10. X-RAY MINERALOGY STUDIES, LEG 42B

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INTRODUCTION

The modern Black Sea basin is supplied with sedimentary material from a drainage area 3.7 times greater than the sea area itself. The geology of the drainage is most heterogeneous; two provenances supply the bulk of the sediment, the Russian platform to the north, and the folded structures of the Alpine zone to the south. According to Kholodov's (1975) calculations, 89% of the source area is a sedimentary assemblage (claystones, sandstones, limestones, flysh, molasse, etc.), 5% is characterized by greatly modified metamorphic rocks, acid and basic intrusions occupy 2% of the area, and volcanic rocks of varying composition occupy about 4% of the area. According to Rateev (1964), Butuzova (1971), Stoffers and Müller (1972, 1973, 1974), Trimonis (1972, 1974, 1975), Ross and Degens (1974), and Butuzova et al. (1975), the mineral composition of recent Black Sea sediments is controlled by the river load content which in turn, reflects the mineral complexes of the supplying provenances.

Clay minerals, micas, calcite, quartz, and feldspars, are the most widespread in recent Black Sea sediments. Illite is predominant among the clay minerals and its maximum abundance is in the sediments of the northern part; in the southern part montmorillonite prevails. Chlorite is relatively abundant in the sediments along the Caucasian coast and in the northeastern part of the sea, and kaolinite is abundant in the northwestern region as well as along the Caucasian coast. Quartz, feldspars, and clastic calcite are mainly concentrated in peripheral regions. The southern part of the sea shows the greatest abundance of feldspars, whereas quartz is more common in the north where the source is platform sedimentary rocks.

The data presented here were obtained from X-ray mineralogy analyses of sediment samples collected during Deep Sea Drilling Project, Leg 42B. Herein is discussed the distribution of the main rock-forming minerals in the late Cenozoic sediments of the Black Sea.

METHODS

Examination of mineral composition by X-ray diffraction techniques was performed both for bulk sediment samples and for the $<2\mu m$ fraction separately according to two semiquantitative methods of analysis.

The bulk samples were studied by means of the X-ray diffractometer DRON-1.5, which uses CuKα radiation. Analysis was done on unorientated powder samples using special sample holders. Machine setting was $U = 40$ kv, $I = 30$ ma; the movement velocity of the counter was $V = 2°/\text{min}$.

Quantitive calculations of mineral percentages were made according to the methods used for previous analysis of DSDP samples (Bader et al., 1970, p. 748-753). This reference gives the calibration coefficients which we used in our calculations. For some minerals, calibration coefficients were obtained by making calibration diagrams. The sum of the crystalline components in a sample was totaled to 100%.

If a sample contained a mineral not included in the calibration matrix, a hypothetical concentration factor of 3.0 was ascribed to the most intensive reflection of the unidentified mineral. The percentage calculation was reported on a ranked scale as outlined below: (1) Trace (<10%); (2) Present (10%-20%); (3) Abundant (20%-50%); (4) Major (*>50%).*

A second method was used for studying clay minerals in the $<2\mu m$ fractions, which was separated out by the elutriation-method taking into account Stokes Law velocities. Carbonates were first dissolved with 1*N* hydrochloric acid. Each sample was run on the X-ray diffractometer DRON-1.5, with CuKα radiation at 40 kv and 20 ma. Samples were run in three ways: (1) in the Mg-saturated state, (2) soaked in glycerine and heated up to 500° for one hour, (3) K-saturated state with glycerine. The ratio of the reflection at 10Å to the one at 7Å compared to that for the Mg-glycerine sample indicates the presence of vermiculite layers (Hayes, 1973). The heat treatment procedures at 80° and 1*N* hydrochloric acid dissolution for one hour allowed us to identify kaolinite against the background of chlorite, and to evaluate the stability of minerals.

In the samples studied, the following main groups of clay minerals were identified: illite, chlorite, kaolinite, and montmorillonite.

Illite is identified by its diffraction peaks as 10Å, 5.0Å, 3.3Å, etc., which do not shift after saturation with different cations, with glycerine, and after heating for one hour under 80° with 1*N* hydrochloric acid the 10Å peak notably decreases, which suggests the presence of iron-rich hydromica (ferruginous variety).

Chlorite was identified by its diffraction peaks at 14.2Å, 7.1Å, 4.7Å, 3.54Å. With heating to 500° the 001 reflection shifts to 13.8Å; and in the presence of glycerine, remains unchanged; with heat treatment to 80° with hydrochloric acid for one hour, the chlorite peaks disappear, indicative of its ferruginous state.

Kaolinite has two reflections, at 7.1Å and 3.58Å, close to those of chlorite, but kaolite is resistant to the

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applications of heated 1*N* HCl to 80° for one hour. The 3.58Å kaolinite peak and the 3.54Å chlorite peak are easily discerned.

Montmorillonite was identified by its basal 15.4Å reflection in the Mg-saturated state, which shifts to 17.6Å with addition of glycerine. Because the 001 peak greatly extends and decreases with glycerine treatment compared with the Mg-saturated variety, and the 002 peak cannot be differentiated from the 001 illite peak, giving drift in the high angle direction we concluded that montmorillonite is absent as a mixed-layer unit with illite. After heating the sample in 1*N* hydrochloric acid for one hour, the intensity of the 001 reflection notably decreased, suggesting the presence of the ferruginous variety.

In the $<2\mu m$ fraction, we found quartz and feldspars, and in the lower part of Hole 380A, clinoptillolite was detected.

The quantitative relations between the clay mineral groups—illite, montmorillonite, kaolinite, and chlorite—are reported according to the method of Biscaye (1964).

DISCUSSION OF RESULTS

The analytical results are presented in Tables 1-5 and shown in Figures 1-5 (scanning electron photomicrographs of some of the studied samples and minerals are shown in Figure 6).

The Leg 42B sites characterize two different sedimentary regimes—the deep-sea accumulation plain of the modern sea (Site 379A) and the region of the continental slope with adjacent peripheral part of the deep-sea basin to the southwest (Sites 380/380A and 381).

Site 379 Hole 379A

Tables 1 and 6 show that the most abundant mineral in the sediments from Hole 379A is illite, followed by chlorite, montmorillonite, and kaolinite. Substantial differences exist between analyzed bulk samples and the $<2\mu m$ fraction. In the latter, montmorillonite usually predominates over illite, and chlorite and kaolinite are present in minor quantities. This is observed throughout the hole and indicates a marked change in mineral composition with grain-size fractions.

The average chlorite content of the bulk samples changes with some periodicity. The chlorite abundances in Units 3, 6, and 8 (glacial) are somewhat enhanced relative to Units 4, 7, and 9 (interglacial). Glacial epochs are thus characterized by slightly higher contents of chlorite.

Montmorillonite constitutes a very minor portion of the deep-sea sediments. The ratio of montmorillonite to illite is extremely low, ranging from 0.1% to 0.6-0.7%. Only in the lower part of the hole is the montmorillonite/illite ratio enhanced. Throughout the hole, greater abundances of montmorillonite occur in conjunction with glacial epochs. The same is true of kaolinite, although its quantities are low. The kaolinite/chlorite ratio does not often exceed 0.1, but the upper limit is usually about 0.4,

Thus, the clay minerals in the Pleistocene accumulated faster during glacial stages, when the climatic regime in the drainage area was wet and cold. A high clay content is also found in the Mindel-Riss sediments. The sources of the clay material remained the same, with minor fluctuations. Rivers from the Caucasus and from Turkey, as now, delivered great quantities of illite. Montmorillonite was derived from effusive and sedimentary-effusive rocks of the Lesser Caucasus and Eastern Pont. The source of the chlorite is metamorphic rocks, as well as many sedimentary aggregates of different metamorphic degree. Judging by the chlorite distribution of the $<2\mu m$ fraction, it was transported into the Black Sea as a fine suspension in the Pleistocene in almost the same way as it does at present. However, its high contents in the bulk sediment gives evidence in favor of increased transport from the Caucasus, especially of the coarse-pelitic and fine-silt fractions. The chlorite content was higher during glacial periods, when sea level was lower and Caucasus rivers supplied a great amount of sedimentary matter slightly modified by chemical weathering.

The principal clastic minerals—quartz and feldspars—constitute more than one-third of the sediment. The upper part of the section is high in quartz. A lesser quartz content occurs below Unit 6. K-feldspars have the same distribution; plagioclase is characterized by more complicated changes which is largely linked with granulometric types of deposits. Plagioclases are more abundant in sediments containing a higher quantity of coarser fractions. For example, in muds (aleurite-pelitic and pelitic muds), the most abundant mineral is quartz. The amount of quartz is less than that of feldspar in present-day Caucasus and Turkey river loads, especially in the sand and silt fractions (Petersen, 1971; Trimonis, 1972). The change in their proportions in deep-sea sediments is most likely linked to mechanical separation, and a provenance change during the penultimate glaciation. The marked change in carbonate content, prevailingly clastic calcite, corresponds to the same period (the interface between Units 6 and 7).

The carbonate matter in Pleistocene deposits is rather uniform. Clastic calcite (Figure 6[a]) is usually the predominant mineral in all units, and dolomite often occurs as an admixture. The distribution pattern of calcite throughout the hole favors a clastic origin. In Unit 4 a considerable part of the calcite is biogenic matter (coccoliths). Unit 4 also shows fine interlayers containing needle-shaped aragonite (Core 11). Aragonite in Black Sea sediments has been described by Degens (1971) in whose opinion it is of inorganic origin.

Variations in deep-sea sediment mineral composition is associated with climatic changes, and the thin aragonite-rich layers correspond to warmer periods.

Pleistocene deposits at Site 379A were formed by rapid sedimentation and burial. The mineral composition is relatively unaffected by diagenesis, except for some zeolite formation.

Sites 380 and 381

Sites 380 and 381 are located close to one another in the marginal area of the basin, but their lithological compositions differ considerably and correlations between units are not always apparent.

TABLE 1
X-Ray Diffraction Analysis of Bulk Samples (Leg 42B, Hole 379A, depth 2171 m) (total crystalline phases = 100%)

Sample (Interval in cm)	Montmoril-lonite	Illite	Chlorite	Kaolinite	Calcite	Dolomite	Siderite	Aragonite	Quartz	K-feld-spars	Plagio-clase	Pyrite	Gypsum	Other Minerals
1-2, 70-78	9.5	23.2	14.5	5.2	13.6	0.0	0.0	0.0	19.1	3.6	11.3	0.0	0.0	–
4-3, 30-40	13.3	26.1	18.0	3.3	10.3	3.4	0.0	0.0	14.2	3.7	7.7	0.0	0.0	tr.
6-2, 32-38	10.3	20.2	13.4	2.1	17.5	0.0	0.0	0.0	21.7	3.9	10.9	0.0	0.0	
6-5, 36-46	3.6	13.3	10.7	tr.	14.8	4.7	0.0	0.0	22.2	8.4	22.3	tr.	0.0	tr.
7-2, 20-30	10.3	24.1	14.3	3.6	20.2	tr.	0.0	0.0	16.1	3.6	7.8	0.0	0.0	tr.
8-1, 9-11	2.3	23.9	6.6	3.1	8.7	10.3	0.0	0.0	28.1	6.8	19.0	0.0	0.0	tr.
8-4, 4-16	9.6	23.8	11.9	2.2	15.7	3.3	0.0	0.0	18.6	5.0	9.9	0.0	0.0	
9-3, 100-108	11.5	21.4	10.1	3.4	9.7	4.0	0.0	0.0	17.2	4.2	15.1	3.4	0.0	tr.
9-5, 50-58	12.1	18.2	7.0	2.4	14.1	0.0	0.0	0.0	18.2	4.2	8.3	4.3	11.2	tr.
10-1, 120-130	5.1	16.7	11.5	tr.	14.5	tr.	0.0	0.0	21.8	4.5	25.9	tr.	0.0	tr.
10-3, 85-93	5.6	11.0	5.6	tr.	19.8	2.8	0.0	0.0	18.0	4.2	33.0	0.0	0.0	tr.
11-2, 55-64	6.4	26.5	10.3	tr.	10.8	0.0	0.0	0.0	14.1	4.6	23.3	4.0	0.0	tr.
11-5, 18	5.6	14.1	9.4	2.5	18.4	0.0	0.0	0.0	17.9	5.9	23.5	2.7	0.0	tr.
11-5, 24-25	8.8	13.2	11.5	tr.	25.3	0.0	0.0	13.2	13.7	3.3	6.6	4.4	0.0	tr.
11-5, 37-38	4.5	20.3	16.9	tr.	18.8	0.0	0.0	9.0	13.2	3.4	11.3	2.6	0.0	tr.
11-5, 53-55	3.5	18.3	12.2	tr.	16.2	0.0	0.0	4.6	13.1	7.8	21.4	2.9	0.0	tr.
12-3, 63-72	7.1	29.7	12.5	4.3	15.6	0.0	0.0	0.0	17.6	5.3	7.9	0.0	0.0	tr.
12-3, 120-130[a]	8.5	20.0	18.1	2.4	23.4	tr.	0.0	0.0	16.1	3.4	8.1	tr.	0.0	
12-3, 120-130[a]	17.9	16.3	8.9	2.4	11.8	0.0	0.0	0.0	26.6	7.2	8.9	0.0	0.0	
13-5, 1-7	7.5	21.3	13.7	3.2	21.0	0.0	0.0	0.0	18.7	3.4	11.2	0.0	0.0	
14-4, 0-10	10.1	19.0	18.4	3.0	20.8	2.3	0.0	0.0	16.4	3.8	6.2	0.0	0.0	
15-2, 55-65	5.2	17.1	12.4	5.4	11.9	tr.	0.0	0.0	16.1	4.7	27.2	0.0	0.0	tr.
16-3, 17-27	7.9	17.7	11.8	tr.	9.9	tr.	0.0	0.0	39.4	5.9	7.4	0.0	0.0	
17-1, 25-35	12.7	24.8	18.2	tr.	12.0	0.0	0.0	0.0	17.1	3.9	9.1	2.2	0.0	
18-2, 128-130	4.9	22.9	27.5	tr.	14.7	3.7	0.0	0.0	12.2	2.8	8.3	3.0	tr.	tr.
18-2, 133-135	7.6	18.3	25.3	3.3	13.1	0.0	0.0	0.0	15.3	3.4	8.0	5.7	0.0	
19-2, 76-78	3.9	26.0	21.3	5.7	12.7	2.0	0.0	0.0	12.3	4.3	11.8	0.0	0.0	tr.
19-2, 80-82	5.1	15.5	25.3	2.4	16.7	2.1	0.0	0.0	13.2	3.8	15.9	0.0	0.0	tr.
19-3, 82-98	14.7	20.5	16.5	2.2	16.2	tr.	0.0	0.0	17.4	3.7	8.8	0.0	0.0	
21-4, 0-10	13.0	23.2	24.2	5.2	8.4	0.0	0.0	0.0	14.7	4.9	6.4	0.0	0.0	
22-4, 47-55	10.1	21.5	22.2	3.1	20.3	0.0	0.0	0.0	13.9	3.2	5.7	0.0	0.0	
23-2, 0-11	9.5	22.4	14.5	2.6	19.0	4.4	0.0	0.0	16.7	3.6	8.3	0.0	0.0	
24-2, 0-18	12.1	24.2	22.2	tr.	14.8	0.0	0.0	0.0	13.5	3.0	10.2	0.0	0.0	tr.
24-6, 62-74	12.5	24.5	19.3	3.4	11.3	0.0	0.0	0.0	15.0	3.4	6.8	3.8	0.0	
25-3, 42-44	8.3	14.1	18.8	3.1	8.6	0.0	0.0	0.0	22.2	5.8	15.2	3.9	0.0	
25-5, 95-106	8.3	22.9	21.4	2.5	18.0	tr.	0.0	0.0	10.2	3.1	9.9	3.7	0.0	tr.
26-4, 0-12	6.7	23.1	16.1	3.3	13.4	0.0	0.0	0.0	19.2	5.6	12.6	0.0	0.0	
28-2, 82-93	7.4	23.4	20.1	4.2	16.3	3.0	0.0	0.0	14.5	3.3	7.8	0.0	0.0	
29-3, 0-14	7.0	25.4	25.5	tr.	17.6	2.3	0.0	0.0	9.1	2.7	7.3	3.1	0.0	tr.
29-5, 4-6	13.0	29.2	13.2	5.3	tr.	0.0	0.0	0.0	19.5	3.9	5.8	7.8	3.3	
29-5, 98-107	5.8	26.8	18.1	tr.	21.2	2.1	0.0	0.0	10.4	3.1	12.5	0.0	0.0	
29-5, 107-112	7.8	5.8	tr.	0.0	82.5	0.0	0.0	0.0	3.9	tr.	tr.	0.0	0.0	
31-5, 120-132	17.5	24.0	10.1	5.2	17.4	0.0	0.0	0.0	15.3	3.9	6.6	0.0	0.0	
34-2, 38-50	8.3	21.4	20.5	3.8	24.4	0.0	0.0	0.0	13.2	2.6	5.7	0.0	0.0	tr.
35-1, 131-141	12.0	22.6	15.3	5.4	15.9	0.0	0.0	0.0	16.6	4.3	7.9	0.0	0.0	tr.
36-4, 9-23	14.3	13.6	11.7	1.3	19.6	tr.	0.0	0.0	24.9	4.4	10.2	0.0	0.0	tr.
37-3, 28-30	11.7	21.5	20.1	2.2	18.8	3.8	0.0	0.0	13.4	2.0	6.5	0.0	0.0	
37-3, 33-35	2.3	24.3	15.7	2.5	20.0	0.0	0.0	0.0	16.1	3.3	15.8	0.0	0.0	tr.
40-4, 140-142	13.7	20.5	19.3	5.3	18.4	2.7	0.0	0.0	10.9	3.0	6.2	0.0	0.0	

TABLE 1 – *Continued*

Sample (Interval in cm)	Montmorillonite	Illite	Chlorite	Kaolinite	Calcite	Dolomite	Siderite	Aragonite	Quartz	K-feldspars	Plagioclase	Pyrite	Gypsum	Other Minerals
40-4, 144-146	4.6	22.2	13.9	tr.	20.8	2.8	0.0	0.0	14.1	4.2	17.4	0.0	0.0	
43-3, 140-150	10.4	18.1	24.1	2.8	21.7	tr.	0.0	0.0	14.5	2.4	6.0	tr.	0.0	
45-2, 108-110	8.8	18.5	20.1	3.4	25.7	2.2	0.0	0.0	11.4	3.3	6.6	0.0	0.0	tr.
45-2, 112-114	6.7	22.4	21.6	tr.	24.5	1.9	0.0	0.0	12.0	2.2	8.7	0.0	0.0	tr.
45-2, 116-118	3.7	14.6	10.9	0.0	16.5	1.8	0.0	0.0	21.6	4.7	24.7	1.5	0.0	tr.
45-4, 98-106	12.4	19.6	15.2	2.4	23.8	0.0	0.0	0.0	15.0	3.5	8.1	0.0	0.0	
47-6, 65-67	5.2	15.6	14.1	0.0	18.2	2.1	0.0	0.0	17.4	3.9	23.5	0.0	0.0	tr.
48-2, 127-135	6.4	28.1	22.4	2.3	21.9	2.3	0.0	0.0	9.4	2.4	4.8	0.0	0.0	
48-4, 125-127	17.3	19.4	16.1	3.2	21.3	0.0	0.0	0.0	15.7	2.8	4.2	0.0	0.0	
48-4, 128-130	4.2	14.0	14.3	2.5	23.7	2.1	0.0	0.0	17.9	4.7	16.6	0.0	0.0	tr.
48-4, 132-140	11.0	17.9	17.4	3.6	25.1	tr.	0.0	0.0	13.8	3.5	7.7	0.0	0.0	
49-5, 122-130	13.3	21.9	21.3	5.2	19.9	0.0	0.0	0.0	11.2	2.4	4.8	0.0	0.0	
50-5, 12-24	9.2	17.3	16.2	tr.	27.7	2.3	0.0	0.0	12.3	4.6	10.4	0.0	0.0	
51-2, 64-66	4.3	15.6	13.1	2.5	21.3	2.1	0.0	0.0	18.7	4.0	18.4	0.0	0.0	tr.
52-1, 55-65	20.7	12.9	17.3	2.1	25.0	0.0	0.0	0.0	13.0	3.2	5.8	0.0	0.0	
54-2, 20-34	4.7	23.1	18.2	2.2	29.5	1.8	0.0	0.0	8.9	3.6	8.0	0.0	0.0	tr.
54-6, 78-85	15.9	10.8	14.3	0.0	34.3	2.4	0.0	0.0	12.7	3.6	6.0	0.0	0.0	
54-6, 85-88	5.3	9.0	8.2	1.8	26.7	2.7	0.0	0.0	23.3	5.0	18.0	tr.	0.0	tr.
55-2, 142-144	24.9	15.2	14.2	4.2	18.3	3.3	0.0	0.0	12.4	2.5	5.0	0.0	0.0	
56-1, 133-143	4.3	26.2	15.3	4.4	16.1	2.8	0.0	0.0	15.6	4.8	10.5	0.0	0.0	tr.
57-5, 124-126	20.3	14.7	11.3	tr.	37.6	2.3	0.0	0.0	9.2	1.8	2.8	0.0	0.0	
57-5, 127-129	5.4	15.0	13.6	3.9	26.0	2.7	0.0	0.0	16.3	3.3	13.8	0.0	0.0	tr.
57-5, 130-132	11.1	13.9	8.3	0.0	56.0	0.0	0.0	0.0	6.5	1.4	2.8	0.0	0.0	
59-1, 148-150	10.1	20.5	21.6	3.5	18.7	0.0	0.0	0.0	13.8	3.5	8.3	0.0	0.0	
59-3, 90-100	14.4	15.0	12.1	3.2	36.9	2.4	0.0	0.0	8.6	2.5	4.9	0.0	0.0	
59-5, 5-13	14.3	20.7	18.1	2.2	24.8	tr.	0.0	0.0	12.7	2.4	4.8	0.0	0.0	
60-2, 135-145	20.5	15.1	13.6	3.3	22.3	0.0	0.0	0.0	16.5	3.1	5.6	0.0	0.0	
64-1, 75-77	7.8	14.1	13.1	2.1	25.8	3.1	0.0	0.0	11.7	5.9	16.4	0.0	0.0	
65-4, 37-49	17.9	22.4	20.4	3.1	14.9	tr.	0.0	0.0	12.7	3.4	5.2	0.0	0.0	
66-2, 46-58	15.2	17.8	14.1	3.5	17.6	2.5	0.0	0.0	16.7	3.8	8.8	0.0	0.0	
67-4, 110-120	9.5	8.0	8.9	0.0	14.9	0.0	0.0	0.0	19.3	7.1	32.3	0.0	0.0	tr.
68-5, 73-75	11.3	12.7	13.7	0.0	26.9	2.1	0.0	0.0	14.8	3.1	13.6	1.8	0.0	tr.

[a] Graded bedding.

TABLE 2
X-Ray Diffraction Analysis of Bulk Samples (Leg 42B, Hole 380, depth 2115 m) (total crystalline phases = 100%)

Sample (Interval in cm)	Montmoril-lonite	Illite	Chlorite	Kaolinite	Calcite	Dolomite	Siderite	Aragonite	Quartz	K-feld-spars	Plagio-clase	Pyrite	Gypsum	Clinoptil-olite
1-1, 60-68	1.8	52.0	10.3	0.0	12.5	8.7	0.0	0.0	9.2	0.0	5.5	0.0	0.0	0.0
1-3, 10-20	7.9	38.6	8.9	0.0	18.8	5.1	0.0	0.0	14.8	0.0	5.9	0.0	0.0	0.0
1-5, 10-20	8.4	31.6	7.4	3.2	12.6	4.2	0.0	0.0	21.0	5.3	6.3	0.0	0.0	0.0
1-6, 71-81	5.8	37.0	10.9	2.2	15.0	9.7	0.0	0.0	14.4	0.0	5.0	0.0	0.0	0.0
2-1, 62-67	3.9	7.8	2.9	0.0	7.1	9.1	0.0	10.4	32.5	10.7	15.6	0.0	0.0	0.0
2-2, 40-52	4.7	22.9	5.3	0.0	10.0	11.1	0.0	5.0	23.5	5.2	12.3	0.0	0.0	0.0
2-3, 57-70	4.1	32.5	9.3	2.3	6.2	4.4	0.0	10.4	20.7	0.0	10.7	0.0	0.0	0.0
4-1, 19-28	3.3	49.1	12.9	1.8	6.5	7.0	0.0	0.0	13.3	0.0	6.1	0.0	0.0	0.0
4-3, 18-31	9.0	43.0	13.5	4.0	0.0	2.7	0.0	0.0	17.9	3.2	6.7	0.0	0.0	0.0
4-4, 120-133	6.2	24.4	6.6	0.0	9.4	7.5	0.0	8.7	25.0	0.0	12.2	0.0	0.0	0.0
5-1, 82-95	4.3	44.1	10.4	tr.	6.4	7.5	0.0	0.0	16.0	1.7	9.6	0.0	0.0	0.0
6-1, 93-105	7.2	39.3	7.9	0.0	9.2	6.6	0.0	0.0	19.7	0.0	6.9	3.2	0.0	0.0
6-4, 12-33	3.3	47.8	9.1	tr.	6.0	7.2	0.0	0.0	19.2	1.6	5.8	0.0	0.0	0.0
7-2, 122-137	4.1	46.6	9.9	tr.	5.6	5.0	0.0	0.0	15.8	0.0	13.0	0.0	0.0	0.0
7-4, 42-54	9.2	39.3	10.8	tr.	9.8	5.9	0.0	0.0	16.4	0.0	6.9	1.7	0.0	0.0
9-1, 115-130	3.8	43.1	11.3	2.1	9.5	5.7	0.0	0.0	14.1	4.9	5.5	0.0	0.0	0.0
10-2, 125-138	3.3	50.3	10.6	1.9	8.0	6.3	0.0	0.0	12.6	2.6	4.4	0.0	0.0	0.0
13-1, 0-14	3.9	51.1	11.7	0.0	9.7	7.8	0.0	0.0	10.2	1.4	4.2	0.0	0.0	0.0
13-5, 2-14	5.4	45.0	11.4	2.5	9.2	4.3	0.0	0.0	16.4	0.0	5.8	0.0	0.0	0.0
15-1, 30-45	2.4	52.0	9.8	0.0	6.5	8.6	0.0	0.0	12.3	1.8	6.6	0.0	0.0	0.0
16-1, 129-145	2.5	57.0	10.1	0.0	5.3	7.6	0.0	0.0	10.5	1.9	5.1	0.0	0.0	0.0
17-4, 45-60	4.0	43.3	10.6	2.0	6.6	8.1	0.0	0.0	16.5	0.0	7.6	0.0	1.3	0.0
18-5, 106-125	3.9	50.2	10.9	tr.	6.8	5.3	0.0	0.0	13.4	3.6	5.9	0.0	0.0	0.0
18-6, 130-148	4.9	47.3	10.2	tr.	4.4	5.8	0.0	0.0	17.0	0.0	8.7	0.0	1.7	0.0
19-6, 58-70	4.1	44.3	6.2	2.3	4.4	6.7	0.0	0.0	23.4	1.6	7.0	0.0	0.0	0.0
19-6, 86-100	3.3	53.0	10.0	1.9	5.0	7.9	0.0	0.0	14.6	0.0	4.5	0.0	0.0	0.0
20-6, 40-50	6.1	36.7	11.0	tr.	8.0	6.1	7.3	0.0	18.4	0.0	6.4	0.0	0.0	0.0
21-3, 56-69	2.7	49.3	11.2	1.4	6.9	6.4	tr.	0.0	13.8	2.0	6.3	0.0	0.0	0.0
21-6, 48-61	3.6	47.8	10.9	tr.	7.3	6.8	0.0	0.0	15.9	0.0	7.7	0.0	0.0	0.0
23-6, 100-110	5.0	41.9	11.2	2.8	9.3	3.7	0.0	0.0	18.6	0.0	7.5	0.0	0.0	0.0
24-5, 0-8	13.1	40.4	9.8	2.2	10.9	0.0	0.0	0.0	18.1	0.0	5.5	0.0	0.0	0.0
27-3, 1-13	7.4	45.2	11.9	2.4	9.0	0.0	0.0	0.0	14.5	4.0	5.6	0.0	0.0	0.0
28-1, 124-136	3.1	48.3	11.8	1.8	12.6	3.9	3.5	0.0	10.8	0.0	4.2	0.0	0.0	0.0
30-1, 94-100	2.5	51.7	11.3	tr.	5.0	5.9	3.4	0.0	12.6	1.9	5.7	0.0	0.0	0.0
32-3, 70-80	3.6	54.3	12.2	2.7	5.8	4.5	0.0	0.0	11.4	0.0	5.5	0.0	0.0	0.0
32-3, 80-90	4.0	44.3	13.1	2.9	5.4	6.3	0.0	0.0	16.9	0.0	7.1	0.0	0.0	0.0
33-3, 95-110	2.1	53.7	9.3	tr.	4.1	8.2	0.0	0.0	13.4	1.8	7.4	0.0	0.0	0.0
35-3, 19-42	7.1	30.0	8.6	0.0	6.8	3.6	5.0	0.0	19.6	5.4	6.4	2.9	4.6	0.0
36-2, 28-38	9.6	35.9	7.2	0.0	8.4	7.5	2.4	0.0	17.9	0.0	5.3	3.0	2.7	0.0
38-2, 73-85	4.4	45.5	10.7	3.3	8.8	4.4	3.6	0.0	15.2	0.0	4.1	0.0	0.0	0.0
39-1, 48-62	8.8	40.7	9.5	2.8	5.1	tr.	tr.	0.0	18.9	4.7	9.5	0.0	0.0	0.0
40-1, 120-135	13.7	33.5	7.7	6.4	14.2	0.0	0.0	0.0	19.3	0.0	5.2	0.0	0.0	0.0

TABLE 3
X-Ray Diffraction Analysis of Bulk Samples (Leg 42B, Hole 380A, depth 2115 m) (total crystalline phases = 100%)

Sample (Interval in cm)	Montmorill-onite	Illite	Chlorite	Kaolinite	Calcite	Dolomite	Siderite	Aragonite	Quartz	K-feld-spars	Plagio-clase	Pyrite	Gypsum	Clinoptil-olite
3-2, 74-87	10.9	35.0	9.3	2.3	7.8	4.7	0.0	0.0	19.5	0.0	5.1	3.8	1.6	0.0
4-5, 38-51	11.9	29.2	8.9	5.1	16.1	0.0	0.0	0.0	21.2	0.0	7.6	0.0	0.0	0.0
5-4, 61-74	4.6	41.4	14.9	0.0	7.4	2.8	tr.	0.0	16.0	7.0	5.9	0.0	0.0	0.0
6-3, 106-119	10.4	36.3	9.5	0.0	19.6	2.9	3.4	0.0	14.4	0.0	3.5	0.0	0.0	0.0
8-4, 129-150	28.4	24.0	5.3	6.7	10.8	0.0	0.0	0.0	15.6	4.0	5.2	0.0	0.0	0.0
9-5, 78-95	8.1	38.2	8.7	2.6	0.0	8.4	3.5	0.0	20.2	4.3	6.0	0.0	0.0	0.0
10-2, 62-74	11.4	36.6	11.0	tr.	11.3	0.0	0.0	0.0	22.4	0.0	7.3	0.0	0.0	0.0
11-6, 58-69	5.1	50.3	12.9	1.5	0.0	3.5	tr.	0.0	15.2	4.6	6.9	0.0	0.0	0.0
12-4, 0-9	8.8	16.1	6.6	tr.	53.0	0.0	3.2	0.0	9.5	0.0	2.8	0.0	0.0	0.0
12-4, 9-16	7.9	9.8	5.9	2.3	62.3	0.0	3.3	0.0	6.5	0.0	2.0	0.0	0.0	0.0
12-6, 49-61	13.6	33.7	9.2	3.1	18.4	0.0	0.0	0.0	17.0	0.0	5.0	0.0	0.0	0.0
13-1, 100-111	1.6	47.3	10.6	5.9	5.5	7.1	0.0	0.0	15.8	0.0	6.2	0.0	0.0	0.0
14-2, 62-77	12.4	24.0	9.3	2.7	20.5	0.0	0.0	0.0	24.4	0.0	6.7	0.0	0.0	0.0
14-3, 15-28	3.7	24.3	9.3	4.7	43.5	0.0	0.0	0.0	10.8	0.0	3.7	0.0	0.0	0.0
14-6, 67-79	4.1	39.0	8.6	1.5	17.1	6.8	0.0	0.0	18.2	0.0	4.7	0.0	0.0	0.0
15-3, 26-36	8.4	27.3	9.4	7.3	21.4	tr.	0.0	0.0	21.0	0.0	5.2	0.0	0.0	0.0
17-2, 56-70	6.7	5.0	0.0	0.0	83.7	0.0	0.0	0.0	4.6	0.0	0.0	0.0	0.0	0.0
17-2, 111-123	18.0	39.0	11.9	tr.	0.0	0.0	0.0	0.0	25.1	0.0	6.0	0.0	0.0	0.0
18-2, 44-54	12.5	35.2	9.4	0.0	16.4	0.0	0.0	0.0	19.5	0.0	7.0	0.0	0.0	0.0
18-3, 33-48	11.7	20.9	7.7	tr.	45.4	0.0	0.0	0.0	11.0	0.0	3.3	0.0	0.0	0.0
19-2, 0-16	24.6	27.7	7.7	0.0	13.3	0.0	0.0	0.0	20.5	0.0	6.2	0.0	0.0	0.0
20-2, 39-51	12.4	34.9	10.4	4.6	12.4	0.0	0.0	0.0	19.5	0.0	5.8	0.0	0.0	0.0
22-3, 84-96	11.7	12.4	7.3	tr.	57.9	0.0	0.0	0.0	8.2	0.0	2.5	0.0	0.0	0.0
23-5, 77-87	13.4	16.3	3.8	tr.	52.6	0.0	3.1	0.0	8.3	0.0	2.5	0.0	0.0	0.0
26-2, 71-87	9.0	18.0	7.9	4.5	44.2	0.0	0.0	0.0	13.1	0.0	3.3	0.0	0.0	0.0
30-1, 108-120	19.5	33.8	11.3	7.9	0.0	tr.	0.0	0.0	20.7	0.0	6.8	0.0	0.0	0.0
30-2, 38-50	14.7	9.7	tr.	tr.	67.3	0.0	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0
31-1, 40-55	17.0	31.8	11.7	7.4	3.9	0.0	0.0	0.0	18.4	0.0	6.4	3.4	0.0	0.0
32-6, 34-39	9.1	8.2	tr.	tr.	67.3	0.0	9.0	0.0	6.4	0.0	0.0	0.0	0.0	0.0
32-6, 39-41	10.6	13.4	5.3	tr.	55.8	0.0	6.0	0.0	8.9	0.0	0.0	0.0	0.0	0.0
34-5, 112-123	24.2	28.0	9.9	0.0	10.9	0.0	4.4	0.0	17.7	0.0	4.9	0.0	0.0	0.0
37-3, 0-12	23.0	32.4	10.8	tr.	0.0	0.0	5.7	0.0	21.6	0.0	6.5	0.0	0.0	0.0
41-6, 108-122	19.5	34.1	9.8	0.0	0.0	0.0	11.4	0.0	20.3	0.0	4.9	0.0	0.0	0.0
43-1, 0-13	24.1	31.6	9.1	0.0	0.0	0.0	0.0	0.0	22.5	2.2	3.0	7.5	0.0	0.0
45-3, 112-125	16.7	31.3	12.5	6.3	8.3	0.0	0.0	0.0	20.8	0.0	4.1	0.0	0.0	0.0
47-1, 50-60	11.6	29.5	12.5	3.4	25.3	0.0	0.0	0.0	12.5	0.0	5.2	0.0	0.0	0.0
48-5, 0-15	5.0	14.9	tr.	0.0	60.6	0.0	9.9	0.0	7.1	0.0	2.5	0.0	0.0	0.0
51-4, 34-50	4.9	14.8	3.3	0.0	54.5	0.0	0.0	0.0	8.5	7.9	4.6	1.5	0.0	0.0
54-1, 66-78	4.2	25.5	4.8	2.4	43.0	0.0	3.2	0.0	9.0	2.3	5.6	0.0	0.0	0.0
56-1, 95-106	7.0	14.0	0.0	0.0	65.0	0.0	0.0	0.0	10.5	0.0	3.5	0.0	0.0	0.0
60-3, 1-12	6.9	20.7	tr.	0.0	5.8	8.0	0.0	48.4	10.2	0.0	0.0	0.0	0.0	0.0
62-2, 0-15	7.9	28.8	3.9	0.0	0.0	37.1	0.0	0.0	11.5	0.0	7.8	2.0	0.0	0.0
63-4, 0-15	5.4	26.5	4.1	0.0	3.4	20.4	0.0	23.1	10.1	3.9	3.1	0.0	0.0	0.0
65-3, 0-15	6.6	50.7	4.9	3.5	1.9	tr.	0.0	0.0	14.1	9.4	8.9	0.0	0.0	0.0
69-3, 86-100	5.1	54.7	6.8	0.0	3.0	3.3	0.0	0.0	12.6	0.0	9.9	1.5	0.0	3.1
71-3, 57-68	7.8	16.5	4.6	3.5	9.3	42.2	0.0	0.0	9.4	1.6	2.3	2.8	0.0	tr.
73-2, 5-18	8.1	35.6	4.7	6.0	3.1	0.0	1.8	0.0	11.4	8.0	9.4	1.2	0.0	10.7
73-3, 16-27	11.5	40.5	4.3	6.0	2.3	0.0	tr.	0.0	11.4	6.1	8.4	1.7	0.0	7.8

TABLE 4
Clay Minerals in the Bottom Sediment Fraction <2μm, Holes 380/380A (clay minerals = 100%)

Sample (Interval in cm)	Depth (m)	Montmorill-onite	Illite	Chlorite, Kaolinite	Other Minerals
Hole 380					
5-3, 49-62	41.49-41.62	26	57	17	Quartz, feld-spars
7-3, 78-86	60.78-60.86	11	68	21	Quartz, feld-spars
10-4, 106-132	91.06-91.32	28	57	15	Quartz, feld-spars
13-3, 0-13	117.00-117.13	29	57	14	Quartz, feld-spars
17-2, 130-148	154.80-154.98	40	47	13	Quartz
20-1, 2-12	180.02-180.12	27	56	17	Quartz
23 (upper part)	209.00	26	59	15	Quartz, feld-spars
27-3, 13-25	250.13-250.25	32	57	11	Quartz, feld-spars
32-4, 73-83	299.73-299.83	34	53	13	Quartz, feld-spars
35-2, 54-64	319.54-319.64	tr.	77	22	Quartz, feld-spars
38, CC	351, 50	32	52	16	Quartz, feld-spars
3-5, 0-12	357.50-357.62	18	63	19	
Hole 380A					
4-3, 60-79	364.60-364.79	18	64	18	Quartz, feld-spars
9-2, 128-142	411.28-411.42	13	67	20	Quartz, feld-spars
12-2, 1-17	438.51-438.67	22	59	19	Quartz, feld-spars
15-3, 26-36	468.76-468.86	16	64	20	Quartz, feld-spars
19-2, 0-16	505.00-505.16	42	43	15	Quartz, feld-spars
25-3, 24-40	563.74-563.90	28	57	15	Quartz, feld-spars
27-6, 116-118	588.16-588.18	34	50	16	Quartz, feld-spars
29-6, 0-25	600.50-600.75	35	54	11	Quartz, feld-spars
35-4, 125-140	651.75-651.90	48	42	10	Quartz, feld-spars
37-6, 14-19	672.64-672.69	50	40	10	Quartz
40-4, 6-20	698.06-698.20	43	57	tr.	Quartz
42-2, 4-14	714.04-714.14	54	36	10	Quartz
46-5, 85-95	757.35-757.45	59	29	12	Quartz
48-6, 41-53	777.41-777.53	57	37	6	Quartz
56-4, 51-60	850.51-850.60	44	41	15	Quartz
63-2, 0-15	913.50-913.65	46	47	7	Quartz
77-3, 104-115	1049.04-1049.15	70	22	8	Quartz, clinoptilo-lite

The Pleistocene deposits at Site 380/380A are characterized by abundant clay minerals, especially illite. Its content in the bulk samples decreases from Unit 2 downwards, where montmorillonite increases (Table 6). The montmorillonite/illite ratio in Pleistocene sediments is extremely low, ranging from 0.04 to 0.2 (sometimes 0.5).

Eopleistocene (Menap, Waal, Eburon) sediments, Units 2 and 3, are characterized by a higher montmorillonite/illite ratio of 1.5, a result of simultaneous increase in montmorillonite and decrease of illite. Another change is seen in Miocene sediments (Units 4e and 5), where montmorillonite diminishes and illite increases, and the montmorillonite/illite ratio is 0.1-0.5.

The average chlorite content decreases gradually down the hole, the most substantial variation occurring is at the Pleistocene-Eopleistocene boundary.

The content of kaolinite is extremely minor; in some instances none was detected. In general the kaolinite varies as at Hole 379A, being higher in warm periods (cold periods are characterized by Units 1_c, 1_e, 1_g, 1_h). This relationship is not seen in the case of the other minerals.

In the <2μm fraction the principal clay minerals are illite and mixed-layer illite-montmorillonite with accessory kaolinite and chlorite (Table 4, Figure 4), and it appears that there is considerable iron in their lattices. Kaolinite and chlorite, in about similar amounts, are detected down to a depth of 600 meters, below which they are absent. The weak and broad reflections within the 7Å interval are most probably due to limited amounts of phillipsite and serpentinite. Vermiculite occurs in trace amounts throughout the hole. The <2μm fraction contains quartz, and feldspars are found in trace quantities to a depth of about 670 meters. Zeolites (most probably a transitional form between geilandite and clinoptilolite) were identified in the bottom of the Hole in Unit 5 (Figure 6[K, L, M]).

The quantitative ratios of basic mineral groups in Site 380/380A sediments is variable and probably linked with variations in the intensity of terrigenous mineral input, dependant on climatic factors. The change from illite to mixed-layer illite/montmorillonite occurs close to the interface of Units 3 and 4_a, e.g., the Eopleistocene-Pliocene boundary.

The sediments at this site may be subdivided on the degree of clay mineral crystallinity or on the ratio of amorphous and crystalline phases in the <2μm fraction (Figure 4). The top two units contain clay minerals of medium to weak degree of crystallization. Between 60-450 meters they contain well-crystallized clay minerals except between 310-360 meters (about the interface of Units 1_h and 2) where they are poorly crystallized. The section from 450 to 590 meters is characterized by medium crystallized minerals, almost like Unit 3. Below this, they are again poorly crystallized. The lowest section is also characterized by a somewhat modified mineral composition similar to lithological Units 4 and 5.

The <2μm fraction varies directly with the abundance of highly dispersed minerals in the sediments and changes greatly from horizon to horizon. Below 700 meters the fine fraction content diminishes markedly reaching minimal values (5%-10%) which continue to the bottom of the hole. The same interval is characterized by poorly crystallized clay minerals, strongly suggestive of their insignificant role in the sediments.

Repeated change of the clay mineral content is seen at Site 380 and Hole 380A, the most substantial change occurring at the interface between the Pleistocene and Eopleistocene. However, distinct correlation between clay mineral content and Pleistocene climatic changes is not apparent.

The quartz distribution pattern (bulk samples) demonstrates a very gradual decrease down the hole. Plagioclases have approximately the same distribution patterns, excluding the Miocene sediments (Units 4 and 5) where they are in relatively greater quantites. K-feldspars are fewer here than in Hole 379A; in some units they are not present at all. Quartz is always more abundant than feldspar (the quartz/feldspar ratio >1).

Carbonate minerals in Site 380/380A have a complicated distribution. Calcite is predominant. In the Pleistocene sediments, the calcite content is low and

TABLE 5
X-Ray Diffraction Analysis of Bulk Samples (Leg 42B, Site 381, depth 1750 m) (total crystalline phases = 100%)

Sample (Interval in cm)	Montmorillonite	Illite	Chlorite	Kaolinite	Calcite	Dolomite	Siderite	Aragonite	Quartz	K-feldspars	Plagioclase	Pyrite	Gypsum	Other Minerals
1-3, 0-20	20.9	22.3	19.7	0.0	4.4	0.0	0.0	0.0	20.6	0.0	8.9	3.2	0.0	0.0
2-2, 124-144	9.1	38.1	11.5	3.9	4.2	8.6	0.0	0.0	17.4	0.0	7.2	tr.	0.0	0.0
3-2, 55-75	11.1	29.4	13.3	4.9	12.1	0.0	3.3	0.0	17.5	0.0	8.2	0.0	0.0	0.0
4-2, 115-140	21.5	24.2	14.3	3.2	11.9	0.0	0.0	0.0	18.4	0.0	6.5	0.0	0.0	0.0
5-3, 115-135	31.9	22.0	17.8	tr.	7.2	0.0	0.0	0.0	13.8	0.0	7.3	0.0	0.0	0.0
6-2, 85-100	11.1	29.1	9.5	6.3	12.5	4.1	0.0	0.0	22.2	0.0	5.2	tr.	0.0	0.0
7-4, 125-145	27.4	25.6	11.4	3.4	13.6	2.1	0.0	0.0	11.4	0.0	5.1	0.0	0.0	0.0
8-3, 126-140	11.1	20.1	8.4	0.0	27.6	5.5	0.0	0.0	16.6	0.0	10.7	tr.	0.0	0.0
8-5, 40-63	6.4	23.0	9.6	3.6	25.0	7.3	0.0	0.0	15.3	4.9	4.9	0.0	0.0	0.0
9-1, 80-100	14.0	18.0	11.9	tr.	19.0	4.6	0.0	0.0	19.0	7.5	6.0	tr.	0.0	0.0
9-4, 135-150	13.3	21.5	14.7	5.0	16.6	3.3	0.0	0.0	19.0	0.0	6.6	0.0	0.0	0.0
9-6, 70-90	14.3	27.9	17.0	4.3	0.0	0.0	0.0	0.0	25.8	0.0	10.7	0.0	0.0	0.0
10-6, 125-150	24.0	25.1	11.0	5.4	18.0	0.0	0.0	0.0	12.0	0.0	4.5	0.0	0.0	0.0
11-2, 0-15	23.6	27.9	7.8	3.9	12.7	5.1	0.0	0.0	16.9	0.0	2.1	0.0	0.0	0.0
12-1, 120-130	10.7	26.7	9.4	6.6	18.8	4.5	0.0	0.0	18.2	0.0	5.1	0.0	0.0	0.0
13-3, 90-105	16.2	19.7	12.0	tr.	28.5	3.0	0.0	0.0	13.2	3.7	3.7	0.0	0.0	0.0
14-3, 0-20	15.8	18.7	13.4	0.0	34.1	2.3	0.0	0.0	11.5	tr.	4.2	0.0	0.0	0.0
15-5, 135-150	12.6	24.2	9.5	2.7	22.5	2.7	11.8	0.0	9.0	0.0	5.0	tr.	0.0	0.0
16-5, 0-20	15.2	16.9	13.6	0.0	39.0	tr.	0.0	0.0	11.7	0.0	3.6	tr.	0.0	0.0
17-3, 135-150	22.9	28.7	15.2	tr.	7.9	0.0	0.0	0.0	18.1	0.0	7.2	tr.	0.0	0.0
17-6, 130-150	12.4	12.6	8.5	tr.	49.7	0.0	0.0	0.0	10.9	2.1	3.8	0.0	0.0	0.0
18-2, 0-15	6.9	3.4	6.0	0.0	10.6	0.0	0.0	0.0	52.8	14.6	3.4	2.3	0.0	0.0
19-1, 0-15	9.5	5.3	3.1	0.0	53.5	tr.	23.8	0.0	4.8	tr.	tr.	tr.	0.0	0.0
19-2, 92-102	71.0	0.0	11.9	10.4	0.0	0.0	0.0	tr.	6.7	0.0	0.0	0.0	0.0	0.0
19-5, 86-88	24.4	15.5	13.6	0.0	22.6	tr.	11.0	0.0	9.4	0.0	3.5	0.0	0.0	0.0
22-1, 40-55	28.8	26.2	19.0	tr.	2.0	0.0	0.0	0.0	18.6	0.0	5.4	tr.	0.0	0.0
22-3, 40-55	34.4	28.6	16.4	tr.	3.0	0.0	0.0	0.0	11.9	0.0	5.7	0.0	0.0	0.0
23-3, 40-55	33.6	31.2	12.7	tr.	0.0	0.0	0.0	tr.	16.2	tr.	6.3	0.0	0.0	0.0
23-4, 92-94	12.2	10.4	0.0	0.0	0.0	0.0	74.2	0.0	3.2	0.0	0.0	0.0	0.0	0.0
24-1, 48-63	29.9	29.7	15.4	5.1	2.6	0.0	0.0	tr.	11.1	0.0	6.2	tr.	0.0	0.0
25-2, 40-55	32.8	19.3	19.3	8.6	0.0	0.0	0.0	0.0	16.0	0.0	4.0	0.0	0.0	0.0
26-3, 40-50	32.6	22.0	14.7	6.1	tr.	0.0	0.0	4.9	14.2	tr.	5.5	0.0	0.0	0.0
27-2, 50-65	33.7	25.3	13.3	6.4	tr.	0.0	0.0	5.1	10.5	0.0	5.7	tr.	0.0	0.0
27-3, 77-79	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28-3, 70-85	32.2	21.2	18.7	6.0	0.0	0.0	0.0	0.0	15.1	0.0	6.8	0.0	0.0	0.0
29-2, 0-15	21.1	20.5	10.0	6.8	19.7	0.0	0.0	0.0	15.1	0.0	6.8	0.0	0.0	0.0
30-3, 15-21	16.4	15.4	9.6	6.2	32.9	0.0	0.0	0.0	10.2	3.8	3.0	2.5	0.0	0.0
31-2, 100-115	17.0	16.8	10.0	0.0	39.4	0.0	0.0	0.0	7.7	2.8	3.5	2.8	0.0	0.0
32-1, 31-44	17.3	14.5	10.2	5.8	31.7	0.0	0.0	0.0	11.9	5.0	3.6	tr.	0.0	0.0
32-1, 81-94	8.6	15.4	4.6	5.1	53.7	0.0	0.0	0.0	4.2	3.2	3.2	2.0	0.0	0.0
32-1, 130-132	16.1	10.3	3.1	0.0	58.4	0.0	0.0	0.0	10.4	0.0	1.7	tr.	0.0	0.0
32-2, 112-114	8.5	6.4	0.0	0.0	76.4	0.0	0.0	0.0	6.3	0.0	0.0	2.4	0.0	0.0
32-2, 115-117	9.6	4.3	0.0	0.0	80.2	0.0	0.0	0.0	4.5	0.0	1.4	0.0	0.0	0.0
33-1, 120-122	28.4	18.9	14.5	0.0	7.8	0.0	0.0	0.0	24.4	0.0	6.0	tr.	0.0	0.0
33-1, 123-125	22.5	19.5	13.7	5.2	21.7	tr.	0.0	tr.	12.0	0.0	5.4	0.0	0.0	0.0
33-1, 126-128	28.0	18.1	14.8	tr.	14.9	tr.	0.0	5.5	14.5	0.0	4.2	0.0	0.0	0.0
33-4, 120-135	6.3	4.7	0.0	0.0	73.5	0.0	0.0	6.7	5.4	tr.	tr.	3.4	0.0	0.0
34-1, 5-7	7.5	12.5	4.3	4.1	53.8	0.0	0.0	0.0	12.1	2.6	3.1	tr.	0.0	0.0
34-1, 8-10	8.2	4.7	4.5	3.1	72.2	0.0	0.0	0.0	5.1	2.3	tr.	tr.	0.0	0.0
34-3, 10-20	3.3	13.6	3.7	tr.	69.7	0.0	0.0	0.0	5.9	0.0	1.9	1.9	0.0	0.0
35-1, 110-120	24.1	22.5	12.1	6.9	tr.	0.0	0.0	4.5	22.3	0.0	5.3	2.3	0.0	0.0
35-2, 60-70	16.1	21.1	12.2	4.5	20.1	0.0	0.0	0.0	17.6	3.7	1.5	3.2	0.0	0.0
35-5, 105-120	14.4	19.2	10.2	8.4	9.6	0.0	0.0	tr.	25.8	0.0	5.7	6.7	0.0	0.0
36-2, 44-46	20.8	19.5	11.7	7.8	0.0	0.0	0.0	tr.	26.2	0.0	6.8	7.2	0.0	0.0
36-3, 70-84	19.3	20.9	12.9	8.1	4.3	0.0	0.0	0.0	24.0	tr.	5.6	4.9	0.0	0.0
37-1, 76-78	15.0	16.1	6.4	3.2	11.8	0.0	0.0	15.0	19.8	3.1	1.7	5.7	2.2	0.0
37-1, 90-92	7.2	12.0	5.4	tr.	7.2	0.0	0.0	40.7	14.4	tr.	3.8	9.3	tr.	0.0
37-1, 134-136	5.0	16.8	3.7	0.0	6.2	2.5	0.0	50.4	7.5	0.0	3.7	4.2	tr.	0.0
37-1, 146-148	3.9	14.3	3.5	0.0	3.7	1.2	0.0	17.3	15.9	11.9	23.9	2.8	1.6	0.0
37-2, 12-14	tr.	tr.	0.0	0.0	0.0	0.0	0.0	77.8	6.2	3.8	8.5	3.7	0.0	0.0
37-2, 30-40	13.0	22.1	5.1	2.3	tr.	0.0	0.0	11.4	30.2	3.9	4.9	7.1	0.0	0.0
37-5, 56-58	4.[illegible]	4.2	1.3	0.0	4.9	0.0	0.0	70.7	5.5	tr.	2.7	4.5	2.1	0.0
37-5, 98-100	14.0	21.0	11.1	2.3	9.0	0.0	0.0	7.9	21.3	4.1	7.1	2.2	0.0	0.0
39-1, 42-44	4.6	10.6	3.5	0.0	2.2	65.6	0.0	0.0	4.7	2.5	6.3	0.0	0.0	0.0
42-1, 90-100	5.1	4.6	0.0	0.0	4.1	9.0	0.0	10.1	40.5	9.1	17.5	tr.	0.0	0.0
42-1, 140-145	12.2	24.5	11.2	3.2	2.7	7.1	0.0	tr.	17.7	6.6	12.4	2.4	tr.	tr.
42, CC	0.0	0.0	0.0	0.0	0.0	97.3	0.0	0.0	1.1	0.0	1.6	0.0	0.0	0.0
44, CC	4.9	5.0	4.3	0.0	4.6	36.6	0.0	tr.	22.2	4.6	17.8	tr.	0.0	tr.
45, CC	4.2	3.3	0.0	0.0	22.4	68.2	0.0	0.0	1.9	0.0	tr.	0.0	0.0	0.0
46, CC	2.9	4.3	3.2	0.0	0.0	34.3	0.0	0.0	30.5	5.4	19.4	0.0	0;0	0.0
47, CC	2.6	1.6	1.8	0.0	0.0	56.4	0.0	0.0	21.8	2.6	13.2	0.0	0.0	tr.
48-2, 5-17	21.1	35.6	17.4	tr.	0.0	0.0	0.0	0.0	10.5	5.5	9.9	0.0	0.0	0.0
48-3, 51-53	20.7	23.4	20.3	4.2	0.0	0.0	0.0	0.0	13.0	4.5	9.1	3.1	1.7	0.0
48-3, 55-57	10.0	35.6	19.7	tr.	0.0	0.0	0.0	0.0	17.2	4.2	10.8	tr.	2.5	tr.
48-5, 120-130	10.6	40.7	17.8	4.9	0.0	0.0	0.0	0.0	6.6	4.4	12.0	3.0	0.0	0.0
48-6, 110-120	12.2	30.1	20.8	7.8	0.0	0.0	0.0	0.0	6.7	5.9	14.1	tr.	2.4	0.0
49-2, 70-83	12.0	37.5	26.1	tr.	0.0	0.0	0.0	0.0	10.5	4.0	9.9	0.0	0.0	0.0
51-5, 0-12	9.4	33.2	16.1	5.1	0.0	0.0	0.0	0.0	12.7	7.2	16.3	0.0	0.0	0.0
51-6, 73-83	5.5	46.2	17.6	3.1	0.0	0.0	0.0	0.0	6.9	5.2	15.5	0.0	0.0	0.0
52-2, 15-30	8.4	42.1	25.1	2.0	tr.	0.0	0.0	0.0	9.6	4.5	8.3	0.0	0.0	0.0
52-2, 65-67	7.3	36.7	23.1	3.1	0.0	0.0	tr.	0.0	14.6	5.7	9.5	0.0	0.0	0.0
53-3, 125-135	6.0	47.4	13.6	3.3	0.0	0.0	tr.	0.0	7.2	8.0	14.5	0.0	0.0	0.0
54-4, 3-13	7.1	46.4	18.4	tr.	0.0	0.0	tr.	0.0	7.6	9.7	10.8	0.0	0.0	tr.

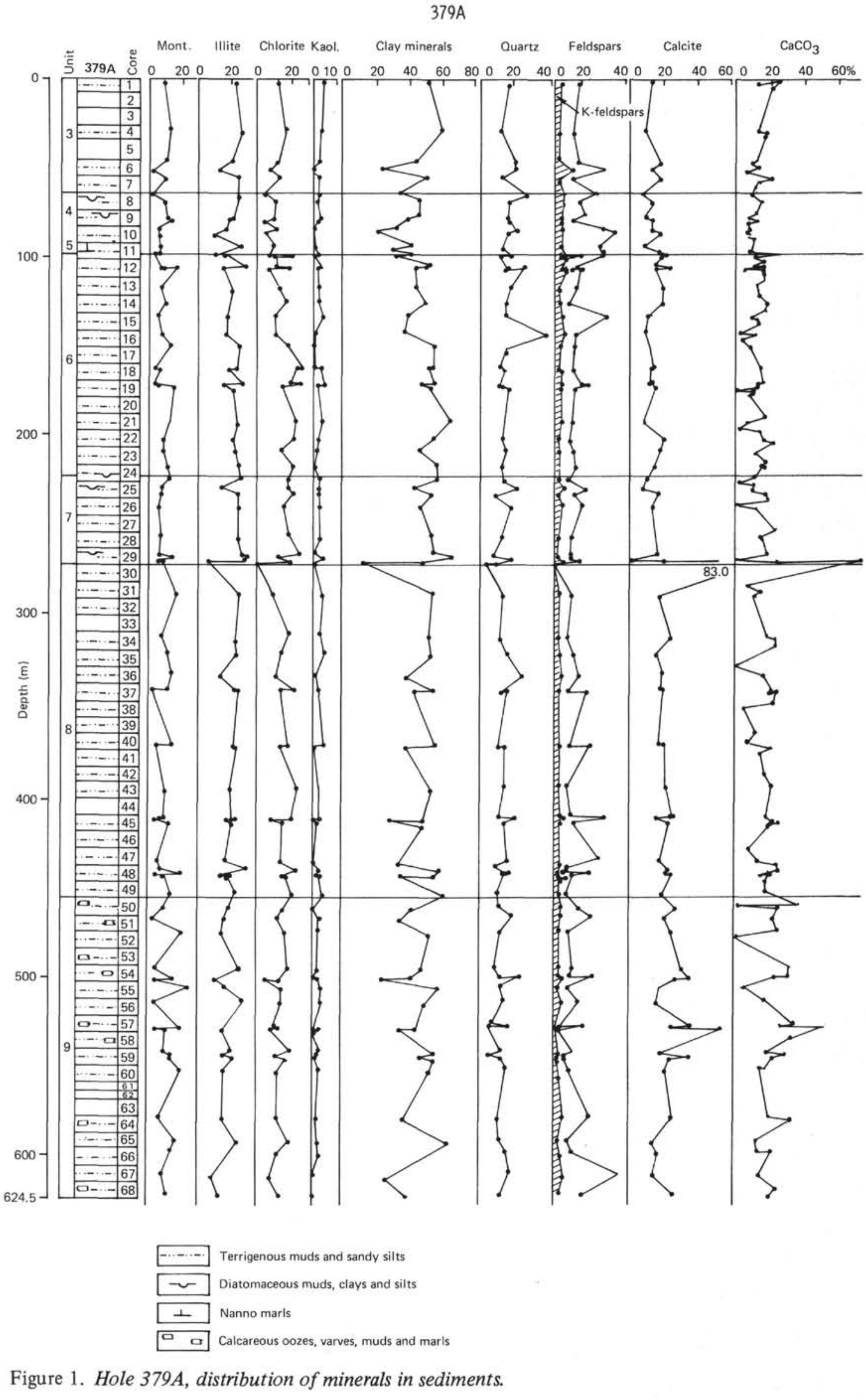


Figure 1. *Hole 379A, distribution of minerals in sediments.*

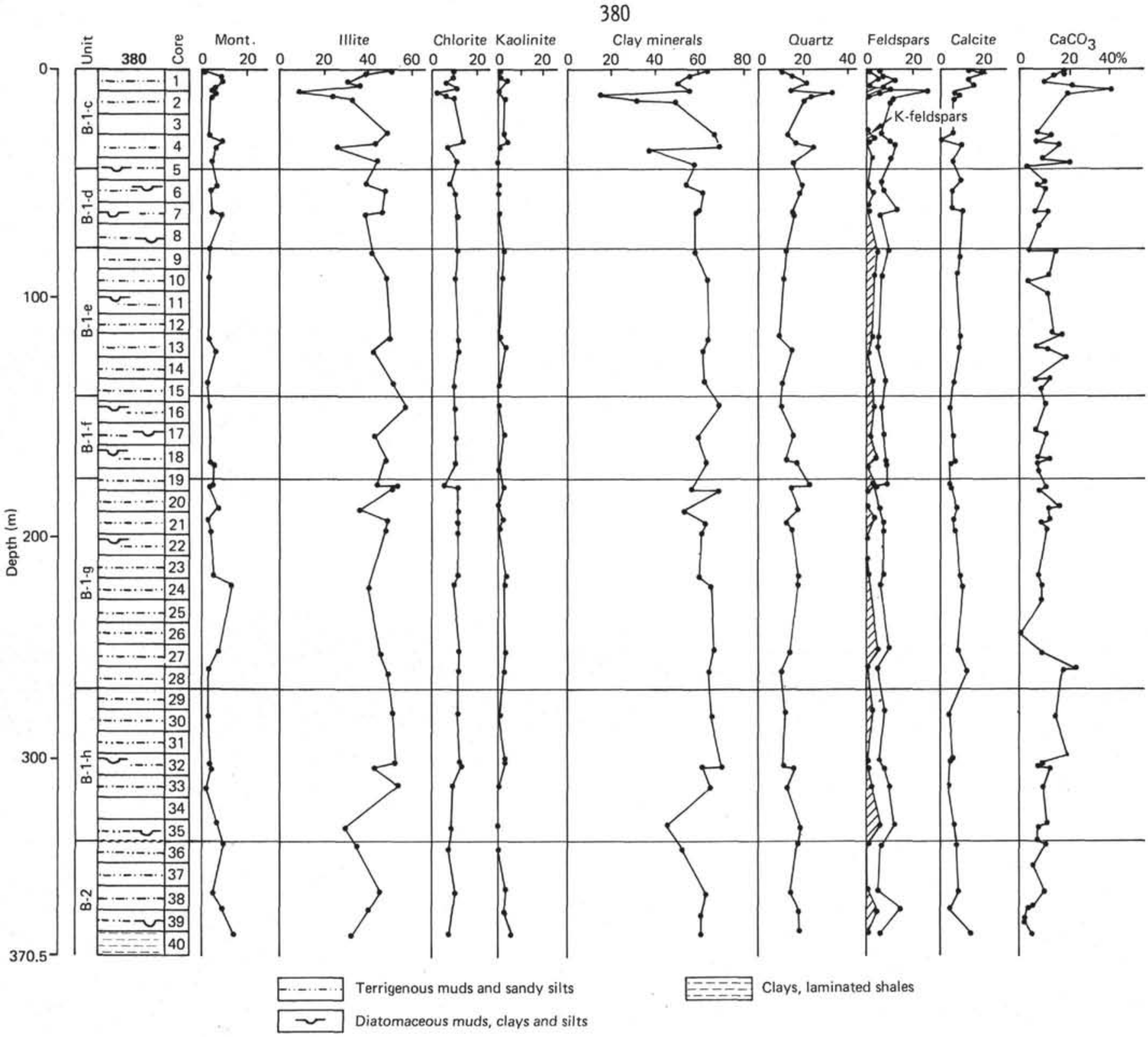


Figure 2. *Hole 380, distribution of minerals in sediments.*

does not show distinct fluctuations with climatic changes. It is present in relatively larger amounts in the Eopleistocene sediments (Units 2 and 3) and in the upper portion of the Pliocene. Units 4_e and 5 (Miocene) contain a minimal content. The greatest variation of calcite thus corresponds to the same time interval to which rapid diversities in clay minerals (illite, montmorillonite and, partially, chlorite) pertain. Biogenic calcite occurs in small quantity in Unit 1_c (Cores 2 and 4), where it is represented by mollusc detritus; in Unit 1_d (Riss-Würm) it is of coccolith origin. Two interlayers of coccolith calcite are also detected in Unit 2 (Core 4A). However, the bulk of the calcite is either of clastic or authigenic origin.

Calcite is often accompanied by sparse dolomite. The presence of dolomite in Pleistocene sediments is a result of its delivery from the surrounding land, as was noted earlier (Müller and Stoffers, 1973; Trimonis, 1972, 1974). In Units 4_e and 5 (Miocene) there are individual interlayers with thickness up to several centimeters enriched in dolomite, the grains of which are of pelitic size (<0.01 mm). Judging from microscopic analysis their formation is probably the result of diagenetic processes (dolomitization).

Siderite as a small admixture is found in some Pleistocene samples, but nowhere is it abundant; in the upper part of the hole (Unit 1_f and above) it was not observed. Siderite is the most typical mineral of the upper portion of the Pliocene (Unit 4_a) where siderite layers several centimeters thick often occur, as do hard sideritic concretions. As a secondary mineral resulting from diagenesis, siderite is not always constant in its

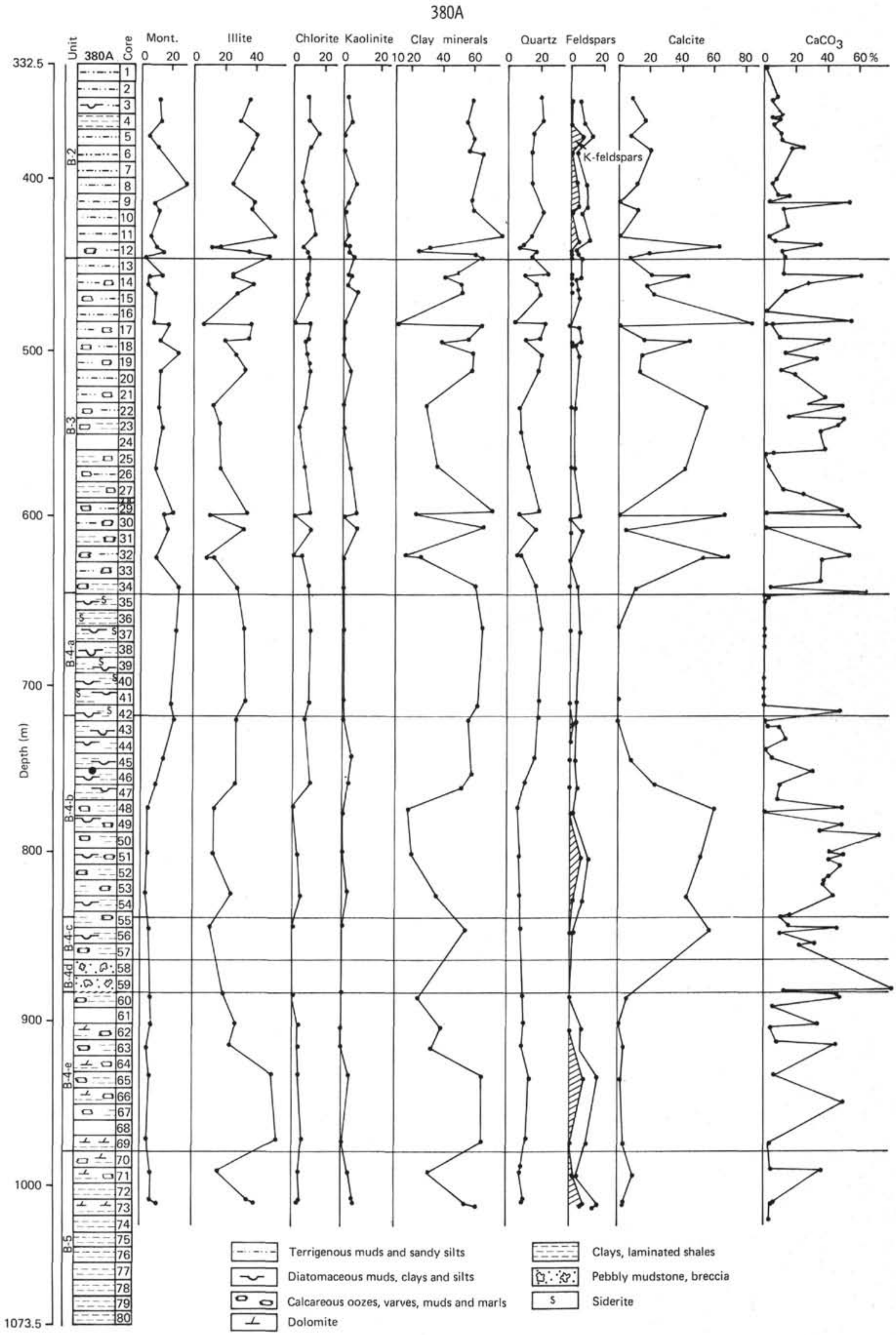


Figure 3. *Hole 380A, distribution of minerals in sediments.*

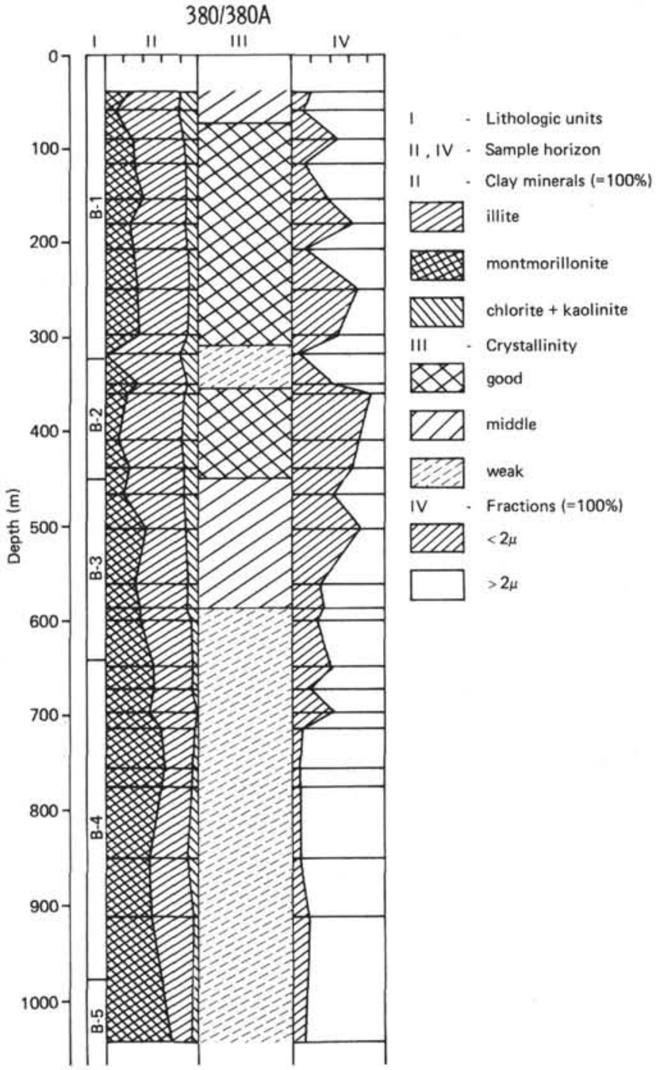


Figure 4. *Site 380/380A, distribution of clay minerals in sediments.*

composition, and sometimes approaches ankerite, or manganosiderite. More study of the siderite layers is required.

Aragonite is seldom abundant occurring in Cores 2, 4, and 36 (Hole 380) as a small needle-shaped admixture. It is extremely common in Unit 4_e, where it occurs as white microlayers 0.5-1 mm thick (Figure 6[G, H]), and accounts for 48.4% of the sediment (from smear slides it constitutes 100% of these microlayers). The carbonate part of the sediments in Site 380/380A is more varied than Hole 379A. This is most likely due to different source areas where ancient deposits contained considerable diagenetic carbonate varieties.

At Site 381, the Pleistocene section is represented by Unit 3. The change in mineral composition in proximity to the interface between Pleistocene and Eopleistocene is distinctly noticeable because the latter (Unit 4) consists of carbonate (micrite) deposits. Eopleistocene sediments are also distinguished from Pliocene in lithology as the upper part of the Pliocene is represented by diatomaceous-sapropelic mud. The lower part of the hole from Unit 8 downward is Miocene.

Clay minerals are variable in content, the most common being illite and montmorillonite. It is characteristic that the montmorillonite/illite ratio reaches rather high values (up to 2.2 in Unit 6); this was not observed at Site 380/380A. The highest ratios are in the Pleistocene and Pliocene deposits. In the Miocene sediments the montmorillonite/illite ratio does not usually exceed 0.9. The greatest abundances of illite are present in Unit 3 (Pleistocene) and in Units 9, 10, and 11. Some intervals in the Pleistocene (Unit 3), Pliocene (Unite 5 and 6), and Miocene (Unit 9) are high also in montmorillonite content. The average amounts of chlorite here are approximately the same as those at Site 380/380A. Only the lower part of the section (Units 9, 10, and 11) presents an exception, where chlorite abundances are relatively enhanced. Kaolinite occurs in small quantities in the deposits; the chlorite/kaolinite ratio is often very low (less than 0.1).

The amounts of quartz and feldspars are nonuniform throughout Hole 381. The highest quartz contents are in the Pleistocene deposits, where they are 1.5 to 2 times that of feldspars. In Pliocene-Miocene deposits the quartz content does not experience much change, but feldspar gradually increases downhole reaching maximum values in Units 8, 9, 10, and 11. In the three lowest units the quartz/feldspar ratio is lower than 1. In addition, K-feldspars are relatively important.

Such changes in mineral composition of the deposits may be linked mainly with increasing (or diminishing) importance of different provenances at different times. The main source areas for this province during the late Cenozoic were the southern Turkish and the Russian platforms. The principal rivers of these regions (the Sacarya in the south and the Danube in the north) in Recent time are characterized by different mineral compositions in their suspended loads. In the Danube, the most abundant clay is illite; montmorillonite is most abundant in the Sacarya. Quartz is 2 to 3 times more abundant than feldspars in the silt pelitic fraction of the Danube (Petersen, 1971). In earlier times, the southern source area seemed to supply abundant montmorillonite, feldspars (both plagioclase and potassium feldspars), as well as carbonates (calcite and dolomite), while more quartz and illite were delivered from the north.

In deposits at this site, carbonate minerals are of special interest, being more varied than at Site 380/380A. Pleistocene deposits distinctly show the dominance of calcite, present in high amounts in Unit 4 (Eopleistocene). In Pliocene deposits it constitutes only an extremely small part, except for Unit 6; no calcite were found in Units 9 and 10 (Miocene).

In Unit 3, the calcite and dolomite are often of terrigenous origin, as were the Pleistocene deposits at Site 380/380A. Siderite was detected in two samples of Pleistocene sediments (Hole 381). The siderite concretion observed in Core 12 favors an authigenic origin in those Pleistocene clays enriched in iron. Calcite in Unit 4 is to a considerable degree biogenic in origin; abundant mollusc detritus occurs there. In the lower part of this unit (Core 19), judging by examination of smear slides and the X-ray analysis, sideritization of micritic calcite has occurred. Biogenic (shell) calcite as an insignificant admixture is contained

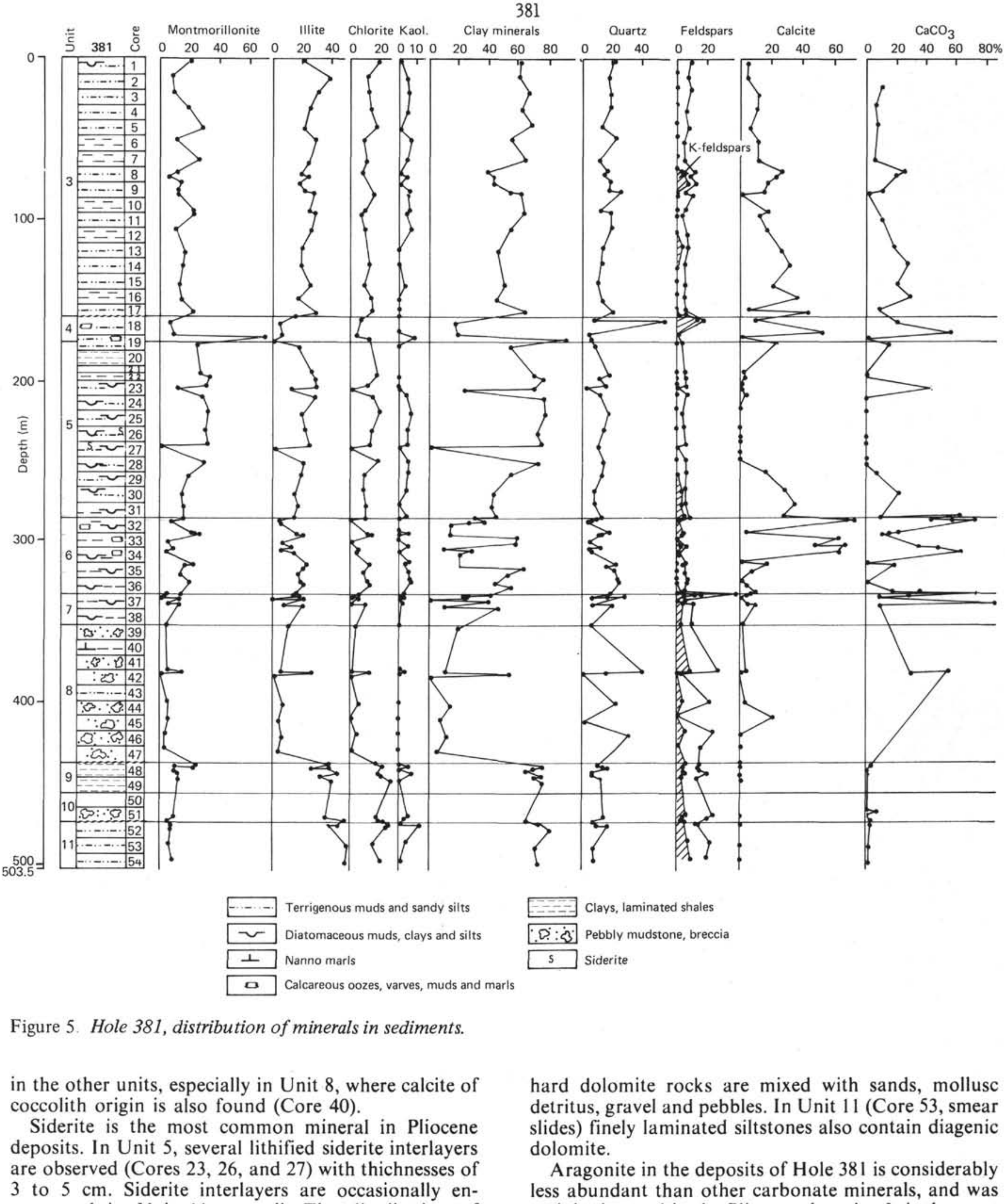


Figure 5. *Hole 381, distribution of minerals in sediments.*

in the other units, especially in Unit 8, where calcite of coccolith origin is also found (Core 40).

Siderite is the most common mineral in Pliocene deposits. In Unit 5, several lithified siderite interlayers are observed (Cores 23, 26, and 27) with thichnesses of 3 to 5 cm. Siderite interlayers are occasionally encountered in Unit 11 as well. The distribution of siderite interlayers throughout the hole and microscopic analysis suggests that their formation results from diagenesis.

The lithified dolomites are also of a diagenetic nature and are widespread in Unit 8. Here many fragments of hard dolomite rocks are mixed with sands, mollusc detritus, gravel and pebbles. In Unit 11 (Core 53, smear slides) finely laminated siltstones also contain diagenic dolomite.

Aragonite in the deposits of Hole 381 is considerably less abundant than other carbonate minerals, and was mainly detected in the Pliocene deposits. It is the most common mineral in Unit 7, where the needle-shaped aragonite crystals are concentrated in fine layers within diatomaceous clays.

In summary, carbonate minerals in the Pliocene-Miocene deposits at Hole 381 are mainly authigenic,

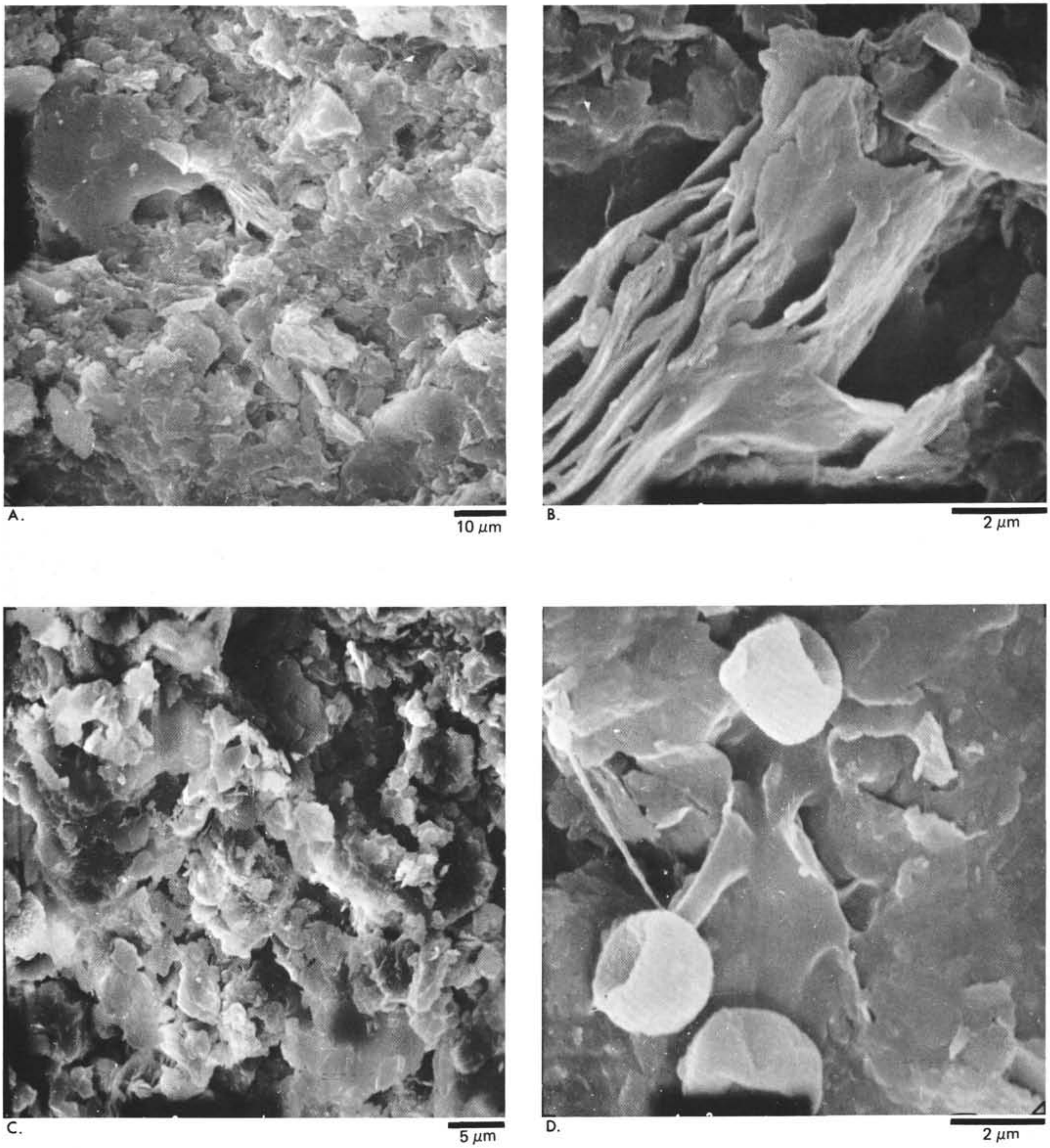


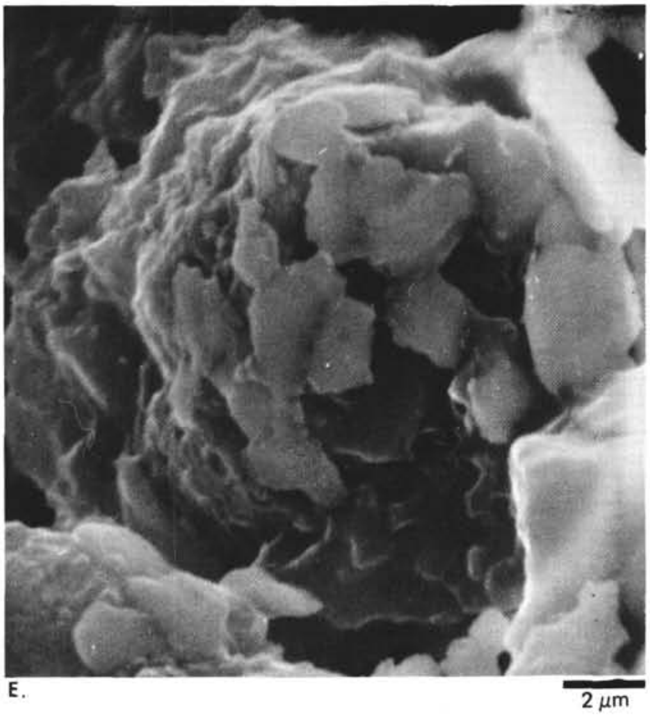
Figure 6. *Scanning electron micrographs. (A) mud consisting of layered silicates and calcite (379A-54-4, 11-13 cm); (B) same sample, detailed view; (C) terrigenous mud with ?-silica remains (379A-42-1-25-37 cm); (D) detail view of same sample; (E, F) diatomaceous sideritic clay (380A-41-1, 53-55 cm); (G, H) aragonite (380A-60-3, 1-2 cm); (I) pyrite (380A-30-1, 108-120 cm); (J) pyrite (379A-11-2, 55-64 cm); (K, L, M) zeolites (380A-73-2, 5-18 cm).*

originating from processes of dolomitization and sideritization.

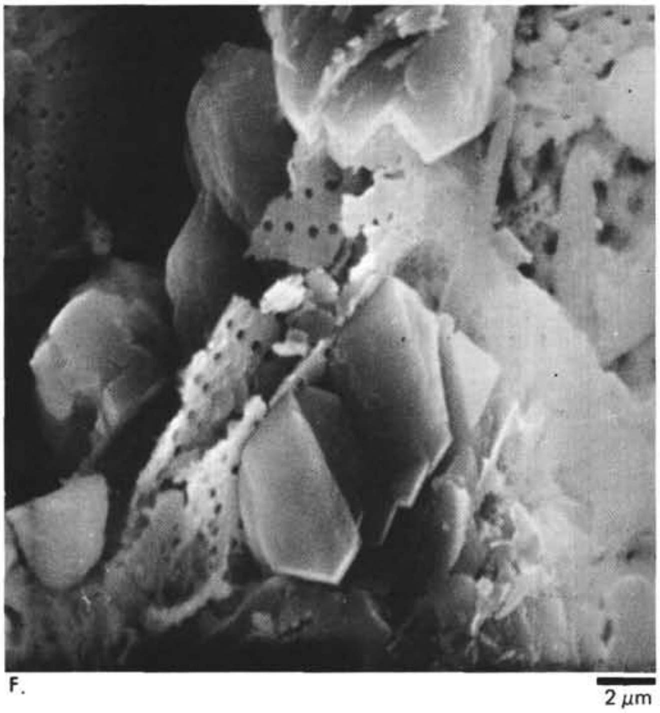
A small admixture of zeolites is present in Pliocene deposits (Cores 23 and 35) and sometimes volcanic glass (smear-slide information) also occurs. Zeolites presumably formed by conversion of volcanic matter.

SUMMARY

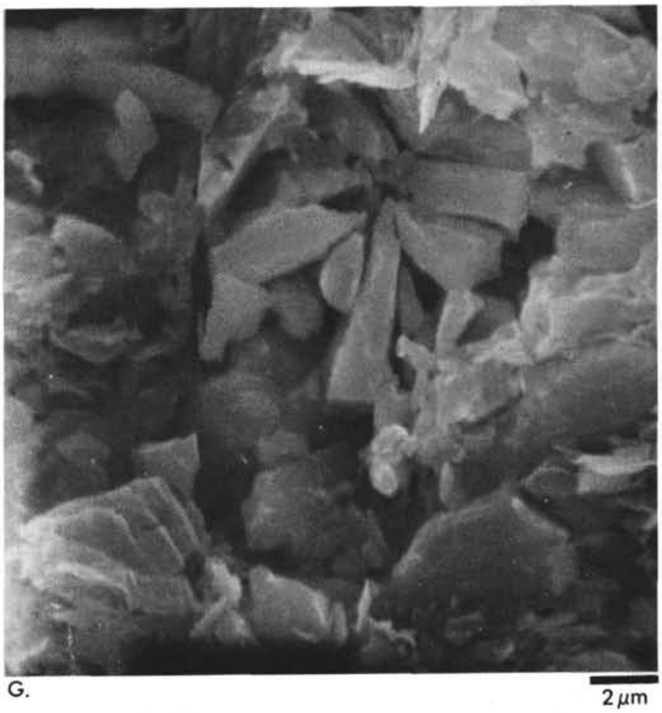
The mineral composition of deep-sea sediments in all sites studied (late Cenozoic) was mostly due to terrigenous transport. The distribution of clay and other minerals within the Black Sea deposits is



E.



F.



G.

Figure 6. *(Continued).*

nonuniform, and their contents are rather variable. In addition, the ratios between individual minerals are inconstant. These pecularities of deep-sea sediment mineral composition are associated with repeated changes in conditions of mobilization of sedimentary matter throughout the drainage area in relation to sharp variations of the climatic regime (alternation of glacial and interglacial epochs). Additionally, the changes in sea level (transgressions and regressions) and changes in the depths of river valley erosion were contributing factors. A substantial part of the sedimentary matter was mobilized by erosion of the bedrock, especially in the folded Alpine zone.

The variation in the biogenic carbonate minerals was produced by a hydrochemical and hydrodynamic regime in the Miocene-Pleistocene differing from that

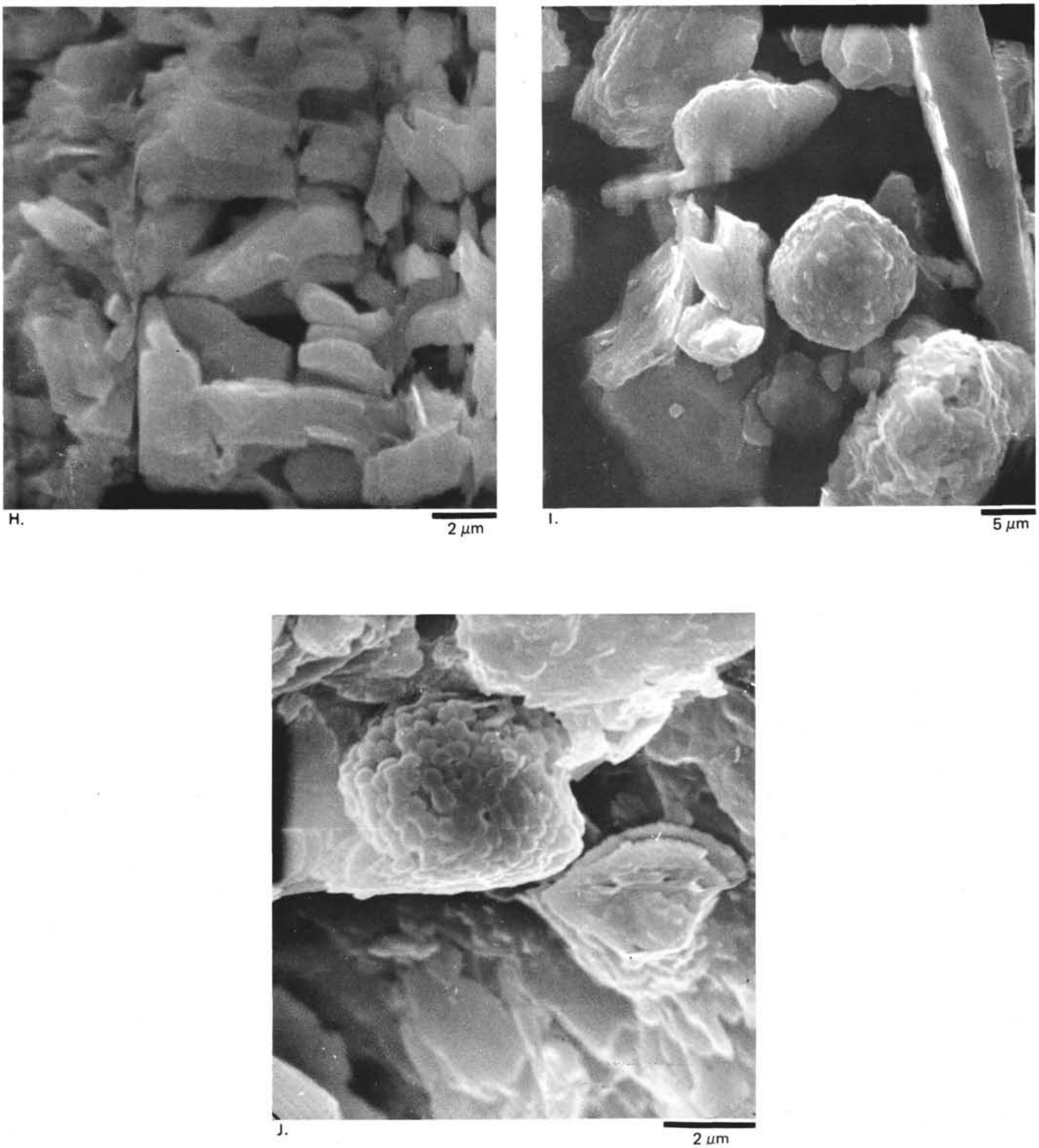


Figure 6. *(Continued).*

of Recent time and which underwent repeated changes. In addition, diagenetic processes played an important role. Secondary mineral formation such as dolomitization, sideritization, etc. is very characteristic of the Pliocene-Miocene deposits.

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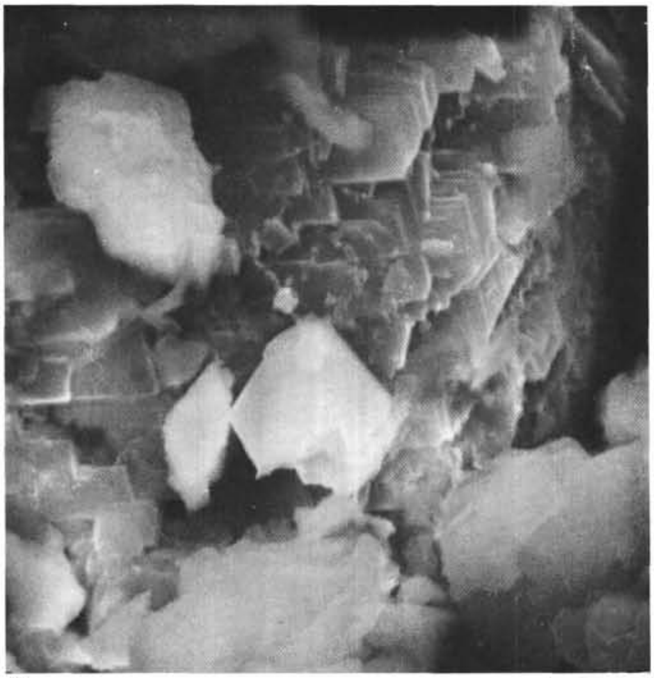
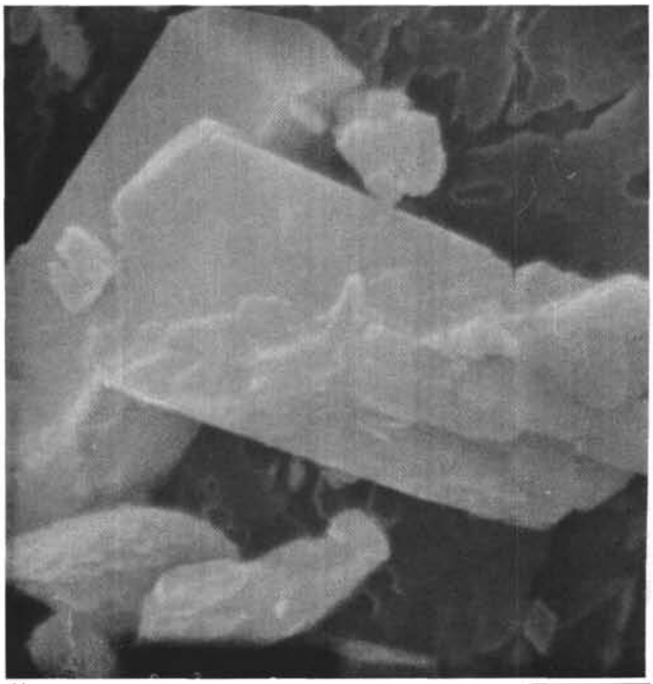


K. 5 μm

L. 5 μm



M. 2 μm

Figure 6. *(Continued)*.

TABLE 6
Average Mineral Content (in %) of Lithologic Units, Sites 379, 380, and 381, Leg 42B

Unit	Number of Samples	Montmorill-onite	Illite	Chlorite	Kaolinite	Calcite	Quartz	K-feld-spars	Plagio-clase
Hole 379A									
3	5	9.4	21.4	14.2	2.8	15.3	18.7	4.6	12.0
4	11	6.8	18.9	10.3	1.2	15.6	17.6	4.9	17.9
6	17	9.3	21.2	18.4	2.7	15.4	17.5	4.1	9.9
7	9	8.5	21.7	16.9	2.4	21.0	13.8	3.4	8.7
8	19	9.7	20.0	17.1	2.7	20.9	14.9	3.3	10.1
9	20	12.4	16.0	14.3	2.1	26.1	13.8	3.6	10.1
Holes 380/380A									
1_c	11	5.4	33.8	8.9	1.2	9.5	18.9	2.4	8.7
1_d	4	5.9	43.3	9.4	0.0	7.7	17.8	0.4	8.2
1_e	5	3.8	48.3	11.0	1.3	8.6	13.1	2.1	5.3
1_f	4	3.8	49.4	10.4	0.5	5.8	14.4	1.4	6.8
1_g	9	5.4	45.2	10.4	1.6	8.2	16.4	0.8	6.1
1_h	5	3.9	46.8	10.9	1.1	5.4	14.8	1.8	6.4
2	15	10.5	33.6	9.1	2.4	16.2	16.5	1.6	5.4
3	20	12.3	24.8	7.6	2.3	32.0	15.0	0.0	4.1
4_a	2	21.2	33.2	10.3	0.0	0.0	21.0	0.0	5.7
4_b	6	11.1	24.6	7.0	2.0	32.0	13.4	2.1	4.2
4_c	1	7.0	14.0	0.0	0.0	65.0	10.5	0.0	3.5
4_e	5	6.4	36.3	3.9	0.7	2.8	11.7	2.7	5.9
5	3	9.1	30.9	4.5	5.2	5.2	10.7	5.2	6.7
Site 381									
3a	4	15.6	28.5	14.7	3.0	8.2	18.5	0.0	7.7
3b	17	16.6	22.8	11.8	2.4	20.7	15.6	1.0	5.6
4	2	8.2	4.4	4.6	0.0	32.0	28.8	7.3	1.7
5	15	28.0	18.8	12.3	3.7	8.1	11.1	0.4	4.2
6	17	15.2	14.5	7.8	3.5	38.1	13.7	1.0	3.2
7	8	7.8	13.3	4.6	1.0	5.4	15.1	3.4	7.0
8	8	4.6	6.7	3.0	0.4	4.5	17.6	3.9	11.0
9	6	14.4	33.8	20.4	2.8	0.0	10.8	4.8	10.9
10	2	7.4	39.7	16.8	4.1	0.0	9.8	6.2	15.9
11	4	7.2	43.2	20.0	2.1	tr.	9.8	7.0	10.8

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