 10% sodium hexametaphosphate (calgon) was added. If lumps of mud were still present after soaking, they were removed by gentle crushing with a rubber-gloved finger (Folk, 1968). The sediment was wet sieved on a 62.5μ screen to separate the sand and mud (silt plus clay) fractions. The sand fraction was dried and sieved on optically calibrated screens at ½ϕ unit intervals for 15 min on a Ro-tap machine (Ingram, 1971). Grain size of the mud fraction was determined in a constant temperature room by pipette technique (Folk, 1968; Galehouse, 1971), which is based on settling velocities of particles calculated from Stokes' Law (Krumbein and Pettijohn, 1938). Pipette withdrawals were taken at times corresponding to ½ unit intervals from 4.5ϕ to 6ϕ and at 1ϕ unit intervals from 7ϕ to 11ϕ. The pipette analyses were terminated at 11ϕ (0.49μ) because particles smaller than this diameter are strongly affected by Brownian movement of the water in which they are suspended (Irani and Callis, 1963).

Cumulative percentages of sand and mud were determined by computer and cumulative curves drawn on arithmetic graph paper. If the cumulative percentage at 11ϕ was less than 95%, the unsampled fine population was interpolated by extending the cumulative curve in a straight line from 11ϕ to 14ϕ at 100% (Folk, 1968). This operation assumes all sediment is coarser than 14ϕ and that the clay mode lies near 12ϕ. Cumulative percentage values for 12ϕ and 13ϕ were read directly from the interpolated curve.

Folk and Ward (1957), Inman (1962), and moment-measure (Griffiths, 1967) statistics were calculated by computer. Folk and Ward statistics are used in this paper since they now are most widely used by sedimentologists. Inman and moment-measure statistics calculated for these samples can be obtained by writing the senior author.

The Folk and Ward (1957) measure for average sediment size is the graphic mean (M_Z), given by the formula

$$M_Z = \frac{\phi 16 + \phi 50 + \phi 84}{3}$$

Their measure for determining the uniformity of grain size (sorting) of sediments is called inclusive graphic standard deviation and is found by the formula

$$\sigma_I = \frac{\phi 84 - \phi 16}{4} + \frac{\phi 95 - \phi 5}{6.6}$$

Plotting of hundreds of analyses from many different environments led Folk and Ward (1957) to suggest the following verbal classification for sorting: σ_I under 0.35ϕ, very well sorted; σ_I 0.35 to 0.50ϕ, well sorted; σ_I 0.50 to 1.00ϕ, moderately sorted; σ_I 1.00 to 2.00ϕ, poorly sorted; σ_I 2.00 to 4.00ϕ, very poorly sorted; and σ_I over 4.00ϕ, extremely poorly sorted.

Skewness is a measure of the degree of asymmetry of the grain-size distribution. Folk and Ward (1957) proposed the measure inclusive graphic skewness, defined as

$$SK_I = \frac{\phi 16 + \phi 84 - 2\phi 50}{2(\phi 84 - \phi 16)} + \frac{\phi 5 + \phi 95 - 2\phi 50}{2(\phi 95 - \phi 5)}$$

Symmetrical population curves have $SK_I = 0$; ones with tails in the fines have positive values to a limit of +1.00, and ones with tails in the coarse have negative values with a limit of -1.00. Folk (1968) suggested the following verbal scale for skewness: SK_I 1.00 to +0.30, strongly fine skewed; DKI + 0.30 to + 0.10, fine skewed; SK_I + 0.10 to -0.10, near symmetrical; SK_I -0.10 to -0.30, coarse skewed; and SK_I -0.30 to -1.00, strongly coarse skewed.

Kurtosis or peakedness of the distribution is computed by comparing the spread in the central part of the distribution to the spread in he tails. Folk nd Ward (1957) define graphic kurtosis as

$$K_G = \frac{\phi 95 - \phi 5}{2.44\,(\phi 75 - \phi 25)}$$

Since the distribution of K_G values is itself strongly skewed in natural sediments, the kurtosis distribution must be normalized using the formula (Folk and Ward, 1957)

$$K'_G = \frac{K_G}{1 + K_G}$$

They called this value transformed kurtosis and suggested the following verbal classification: K'_G under 0.40, very platykurtic; K'_G 0.40 to 0.47, platykurtic; K'_G 0.47 to 0.53, mesokurtic; K'_G 0.53 to 0.60, leptokurtic; K'_G 0.60 to 0.75, very leptokurtic; and K'_G over 0.75, extremely leptokurtic. For normal probability distributions K'_G is equal to 0.50.

Sediment textural classification is that of Shepard (1954), with the sand, silt, and clay boundaries based on the Wentworth (1922) scale. Sand is composed of particles between 2.00 mm and 62.5μ (-1ϕ to +4ϕ); silt particles are between 62.5μ and 3.9μ (+4ϕ to +8ϕ); and clay is material less than 3.9μ (+8ϕ).

Replicate analyses on eight standard samples indicate a level of precision of ±3% for the sand fraction and ±5% for the clay and silt fractions. Numerous workers (e.g., Maiklem, 1968; Gealy, 1971; and Braithwaite, 1973) have pointed out that skeletal debris (foraminifers, radiolarians, diatoms, etc.) have high specific surface areas so that their settling velocities are slower than their nominal diameter would indicate according to Stokes' formula. Thus, grain-size distributions for biogenous sediments are skewed towards values smaller than their "true" distribution. Grain-size parameters for

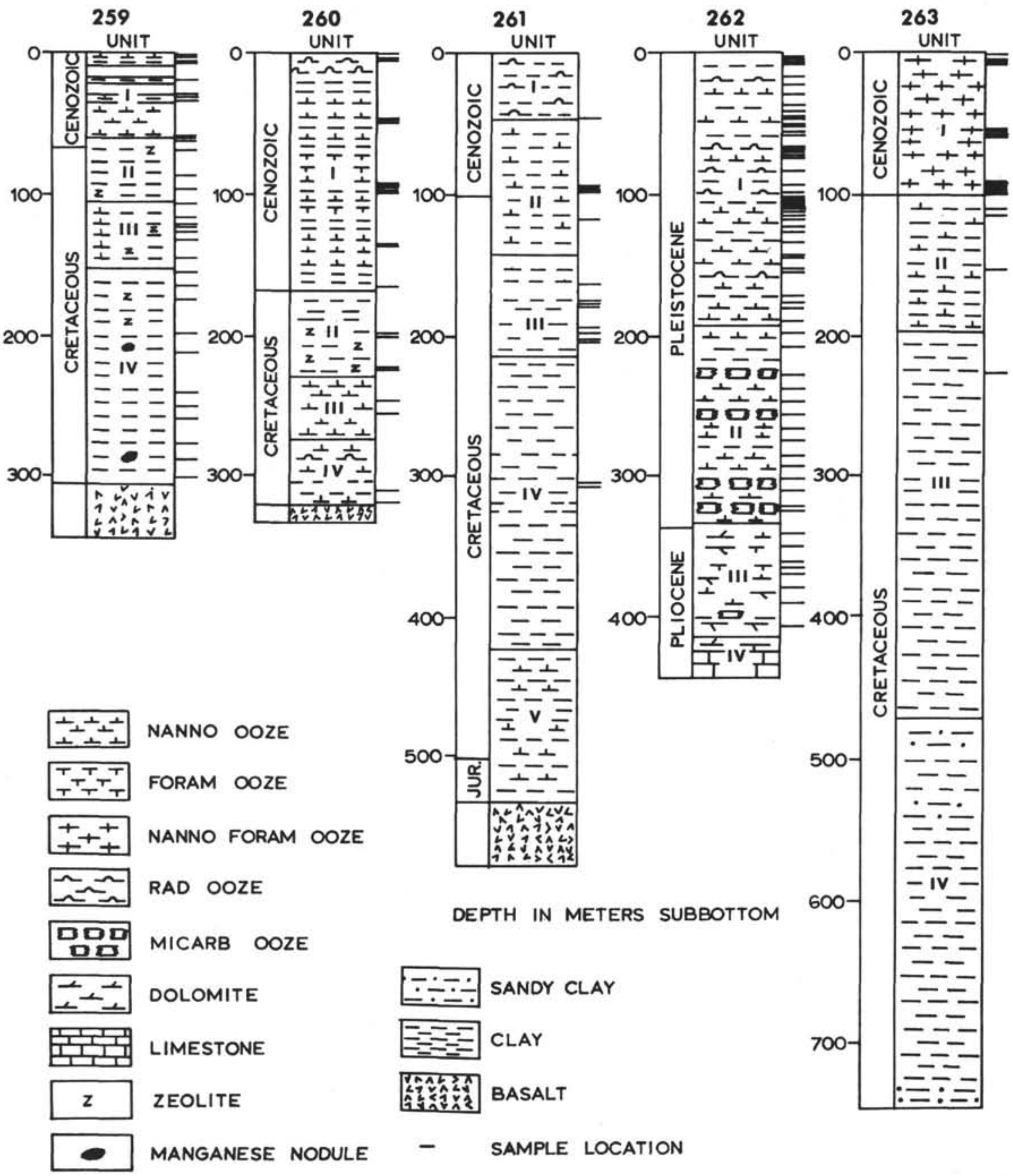

Figure 2. *Generalized stratigraphic sections of Leg 27 drill sites with sample locations indicated by horizontal lines.*

sediments with abundant radiolarians and diatoms are also smaller than "true" values since their opaline skeletons have densities of 2.2 g/cc, whereas Stokes' Law assumes density to be 2.67 g/cc for all particles.

RESULTS

Triangular diagrams showing sand-silt-clay percentages for different stratigraphic units at each Leg 17 site are shown in Figure 3. Table 1 lists Folk and Ward (1957) statistical parameters for all samples. Percentages of sand-silt-clay and Shepard's (1954) textural terms for individual samples are tabulated in Table 2. Table 3 summarizes arithmetic means and standard deviations of statistical parameters for different lithologic units at each site. Details concerning stratigraphic subdivision and lithologic features are discussed in Part I (Site Reports) of this volume.

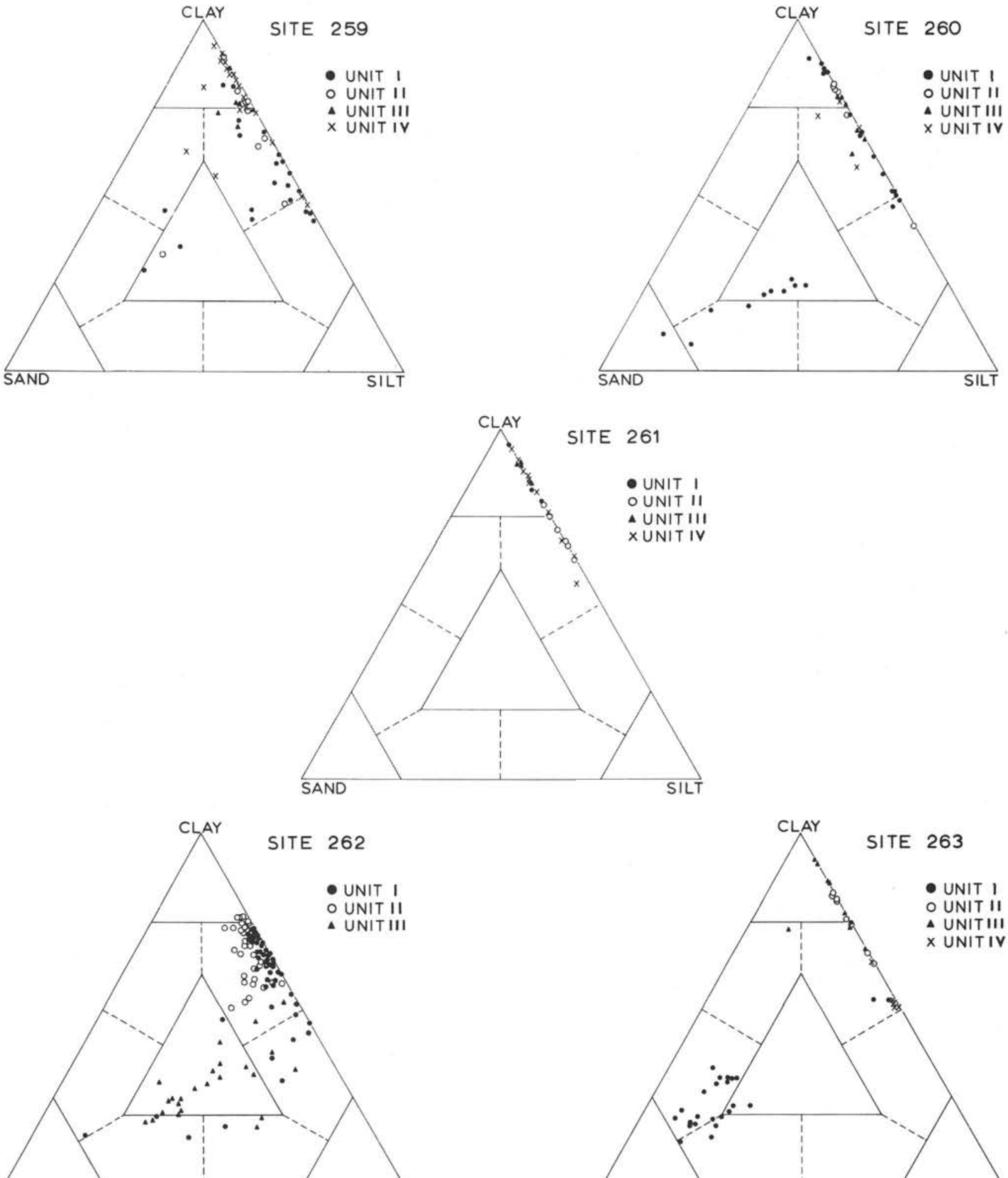

Figure 3. *Triangular diagrams showing sand-silt-clay percentages of samples from stratigraphic units at each Leg 27 drilling site. Fields outlined on each diagram are those of Shepard (1954)*

TABLE 1
Folk's Statistical Parameters

Sample (Interval in cm)	Depth (m)	$\phi 5$	M_z (ϕ)	σ_I (ϕ)	SK_I	K_G'
259-1-1, 122-124	1.2	1.11	5.02	3.77	0.51	0.40
259-1-2, 90-92	2.41	3.04	8.37	2.87	-0.15	0.58
259-1-2, 93-95	2.42	1.67	6.95	4.11	0.15	0.39
259-1-6, 74-76	8.25	4.58	8.94	2.61	0.11	0.48
259-1, CC	9.2	4.02	7.90	3.32	0.14	0.49
259-3-2, 84-86	19.85	4.53	8.56	2.25	0.01	0.52
259-4-1, 85-87	27.86	0.56	6.13	4.19	-0.07	0.38
259-4-3, 74-76	30.75	1.08	7.74	3.76	-0.02	0.56
259-4-4, 74-76	32.25	1.05	7.33	3.68	-0.09	0.51
259-7-3, 74-76	59.25	3.65	8.64	2.52	0.03	0.57
259-7-4, 94-95	60.95	-1.45	5.31	5.74	0.16	0.33
259-7-5, 127-129	62.78	5.70	9.95	2.50	0.11	0.39
259-8-3, 74-76	68.75	4.51	9.32	2.92	0.21	0.39
259-10-3, 74-76	87.75	3.67	10.87	3.01	-0.45	0.45
259-11-3, 74-76	97.25	6.53	10.34	2.37	-0.19	0.42
259-12-3, 74-76	106.75	5.56	10.31	2.53	-0.23	0.45
259-13-3, 74-76	116.25	4.66	10.35	2.63	-0.26	0.48
259-13-6, 56-58	120.57	5.15	9.96	2.79	-0.27	0.47
259-13-6, 130-132	121.31	5.06	10.25	2.58	-0.21	0.52
259-14-3, 74-76	125.75	5.21	10.28	2.57	-0.22	0.46
259-14-6, 66-68	130.17	3.17	9.65	3.13	-0.14	0.47
259-14-6, 126-128	130.77	2.69	9.91	3.19	-0.36	0.48
259-16-3, 74-76	144.75	6.53	9.98	2.35	0.15	0.38
259-17-3, 74-76	154.25	5.74	11.20	2.44	-0.34	0.45
259-18-3, 74-76	163.75	5.74	10.35	2.47	-0.21	0.46
259-19-3, 74-76	173.25	4.69	9.63	2.87	-0.04	0.47
259-22-1, 89-91	198.90	4.23	9.68	2.93	-0.08	0.44
259-23-3, 74-76	211.25	5.05	11.26	2.54	-0.36	0.53
259-26-3, 64-66	239.65	6.66	10.65	2.51	-0.10	0.48
259-27-3, 74-76	249.25	5.24	11.27	2.50	-0.36	0.53
259-28-3, 74-76	258.75	4.62	10.03	2.64	0.02	0.48
259-30-3, 74-76	277.75	4.64	10.94	2.59	-0.10	0.55
259-31-3, 74-76	287.25	1.51	10.33	3.13	-0.35	0.56
259-33-1, 84-86	303.35	4.67	8.29	2.48	-0.04	0.45
260-1-1, 9-11	0.10	4.24	9.76	3.52	-0.34	0.36
260-1-3, 74-76	3.75	4.24	10.23	3.41	-0.52	0.39
260-1-3, 76-78	3.77	4.19	9.34	3.23	-0.17	0.39
260-2-2, 61-63	46.12	4.67	9.97	2.65	0.03	0.4[illegible]
260-2-2, 139-141	46.90	1.18	4.59	3.72	0.74	0.49
260-2-3, 38-40	47.39	0.06	2.64	2.73	0.60	0.56
260-2-3, 48-50	47.49	-1.41	1.16	3.65	0.61	0.59
260-3-2, 90-92	93.91	6.53	9.63	1.39	-0.01	0.93
260-3-3, 74-76	95.25	6.66	9.31	1.20	-0.38	0.93
260-3-4, 83-85	96.84	6.56	9.60	2.34	0.49	0.42
260-3-5, 10-12	97.61	2.14	6.49	3.92	0.45	0.51
260-3-5, 34-36	97.85	1.72	5.81	3.58	0.36	0.46
260-3-5, 74-76	98.25	1.74	5.83	3.43	0.32	0.49
260-3-5, 104-106	98.55	4.59	8.28	2.89	0.29	0.54
260-3-5, 139-141	98.90	2.56	5.42	2.97	0.54	0.48
260-3-6, 49-51	99.50	2.14	5.59	3.35	0.49	0.47
260-3-6, 79-81	99.80	2.09	5.91	3.60	0.51	0.47
260-3-6, 108-110	100.09	1.53	5.37	3.83	0.64	0.46
260-3-6, 123-125	100.24	5.18	11.56	2.28	-0.26	0.62
260-4-5, 40-44	135.92	6.50	8.90	1.73	0.36	0.46
260-4-6, 6-8	137.07	5.14	8.64	2.48	0.47	0.53
260-5-6, 80-82	166.31	7.51	11.25	2.18	-0.28	0.54
260-7-3, 74-76	199.75	6.54	10.92	2.56	-0.38	0.42
260-7-4, 4-6	200.55	6.58	10.91	2.56	-0.37	0.42
260-8-5, 105-107	222.06	4.58	8.43	3.20	0.33	0.42
260-8-6, 133-135	223.84	4.74	10.28	2.64	-0.25	0.43
260-10-2, 55-59	244.64	4.57	8.67	3.32	0.03	0.48
260-11-1, 90-92	253.91	5.61	10.29	2.48	-0.19	0.45
260-17-1, 114-116	311.15	5.54	9.99	2.53	0.07	0.41
260-18-1, 117-119	320.68	-1.25	10.23	3.52	-0.39	0.61
261-3-1, 105-107	48.56	5.14	9.29	3.02	-0.09	0.46

TABLE 1 – *Continued*

Sample (Interval in cm)	Depth (m)	$\phi 5$	M_z (ϕ)	σ_I (ϕ)	SK_I	K_G'
261-4-2, 13-15	96.64	6.56	9.96	2.30	0.13	0.60
261-4-2, 60-62	97.11	4.51	8.92	3.35	-0.18	0.37
261-4-2, 79-81	97.30	5.07	9.91	2.56	0.05	0.47
261-4-2, 102-104	97.53	5.62	9.38	2.43	-0.13	0.60
261-5-1, 95-97	162.46	5.20	10.06	2.79	-0.32	0.41
261-6-3, 84-86	174.85	7.54	10.99	2.12	0.05	0.46
261-6-5, 49-51	177.50	7.65	11.63	1.88	-0.16	0.54
261-8-3, 74-76	193.75	8.51	11.64	1.74	-0.11	0.50
261-8-6, 94-96	198.45	6.61	11.02	2.54	-0.40	0.48
261-9-3, 0-5	202.53	6.55	9.88	2.32	0.20	0.49
261-9-3, 74-76	203.25	6.65	11.27	2.32	-0.33	0.57
261-19-2, 140-142	306.91	4.57	8.45	2.97	0.03	0.43
261-19-4, 134-137	309.85	2.04	3.09	0.52	-0.18	0.43
262-1-2, 129-131	2.80	8.51	10.23	1.75	0.53	0.41
262-1-2, 131-132	2.82	5.02	9.58	2.80	-0.02	0.47
262-1-3, 73-75	3.74	5.12	9.59	2.79	0.00	0.46
262-1-4, 99-101	5.50	1.55	3.63	2.32	0.03	0.69
262-2-3, 74-76	8.75	4.59	9.27	3.10	-0.11	0.43
262-3-3, 94-96	18.45	4.66	9.24	3.12	-0.12	0.42
262-3-6, 95-97	22.96	4.71	9.60	2.85	-0.07	0.48
262-4-3, 136-138	28.37	4.70	9.58	2.86	-0.02	0.47
262-5-3, 74-76	37.25	4.71	9.67	2.87	-0.08	0.46
262-5-6, 43-45	41.44	3.62	9.59	3.04	-0.09	0.45
262-6-1, 102-104	43.53	0.70	2.79	0.94	-0.51	0.55
262-6-2, 140-142	45.91	4.72	9.98	2.91	-0.32	0.38
262-6-3, 74-76	46.75	4.09	9.31	3.19	-0.14	0.44
262-6-5, 99-101	50.00	5.16	9.62	2.78	-0.03	0.46
262-6-6, 44-46	50.95	5.06	9.62	2.83	-0.04	0.46
262-7-3, 104-106	56.55	5.11	9.94	2.79	-0.29	0.46
262-7-5, 52-54	59.03	4.61	9.96	2.88	-0.29	0.43
262-8-4, 88-90	68.89	4.18	9.31	3.21	-0.12	0.40
262-8-5, 124-126	69.25	4.52	8.79	3.23	0.07	0.43
262-8-6, 94-96	70.45	5.56	9.71	2.73	-0.02	0.40
262-9-1, 108-110	72.59	4.62	8.35	2.67	0.26	0.46
262-9-3, 74-76	75.25	5.53	9.67	2.74	-0.01	0.40
262-10-3, 74-76	84.75	5.17	9.67	2.83	-0.05	0.37
262-11-3, 104-106	94.55	4.09	9.02	3.17	0.08	0.44
262-11-6, 119-121	99.20	3.17	7.12	3.45	0.54	0.45
262-12-1, 138-140	101.39	4.05	8.48	3.56	-0.01	0.36
262-12-2, 59-61	102.10	3.61	8.60	3.49	0.02	0.39
262-12-2, 103-105	102.53	3.09	7.97	3.84	0.12	0.37
262-12-3, 74-76	103.75	2.72	6.49	3.76	0.64	0.39
262-12-4, 9-11	104.60	0.66	4.48	3.72	0.46	0.55
262-12-4, 129-131	105.80	2.54	5.29	2.91	0.61	0.73
262-12-5, 112-114	107.13	3.05	6.91	3.50	0.66	0.44
262-12-6, 52-55	108.03	4.56	8.61	3.34	0.08	0.38
262-13-3, 74-76	113.25	5.06	9.34	2.38	-0.18	0.50
262-13-4, 115-117	115.16	4.51	8.30	3.36	0.28	0.42
262-13-6, 123-125	118.24	3.64	8.09	3.60	0.19	0.40
262-14-3, 74-76	122.75	5.09	9.59	2.82	0.01	0.42
262-14-5, 43-45	125.44	4.04	8.92	3.20	0.09	0.44
262-15-3, 74-76	132.25	4.70	9.66	2.87	-0.04	0.43
262-16-3, 74-76	141.75	4.57	9.61	2.91	-0.05	0.39
262-16-4, 52-54	143.03	2.00	4.02	2.73	0.70	0.68
262-17-3, 74-76	151.25	4.61	9.56	2.87	-0.04	0.48
262-17-5, 68-70	154.19	4.04	8.48	3.54	-0.02	0.40
262-19-3, 74-76	170.25	4.68	9.65	2.88	-0.06	0.47
262-19-6, 122-124	175.23	4.54	9.61	2.93	-0.07	0.39
262-20-3, 74-76	179.75	5.63	9.67	2.70	0.00	0.45
262-21-3, 74-76	189.25	5.03	9.67	2.81	-0.05	0.46
262-22-3, 74-76	198.75	5.19	10.02	2.78	-0.28	0.42
262-23-3, 74-76	208.25	5.72	10.27	2.47	-0.18	0.45
262-25-3, 74-76	227.25	5.05	9.69	2.80	-0.04	0.46
262-26-3, 74-76	236.75	5.69	9.96	2.70	-0.24	0.45
262-27-3, 74-76	246.25	5.20	9.72	2.77	-0.04	0.47
262-28-3, 44-46	255.45	1.73	8.25	4.04	-0.12	0.42

TABLE 1 – *Continued*

Sample (Interval in cm)	Depth (m)	$\phi 5$	M_z (ϕ)	σ_I (ϕ)	Sk_I	K_G'
262-29-3, 74-76	265.25	2.53	9.68	3.21	-0.17	0.49
262-30-3, 74-76	274.75	2.22	9.17	3.60	-0.25	0.48
262-31-4, 89-91	285.90	1.67	8.58	3.84	-0.10	0.45
262-32-3, 74-76	293.75	4.50	9.34	3.16	-0.16	0.39
262-33-3, 74-76	303.25	4.12	10.27	3.19	-0.30	0.44
262-34-3, 74-76	312.75	4.51	9.61	2.92	-0.08	0.43
262-35-3, 74-76	322.25	5.06	9.66	2.82	0.04	0.42
262-35-5, 39-40	324.90	4.56	9.65	3.13	-0.36	0.39
262-37-3, 66-70	341.18	2.69	8.25	3.66	0.16	0.41
262-38-3, 68-72	350.70	1.71	6.50	4.00	0.42	0.44
262-39-4, 49-51	361.50	2.23	6.61	3.81	0.49	0.44
262-39-6, 49-51	364.50	2.11	6.63	3.83	0.48	0.44
262-40-3, 77-80	369.78	3.12	8.99	3.64	-0.25	0.38
262-41-4, 139-141	381.40	1.64	5.79	3.71	0.58	0.48
262-42-5, 113-116	392.15	1.62	5.80	3.72	0.55	0.49
262-44-3, 74-76	407.75	1.14	5.73	3.89	0.42	0.39
263-1-1, 145-147	1.46	3.65	8.63	3.46	0.00	0.41
263-1-3, 124-126	4.25	1.05	4.10	3.51	0.80	0.62
263-1-4, 10-12	4.61	1.02	2.93	2.54	0.68	0.61
263-1-4, 100-102	5.52	0.65	4.07	3.54	0.65	0.57
263-1-4, 118-120	5.69	0.67	4.64	4.33	0.77	0.54
263-1-4, 139-141	5.90	0.08	3.83	3.88	0.67	0.55
263-2-2, 15-17	54.16	0.75	4.84	4.17	0.68	0.38
263-2-2, 70-72	54.71	0.73	4.97	4.16	0.59	0.41
263-2-2, 122-124	55.23	0.70	4.64	3.96	0.58	0.41
263-2-3, 40-42	55.91	0.72	5.01	4.18	0.58	0.41
263-2-3, 124-126	56.75	0.56	4.92	4.23	0.57	0.40
263-2-4, 10-12	57.11	0.58	4.99	4.37	0.58	0.42
263-2-4, 19-20	57.19	0.10	4.99	4.54	0.46	0.39
263-3-1, 110-112	91.61	1.21	4.61	3.69	0.74	0.50
263-3-2, 69-70	92.70	1.67	4.64	3.30	0.72	0.53
263-3-2, 109-111	93.10	1.64	4.23	2.85	0.68	0.57
263-3-3, 74-76	94.25	1.63	4.64	3.29	0.70	0.59
263-3-4, 50-52	95.51	1.18	4.14	3.34	0.81	0.60
263-3-4, 124-126	96.25	1.23	4.59	3.70	0.75	0.55
263-3-6, 100-102	99.01	1.08	4.77	4.02	0.83	0.48
263-3-6, 142-144	99.43	1.14	4.46	3.52	0.62	0.45
263-4-1, 9-11	109.60	5.50	10.61	2.72	-0.17	0.45
263-4-3, 74-76	113.25	5.67	10.27	2.50	-0.20	0.41
263-6-3, 74-76	151.25	6.51	9.61	2.34	0.44	0.42
263-9-3, 77-79	227.28	5.71	9.93	2.46	0.07	0.46

TABLE 2
Percentage of Sand, Silt, and Clay

Sample (Interval in cm)	Depth (m)	Sand (%)	Silt (%)	Clay (%)	Shepard's (1954) Textural Classification
259-1-1, 122-124	1.20	50.7	20.9	28.4	Sand-silt-clay
259-1-2, 90-92	2.41	7.3	25.4	67.3	Silty clay
259-1-2, 93-95	2.42	37.0	17.1	45.9	Sandy clay
259-1-6, 74-76	8.25	2.1	38.7	59.2	Silty clay
259-1, CC	9.20	3.9	47.2	48.9	Silty clay
259-3-2, 84-86	19.85	2.7	44.3	53.0	Silty clay
259-4-1, 85-87	27.86	38.1	26.1	35.8	Sand-silt-clay
259-4-3, 74-76	30.75	15.0	38.8	46.2	Silty clay
259-4-4, 74-76	32.25	16.3	40.6	43.1	Silty clay
259-7-3, 74-76	59.25	5.1	41.0	53.9	Silty clay
259-7-4, 94-95	60.95	43.9	22.6	33.5	Sand-silt-clay
259-7-5, 127-129	62.78	1.3	32.4	66.3	Silty clay
259-8-3, 74-76	68.75	0.1	43.3	56.7	Silty clay
259-10-3, 74-76	87.75	5.4	23.2	71.4	Silty clay
259-11-3, 75-76	97.25	1.1	22.4	76.5	Clay
259-12-3, 74-76	106.75	3.0	20.2	76.8	Clay
259-13-3, 74-76	116.25	4.4	14.2	81.4	Clay
259-13-6, 56-58	120.57	1.6	21.5	76.9	Clay
259-13-6, 130-132	121.31	3.7	20.1	76.2	Clay
259-14-3, 74-76	125.75	3.0	21.4	75.6	Clay
259-14-6, 66-68	130.17	6.7	23.3	70.0	Silty clay
259-14-6, 126-128	130.77	9.9	16.2	73.9	Silty clay
259-16-3, 74-76	144.75	0.5	25.2	74.3	Silty clay
259-17-3, 74-76	154.25	0	13.5	86.5	Clay
259-18-3, 74-76	163.75	0.2	18.5	81.3	Clay
259-19-3, 74-76	173.25	0.2	34.2	65.6	Silty clay
259-22-1, 89-91	198.90	0.1	30.9	68.9	Silty clay
259-23-3, 74-76	211.25	0.4	11.7	87.9	Clay
259-26-3, 64-66	239.65	0.1	17.7	82.2	Clay
259-27-3, 74-76	249.25	0.1	9.4	90.5	Clay
259-28-3, 74-76	258.75	1.2	19.5	79.3	Clay
259-30-3, 74-76	277.75	0.1	13.8	86.1	Clay
259-31-3, 74-76	287.25	9.6	9.4	81.0	Clay
259-33-1, 84-86	303.35	0.3	49.5	50.2	Silty clay
260-1-1, 9-11	0.10	0.7	43.0	56.3	Silty clay
260-1-3, 74-76	3.75	0.8	30.6	68.6	Silty clay
260-1-3, 76-78	3.77	0.4	31.7	67.9	Silty clay
260-2-2, 61-63	46.12	0.1	26.8	73.1	Silty clay
260-2-2, 139-141	46.90	63.3	19.4	17.3	Silty sand
260-2-3, 38-40	47.39	73.1	19.1	7.8	Silty sand
260-2-3, 48-50	47.49	78.7	10.8	10.5	Sand
260-3-2, 90-92	93.91	0	12.4	87.6	Clay
260-3-3, 74-76	95.25	0.1	13.8	86.1	Clay
260-3-4, 83-85	96.84	0	38.7	61.3	Silty clay
260-3-5, 10-12	97.61	36.0	39.9	24.1	Sand-silt-clay
260-3-5, 34-36	97.85	41.2	32.2	26.6	Sand-silt-clay
260-3-5, 74-76	98.25	41.4	34.3	24.3	Sand-silt-clay
260-3-5, 104-106	98.55	2.7	50.2	47.1	Clayey silt
260-3-5, 139-141	98.90	42.2	35.3	22.5	Sand-silt-clay
260-3-6, 49-51	99.50	47.9	30.7	21.4	Sand-silt-clay
260-3-6, 79-81	99.80	45.5	31.9	22.6	Sand-silt-clay
260-3-6, 108-110	100.09	53.1	28.6	18.3	Silty sand
260-3-6, 123-125	100.24	2.8	8.2	89.0	Clay
260-4-5, 40-44	135.92	0.4	48.6	51.0	Clay
260-4-6, 6-8	137.07	0	51.1	48.9	Clayey silt
260-5-6, 80-82	166.31	0.2	14.6	85.2	Clay
260-7-3, 74-76	199.75	0.1	21.1	78.9	Clay
260-7-4, 4-6	200.55	0.5	18.4	81.1	Clay
260-8-5, 105-107	222.06	0	58.5	41.5	Clayey silt
260-8-6, 133-135	223.84	1.5	25.6	72.9	Silty clay
260-10-2, 55-59	244.64	0.3	33.9	65.8	Silty clay
260-11-1, 90-92	253.91	0.3	23.8	75.9	Clay
260-17-1, 114-116	311.15	0	30.8	69.2	Silty clay
260-18-1, 117-119	320.68	8.8	18.3	72.9	Silty clay

TABLE 2 – *Continued*

Sample (Interval in cm)	Depth (m)	Sand (%)	Silt (%)	Clay (%)	Shepard's (1954) Textural Classification
261-3-1, 105-107	48.56	0	32.1	67.9	Silty clay
261-4-2, 13-15	96.64	0.3	21.5	78.2	Clay
261-4-2, 60-62	97.11	0.5	36.6	62.9	Silty clay
261-4-2, 79-81	97.30	0.4	28.5	71.1	Silty clay
261-4-2, 102-104	97.53	0	24.8	75.2	Clay
261-5-1, 95-97	162.46	0.9	31.0	68.1	Silty clay
261-6-3, 84-86	174.85	0.2	9.5	90.3	Clay
261-6-5, 49-51	177.50	0.2	5.2	94.6	Clay
261-8-3, 74-76	193.75	0.2	4.4	95.4	Clay
261-8-6, 94-96	198.45	0	16.2	83.8	Clay
261-9-3, 0-5	202.53	0	23.6	76.4	Clay
261-9-3, 74-76	203.25	0.2	14.1	85.7	Clay
261-19-2, 140-142	306.91	3.3	41.0	55.7	Silty clay
261-19-4, 134-137	309.85	99.9	0	0.1	Sand
262-1-2, 129-131	2.80	0	3.9	96.1	Clay
262-1-2, 131-132	2.82	0	39.6	60.4	Silty clay
262-1-3, 73-75	3.74	0.1	30.7	69.2	Silty clay
262-1-4, 99-101	5.50	47.0	39.4	13.6	Silty sand
262-2-3, 74-76	8.75	2.5	34.8	62.7	Silty clay
262-3-3, 94-96	18.45	2.9	36.4	60.7	Silty clay
262-3-6, 95-97	22.96	0.8	31.6	67.6	Silty clay
262-4-3, 136-138	28.37	1.6	34.3	64.1	Silty clay
262-5-3, 74-76	37.25	1.7	33.2	65.1	Silty clay
262-5-6, 43-45	41.44	5.9	32.5	61.6	Silty clay
262-6-2, 140-142	45.91	3.1	26.9	70.0	Silty clay
262-6-3, 74-76	46.75	3.0	30.5	66.5	Silty clay
262-6-5, 99-101	50.00	1.8	29.1	69.1	Silty clay
262-6-6, 44-46	50.95	3.3	27.9	68.8	Silty clay
262-7-3, 104-106	56.55	0.8	33.6	65.6	Silty clay
262-7-5, 52-54	59.03	2.3	31.0	66.7	Silty clay
262-8-4, 88-90	68.89	2.8	27.8	69.4	Silty clay
262-8-5, 124-126	69.25	4.5	37.0	58.5	Silty clay
262-8-6, 94-96	70.45	1.2	28.3	70.5	Silty clay
262-9-1, 108-110	72.59	2.3	48.9	48.8	Clayey silt
262-9-3, 74-76	75.25	2.1	28.4	69.5	Silty clay
262-10-3, 74-76	84.75	1.6	33.0	65.4	Silty clay
262-11-3, 104-106	94.55	3.2	30.8	66.0	Silty clay
262-11-6, 119-121	99.20	14.6	49.2	36.2	Clayey silt
262-12-1, 138-140	101.39	0.5	45.1	54.4	Silty clay
262-12-2, 59-61	102.10	7.3	41.9	50.8	Silty clay
262-12-2, 103-105	102.53	21.7	31.2	47.1	Sand-silt-clay
262-12-3, 74-76	103.75	38.2	34.0	27.8	Sand-silt-clay
262-12-4, 9-11	104.60	52.0	28.2	19.8	Silty sand
262-12-4, 129-131	105.80	36.2	47.2	16.6	Sandy silt
262-12-5, 112-114	107.13	15.2	54.8	30.0	Clayey silt
262-12-6, 52-55	108.03	0.6	47.5	51.9	Silty clay
262-13-3, 74-76	113.25	1.8	27.0	71.2	Silty clay
262-13-4, 115-117	115.16	2.8	53.5	43.7	Clayey silt
262-13-6, 123-125	118.24	6.7	51.9	41.4	Clayey silt
262-14-3, 74-76	122.75	1.6	31.4	67.0	Silty clay
262-14-5, 43-45	125.44	3.9	39.1	57.0	Silty clay
262-15-3, 74-76	132.25	0.7	29.1	70.2	Silty clay
262-16-3, 74-76	141.75	1.5	27.6	70.9	Silty clay
262-16-4, 52-54	143.03	72.2	13.6	14.2	Clayey sand
262-17-3, 74-76	151.25	2.3	33.9	63.8	Silty clay
262-17-5, 68-70	154.19	2.5	39.4	58.1	Silty clay
262-19-3, 74-76	170.25	1.9	27.7	70.4	Silty clay
262-19-6, 122-124	175.23	3.5	31.5	65.0	Silty clay
262-20-3, 74-76	179.75	1.6	28.3	70.1	Silty clay
262-21-3, 74-76	189.25	2.8	25.6	71.6	Silty clay
262-22-3, 74-76	198.75	0.8	24.4	74.8	Silty clay
262-23-3, 74-76	208.25	2.2	21.1	76.7	Clay
262-25-3, 74-76	227.25	3.9	24.2	71.9	Silty clay
262-26-3, 74-76	236.75	2.7	22.5	74.8	Silty clay
262-27-3, 74-76	246.25	2.8	20.7	76.5	Clay
262-28-3, 44-46	255.45	17.5	31.9	50.6	Silty clay

TABLE 2 – *Continued*

Sample (Interval in cm)	Depth (m)	Sand (%)	Silt (%)	Clay (%)	Shepard's (1954) Textural Classification
262-29-3, 74-76	265.25	7.8	18.4	73.8	Silty clay
262-30-3, 74-76	274.75	8.2	25.7	66.1	Silty clay
262-31-4, 89-91	285.90	11.7	34.8	53.5	Silty clay
262-32-3, 74-76	293.75	5.0	32.6	62.4	Silty clay
262-33-3, 74-76	303.25	4.0	23.6	72.4	Silty clay
262-34-3, 74-76	312.75	4.1	30.1	65.8	Silty clay
262-35-3, 74-76	322.25	3.7	27.9	68.4	Silty clay
262-35-5, 39-40	324.90	3.1	31.7	65.2	Silty clay
262-37-3, 66-70	341.18	13.5	40.1	46.4	Silty clay
262-38-3, 68-72	350.70	30.2	39.0	30.8	Sand-silt-clay
262-39-4, 49-51	361.50	31.4	36.0	32.6	Sand-silt-clay
262-39-6, 49-51	364.50	28.9	36.5	34.6	Sand-silt-clay
262-40-3, 77-80	369.78	10.6	32.0	57.4	Silty clay
262-41-4, 139-141	381.40	45.6	30.3	24.4	Sand-silt-clay
262-42-5, 113-116	392.15	43.5	32.1	24.4	Sand-silt-clay
262-44-3, 74-76	407.75	46.4	24.2	29.4	Sand-silt-clay
263-1-1, 145-147	1.46	5.8	41.6	52.6	Silty clay
263-1-3, 124-126	4.25	72.4	9.0	18.6	Clayey sand
263-1-4, 10-12	4.61	74.6	13.3	12.1	Silty sand
263-1-4, 100-102	5.52	68.3	14.6	17.1	Clayey sand
263-1-4, 118-120	5.69	69.6	13.3	17.1	Clayey sand
263-1-4, 139-141	5.90	69.3	13.2	17.5	Clayey sand
263-2-2, 15-17	54.16	61.2	12.4	26.4	Clayey sand
263-2-2, 70-72	54.71	55.1	14.4	30.5	Clayey sand
263-2-2, 122-124	55.23	57.1	14.5	28.4	Clayey sand
263-2-3, 40-42	55.91	53.2	16.4	30.4	Clayey sand
263-2-3, 124-126	56.75	54.0	16.8	29.2	Clayey sand
263-2-4, 10-12	57.11	52.8	17.1	30.1	Clayey sand
263-2-4, 19-20	57.19	55.6	14.7	33.7	Clayey sand
263-3-1, 110-112	91.61	66.4	13.7	19.9	Clayey sand
263-3-2, 69-70	92.70	63.1	18.3	18.6	Clayey sand
263-3-2, 109-111	93.10	66.0	20.2	13.8	Silty sand
263-3-3, 74-76	94.25	60.5	20.1	19.4	Silty sand
263-3-4, 50-52	95.51	69.9	13.2	16.9	Clayey sand
263-3-4, 124-126	96.25	63.2	20.1	16.7	Silty sand
263-3-6, 100-102	99.01	69.8	9.1	21.1	Clayey sand
263-3-6, 142-144	99.43	57.7	21.3	21.0	Sand-silt-clay
263-4-1, 9-11	109.60	0.8	23.2	76.0	Clay
263-4-3, 74-76	113.25	0.1	25.7	74.2	Silty clay
263-6-3, 74-76	151.25	0.1	33.9	66.0	Silty clay
263-9-3, 77-79	227.28	0.1	25.4	74.5	Silty clay

TABLE 3
Arithmetic Mean and Standard Deviation of Folk Parameters for Lithologic Units

Unit	Samples	$\phi 5$	$M_z (\phi)$	$\sigma_I (\phi)$	SK_I	K'_G
Site 259						
I	10	2.52 ±1.59	7.56 ±1.24	3.31 ±0.70	0.06 ±0.19	0.49 ±0.08
II	5	3.79 ±3.12	9.15 ±2.22	3.31 ±1.39	0.03 ±0.28	0.39 ±0.04
III	9	4.86 ±1.22	10.21 ±0.44	2.69 ±0.29	-0.21 ±0.15	0.46 ±0.04
IV	10	4.70 ±1.32	10.24 ±0.90	2.67 ±0.23	-0.16 ±0.15	0.50 ±0.04
Site 260						
I	22	3.62 ±2.34	7.51 ±2.78	2.93 ±0.80	0.22 ±0.39	0.52 ±0.15
II	4	5.61 ±1.09	10.14 ±1.18	2.74 ±0.31	-0.17 ±0.34	0.42 ±0.01
III	2	5.09 ±0.73	9.48 ±1.14	2.90 ±0.59	-0.08 ±0.16	0.46 ±0.02
IV	2	2.14 ±4.80	10.11 ±0.17	3.02 ±0.70	-0.16 ±0.32	0.51 ±0.14
Site 261						
II	5	5.37 ±0.76	9.49 ±0.44	2.73 ±0.44	-0.04 ±0.13	0.50 ±0.01
III	7	6.96 ±1.06	10.93 ±0.70	2.24 ±0.37	-0.15 ±0.22	0.49 ±0.05
IV	2	3.31 ±1.79	5.77 ±3.79	1.74 ±1.73	-0.07 ±0.15	0.43 ±0.00
Site 262						
I	47	4.25 ±1.32	8.59 ±1.79	2.97 ±0.49	0.05 ±0.26	0.45 ±0.08
II	14	4.12 ±1.45	9.56 ±0.58	3.10 ±0.45	-0.17 ±0.10	0.44 ±0.03
III	8	2.03 ±0.64	6.79 ±1.21	3.78 ±0.12	0.36 ±0.27	0.43 ±0.04
Site 263						
I	21	1.05 ±0.74	4.70 ±1.03	3.74 ±0.52	0.64 ±0.17	0.49 ±0.08
II	3	5.89 ±0.54	10.16 ±0.51	2.52 ±0.19	0.02 ±0.36	0.46 ±0.02

Site 259

Thirty-four samples were analyzed from Site 259. Vertical variations in grain-size parameters for this site are plotted in Figure 4.

Unit I is a clay-rich nanno ooze and zeolite clay. It is chiefly a silty clay, although a few sand-silt-clay layers (foram-bearing nanno oozes) occur (Figure 3). The coarsest 5% of the distribution ($\phi 5$), analogous to Carozzi's (1958) clasticity, averages 2.52ϕ (174μ) and shows no vertical trend. Mean size decreases from 5.02ϕ (30.8μ) at the top of the unit to 8.94ϕ (2.0μ) near the base and averages 7.56ϕ (5.3μ). The sediments are poorly sorted (sample average = $\bar{x}$ = 3.31ϕ) and mesokurtic ($\bar{x}$ = 0.49). Skewness is near symmetrical ($\bar{x}$ = 0.06). Sorting becomes better near the base and skewness shows an erratic decrease from 0.51 at the top to 0.01 at the base. Transformed kurtosis shows no vertical trend.

Unit II is a dark, yellow-brown zeolitic silty clay (Figure 3). Phi 5 averaged 72μ (3.79ϕ) and average mean size is 1.8μ (9.15ϕ). The unit is poorly sorted ($\bar{x}$ = 3.31ϕ) and very platykurtic ($\bar{x}$ = 0.39); skewness is near symmetrical ($\bar{x}$ = 0.03). Mean size and phi 5 decrease downward, and sorting becomes slightly better near the base of the unit. Sediments are fine skewed at the top and become coarse skewed near the base. Transformed kurtosis shows a slight increase near the base of the unit.

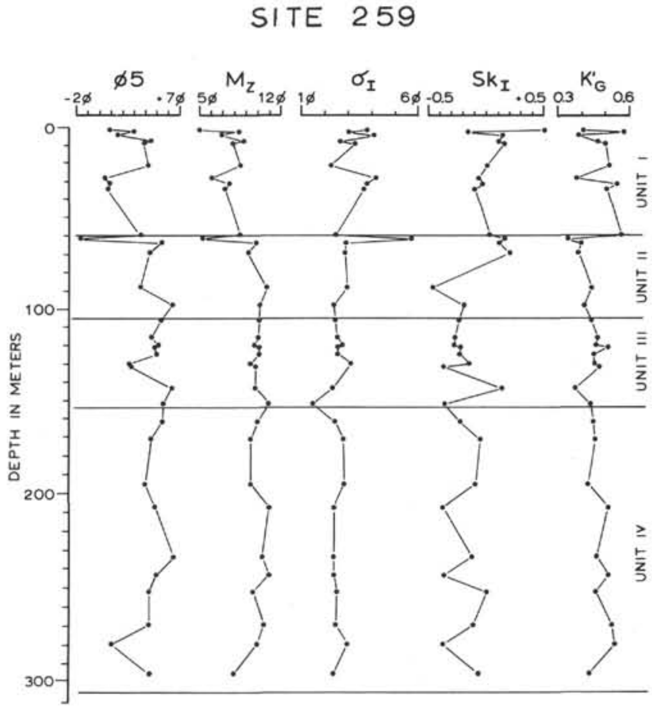

Figure 4. *Vertical variation in grain-size parameters of Mesozoic-Cenozoic sediments at DSDP, Site 259.*

Light brown zeolite-rich nanno clay and clayey nanno ooze comprise Unit III (Figure 3). Phi 5 averages 34.4μ (4.86φ) and becomes slightly finer near the base. Mean size averages 10.21φ (0.84μ) and shows no trend. The sediments are better sorted (x = 2.69φ) than those of Units I or II. They are coarse skewed (x = -0.21) and platykurtic (x = 0.46). Sorting becomes better near the base; otherwise, there are no trends.

Unit IV is a greenish-gray zeolite-bearing clay (Figure 3) that displays little vertical variability in grain-size parameters (Figure 4). The coarsest 5% of the distribution averages 4.7φ (38.5μ), and average mean size is 10.24φ (0.83μ). Average values for sorting, skewness, and kurtosis are nearly identical to those for Unit III and are listed in Table 3.

Site 260

Thirty samples were analyzed from this site. Because of intermittent coring, a vertical variation diagram of grain-size parameters could not be constructed.

Unit I is a nanno ooze with lesser amounts of brown clay, rad ooze, and graded detrital foram ooze. Texturally, this unit is extremely variable (Figure 3). The brown clays and nanno oozes are chiefly silty clay and clay, whereas the detrital foram oozes are sand-silt-clay, silty sand, and sand. Phi 5 averages 81μ (3.63φ) and mean size is 5.5μ (7.51φ). Most sediments are very poorly sorted ($\bar{x}$ = 2.93φ), although a few of the clays attain slightly better sorting values (Table 1). Skewness averages 0.22 (fine skewed) and transformed kurtosis 0.52 (mesokurtic). Because of the wide variety of lithologic types included in this unit, average values for statistical parameters display large standard deviations (Table 3).

Figure 5 illustrates vertical variation in sand-silt-clay percentage, mean size, and sorting of one of the carbonate turbidite sequences in Unit I. The sequence is sharply bounded on both sides by zeolite-bearing nanno-rich clays. Except for the break at 98 meters, there is a systematic increase in percent sand (foraminifers) along with a concomitant decrease in silt and clay percentages toward the base of the unit. Because of the high percentage of silt and clay in this unit, mean size lies within the silt range. Like percent sand, mean size increases toward the base of the unit. Sorting values are poorest at the top and base of the unit and best near the middle.

Unit II is a brown zeolitic clay and clay. Average mean values for this unit are: phi 5, 5.61φ (20.5μ); mean size, 10.14φ (0.89μ); sorting, 2.74φ (very poorly sorted); skewness, -0.17 (coarse skewed); and transformed kurtosis, 0.42 (platykurtic).

Unit III is chiefly a nanno ooze with minor brown clay, and Unit IV consists of nanno ooze, rad ooze, and zeolitic clay. Grain-size data (Figure 3, Tables 1, 2, and 3) are based on only two samples from each unit and cannot be considered representative for the entire units.

Site 261

Because of poor core recovery and induration of the sediments, only 14 samples were analyzed. Additional sand-silt-clay data from DSDP grain-size analyses

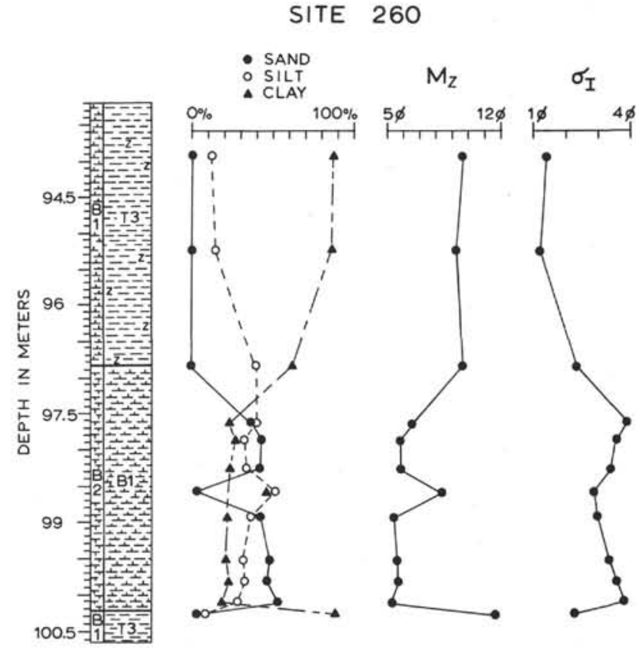

Figure 5. *Vertical variation in sand-silt-clay percentage, mean size (M_Z), and sorting (σ_I) of Middle Miocene (?) fine carbonate turbidite sequence at Site 260. The sequence is bounded on both sides by zeolite bearing nanno rich clays.*

(Bode, Chapter 22, this volume) were utilized in constructing the textural plot shown in Figure 3. The most conspicuous textural feature of the sediments at this site is that all fall in the clay and silty clay fields and that there is virtually no sand present. Only Units II and III were sampled in sufficient detail to warrant discussion.

Unit II consists of greenish-gray nanno ooze and nanno-rich clay. Average mean values for statistical parameters are: phi 5, 5.37φ (24μ); mean size, 9.49φ (1.39μ); sorting, 2.73φ (very poorly sorted); skewness, -0.04 (near symmetrical); and transformed kurtosis, 0.50 (mesokurtic).

Unit III is a gray, zeolite-bearing clay with the following average values for statistical parameters: phi 5, 8μ (6.96φ); mean size, 0.51μ (10.93φ); sorting, 2.24φ (very poorly sorted); skewness, -0.15 (coarse skewed); and transformed kurtosis, 0.49 (mesokurtic).

Site 262

Because of continuous coring, good recovery, and the unconsolidated nature of the sediments, 69 samples were analyzed from the upper three units at this site (Figure 2). Vertical variations in grain-size parameters are plotted in Figure 6.

Unit I is a grayish-olive rad and clay-rich nanno ooze with subordinate detrital foram sands. Most samples are silty clays (Figure 3). The coarsest 5% averages 4.25φ (52μ), and mean size is 8.59φ (2.59μ). The sediments are very poorly sorted ($\bar{x}$ = 2.97φ), near symmetrical ($\bar{x}$ = 0.05′, and platykurtic ($\bar{x}$ = 0.45). Generally, there are no systematic vertical variations in grain-size parameters in this unit. There are, however, sharp peaks between 0-10, 40-50, 100-110, and 140-150 meters. These peaks result from the occurrence of detrital foram sands at these depths. The foram sands are turbidites that are generally coarser grained and better sorted than the associated nanno oozes of Unit I. These sands also tend to be strongly fine skewed and very leptokurtic (Figure 6).

Figure 7 illustrates one of the carbonate turbidite sequences composed of foram sand-silt-clay, silty sand, and sandy silt that occurs between 101 and 108.5 meters. This may represent a multiple turbidite sequence because (1) there is no sharp break between the detrital foram sand and overlying foram sandy silt at 104.5 meters, and (2) the detrital foram sand does not display a systematic upward fining of mean size or an upward decrease in percent sand. The detrital foram sands display slightly better sorting values than the associated nanno oozes, and they are more fine skewed.

Unit II is a grayish-olive micarb and clay-rich nanno ooze. The great bulk of Unit II samples are silty clays (Figure 3). Phi 5 averages 4.12ϕ (57.5μ), although values between 1ϕ and 2ϕ are common from 250 to 285 meters. Mean size averages 9.56ϕ (1.32μ) and shows a slight coarsening towards the base of the unit. Sorting averages 3.10ϕ (very poorly sorted) and becomes poorer toward the base. Average skewness is -0.17 (coarse skewed); values become positive (i.e., near symmetrical and fine skewed) near the base. Transformed kurtosis averages 0.44 (platykurtic) and shows no trend.

Unit III, a grayish-olive nanno-rich foram ooze, has the following average values: phi 5, 2.03ϕ (245μ); mean size, 6.79ϕ (9μ); sorting 3.78ϕ (very poorly sorted); skewness, 0.36 (strongly fine skewed); and transformed

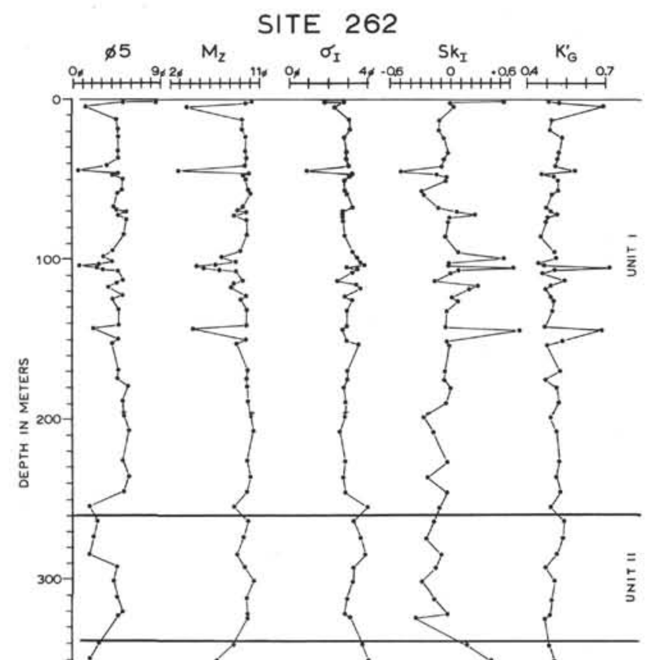

Figure 6. *Vertical variation in grain-size parameters of Plio-cene-Pleistocene sediments at DSDP, Site 262.*

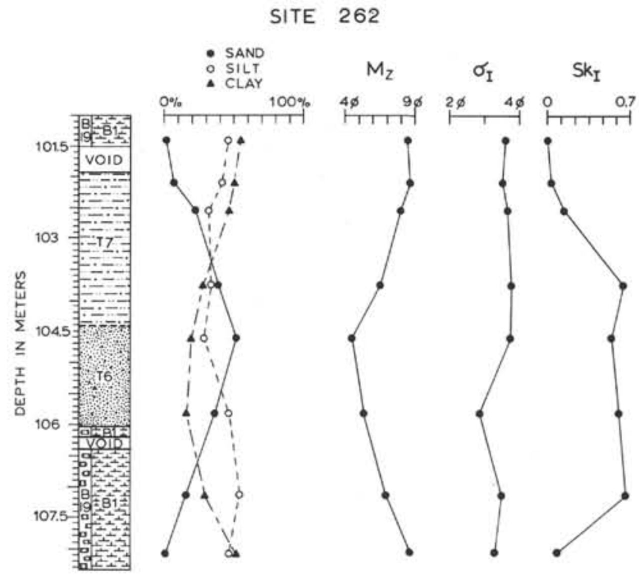

Figure 7. *Vertical variation in sand-silt-clay percentage, mean size (M_Z), and sorting (σ_I) of Pleistocene-Holocene turbidite sequence at Site 262. The sequence is bounded on both sides by micarb rich nanno ooze. T7 is a foram sand-silt-clay and T6 is foram silty sand and sandy silt.*

kurtosis, 0.43 (platykurtic). Unit III samples display wide textural variability (Figure 3) because of varying proportions of foraminifers. Most samples, however, fall in the sand-silt-clay field of Shepard (1954). Phi 5 and mean size become coarser near the base, whereas sorting shows no trend. Skewness increases towards higher positive values (i.e., becomes strongly fine skewed) near the base. Transformed kurtosis increases slightly in a downward direction.

Site 263

Twenty-five samples were analyzed from this site and most of these (21) are from Unit I. Grain-size analyses were not performed on Units III and IV because of their induration. Sand-silt-clay ratios shown in Figure 3 for Units III IV are from Bode (this volume). Sediments in Units II, III, and IV are dominantly clays and silty clays. Because of the high foram content of Unit I sediments, they lie chiefly in the clayey sand and silty sand textural fields (Figure 3).

Unit I is dominantly a detrital foram nanno ooze with minor nanno ooze. Phi 5 averages 473μ (1.05ϕ) and mean size is 38.5μ (4.70ϕ). The coarse size of both parameters is attributable to the large percentage of foraminifers that occur in this unit. The sediments are very poorly sorted ($\overline{x}$ = 3.74), strongly fine skewed ($\overline{x}$ = 0.64), and mesokurtic ($\overline{x}$ = 0.49).

Unit II is a greenish-gray to olive black clay, nanno-bearing clay, and clayey nanno ooze. Average mean values for this unit are: phi 5, 5.89ϕ (16.8μ); mean size, 10.16ϕ (0.87μ); sorting, 2.52ϕ (very poorly sorted); skewness, 0.02 (near symmetrical); and transformed kurtosis, 0.46 (platykurtic).

DISCUSSION

Cook (Chapter 20, this volume) has demonstrated that there are marked geochemical differences in composition of Mesozoic and Cenozoic sediments cored at Leg 27 sites. This observation is supported by the carbonate percentage data of Bode (Chapter 21, this volume) and by the X-ray mineralogical data of Cook, Zemmels, and Matti (this volume).

These data show that the basic difference between the two is in the percentage of carbonate. Mesozoic sediments are composed chiefly of quartz and clay minerals, with varying amounts of zeolites and minor carbonate. In contrast, Cenozoic sediments are dominantly composed of carbonate (mostly calcite), with subordinate quartz and minor clay minerals and zeolites.

Grain-size results from this study also indicate differences between Mesozoic and Cenozoic sediments (Table 4). Generally, Cenozoic sediments are coarser grained, more poorly sorted, and finer skewed than Mesozoic ones. Transformed kurtosis values are similar for both.

TABLE 4
Average Grain-Size Parameters by Age

	Mesozoic Sediments (44 Samples)	Cenozoic Sediments (128 Samples)
M_z	10.07 ϕ ±1.35 ϕ	7.67 ϕ ±2.26 ϕ
σ_I	2.58 ϕ ±0.48 ϕ	3.19 ϕ ±0.68 ϕ
SK_I	-0.14 ±0.21	+0.18 ±0.34
K'_G	0.47 ±0.05	0.47 ±0.09

It should be pointed out that part of these differences may be due to biased sampling techniques, which included: (1) preferential sampling of Cenozoic sediments over Mesozoic ones by a factor of almost three to one, and (2) preferential sampling of coarse-grained Cenozoic sediments over fine-grained ones. However, since the grain-size data are in close agreement with the geochemical and mineralogical evidence, these differences are believed to be real and not due to sample bias.

Average mean size of Mesozoic sediments lies in the clay size class (0.92μ) while that of Cenozoic sediments is in the very fine silt class (4.91μ). Mean size of both is a function of sediment composition (Table 5). Mesozoic sediments are predominantly zeolite clays, quartz and cristobalite clays, and nanno clays; hence, their mean size falls in the clay range. Cenozoic sediments, on the other hand, are calcareous oozes of two basic types: (1) foram oozes whose mean size falls in the medium and coarse silt range (4.89ϕ to 5.86ϕ); and (2) nanno oozes whose mean size lies in the clay range (9.14ϕ to 9.52ϕ) (Table 5). The mean size of 7.67ϕ (fine silt) for Cenozoic sediments results from averaging the coarse and medium silt-size foram oozes with clay-size nanno oozes.

Mesozoic sediments have an average sorting value (σ_I) of 2.58ϕ while Cenozoic sediments average 3.19ϕ. Both are very poorly sorted according to the terminology of Folk and Ward (1957). As Folk (1968) has pointed out, sorting is strongly dependent on mean grain size. A scatter plot of mean size versus sorting for Mesozoic and Cenozoic sediments reveals the following: (1) the best-sorted sediments have mean diameters of about 3ϕ; (2) the worst-sorted sediments have mean sizes between 5.5ϕ and 8ϕ; and (3) below 8ϕ sorting becomes better with increasing mean size, so that best-sorted sediments in the clay range have mean diameters between 10ϕ and 11ϕ. Since Mesozoic sediments consist dominantly of one size population (i.e., clay), they display the best sorting values. Cenozoic sediments, in contrast, are mixtures of two different size populations (sand and coarse silt and clay); hence, they have poorer sorting values.

Mesozoic sediments are coarse skewed ($\overline{x}$ = -0.14), i.e., they have an excess of coarse material. Cenozoic sediments have an excess of fine material and are fine skewed ($\overline{x}$ = +0.18). Folk and Ward (1957) have shown that skewness values which depart from normality (greater than +0.1 or less than -0.1) result from subequal mixing of two normal size populations. Mesozoic sediments consist of a dominant fine clay population along with a subordinate coarse population (sand- and silt-size grains of zeolites, quartz, radiolarians, etc.).

TABLE 5
Average Grain-Size Parameters for Major Lithologic Types

Lithology	Samples	M_z (ϕ)	σ_I (ϕ)	SK_I	K'_G
Foram nanno ooze	37	5.86	3.51	+0.48	0.48
Micarb nanno ooze	8	8.69	3.31	+0.06	0.41
Rad nanno ooze	17	9.14	2.99	+0.03	0.44
Clay nanno ooze	36	9.47	2.85	- 0.13	0.45
Nanno ooze	9	9.52	2.91	- 0.04	0.46
Nanno foram ooze	8	5.51	3.66	+0.42	0.46
Foram ooze	8	4.89	2.91	+0.39	0.56
Rad ooze	3	9.77	3.39	- 0.34	0.38
Zeolite clay	20	9.52	2.89	- 0.11	0.45
Quartz and cristobalite clay	12	10.07	2.67	- 0.13	0.49
Nanno clay	10	10.25	2.15	+0.01	0.56

This slight excess of coarse material produces the negative skewness. Cenozoic sediments have a dominant coarse population (sand and coarse silt), which is mixed with a subordinate fine clay population (chiefly clay minerals and broken coccoliths). They have more fine material than a normal population should have, and thus, are positively skewed.

Transformed kurtosis averages 0.47 (mesokurtic) for both Mesozoic and Cenozoic sediments. As noted previously, normal probability distributions have transformed kurtosis values equal to 0.50. The slight departure of Mesozoic and Cenozoic sediments from normality is probably a consequence of subequal mixing of two different size populations (Folk and Ward, 1957). In Mesozoic sediments this results from mixing of a dominant fine population (clay) with a subordinate coarse one (sand and coarse silt). The departure from normality of Cenozoic sediments results from mixing a dominant coarse population (sand and coarse silt) with a subordinate clay one.

CONCLUSIONS

1. Folk and Ward grain-size parameters can be used to distinguish unconsolidated stratigraphic units at Leg 27 sites.

2. Almost all samples analyzed have mean sizes in the silt and clay range and are very poorly sorted. Skewness and kurtosis values exhibit greater variability.

3. Grain-size results from this study indicate marked variability between Mesozoic and Cenozoic sediments. Generally, Cenozoic sediments are coarser grained, more poorly sorted, and finer skewed than Mesozoic ones. Kurtosis values are similar for both.

4. Sorting is strongly dependent on mean size. Sediments with mean sizes between 5.5 and 8ϕ have the poorest sorting values. Below 8ϕ sorting becomes better with increasing mean size, so that best-sorted sediments are in the clay range with mean diameters between 10ϕ and 11ϕ.

5. Values for skewness and kurtosis show slight departures from those predicted by the normal probability distribution. These departures most likely result from subequal mixing of fine and coarse sediment populations.

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