8. X-RAY MINERALOGY OF DEEP SEA DRILLING PROJECT LEGS 51 THROUGH 53, WESTERN NORTH ATLANTIC

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INTRODUCTION

A series of 140 samples from Holes 417A, 417B, 418A, and 418B were examined semiquantitatively for their X-ray mineralogy. We selected most samples from the dominant lithologies rather than by coring the same sedimentary sequence at Sites 417 and 418, only 8 km apart (Figure 1). Both sites are located at the foot of the Bermuda Rise (Figure 2) along the *M*0 magnetic anomaly on crust of lower Aptian age. Sediments are mainly abyssal pelagic clays, with various authigenic minerals low in carbonates.

METHODS

Analysis Conditions

The mineralogical data in Tables 1 and 2 are for samples dried at 70°C, powdered and X-rayed under the following conditions: CuKα radiation, nickel filter, 36 kv/24mA, and 1° detection slit. Goniometer speed was 0.5° = 2θ/min, paper speed 10 mm/min. All samples were X-rayed from 3° to 40° = 2θ.

Clay minerals were identified on oriented glass smear mounts. To obtain the optimal texture, the <2 μm fraction was first disintegrated with a KLN 582 ultrasonic generator and then centrifuged to clearness. The residue was mixed to a homogeneous paste and finally placed on the glass slide. It was X-rayed in an untreated state and glycolated, when necessary, after heating.

Factor Analysis

For the bulk mineralogy, the factors used are those listed in Table 3. When multiplied by their peak heights, they add up to 100 per cent. Because of the large amount of amorphous material — i.e., volcanic glass, opal, and amorphous clay minerals — and without using the monochromator, diffuse scattering was relatively high. Thus, if these components vary, the factors have to be redetermined. These factors can only be used for sedimentary types that are very similar to those above; for example, they cannot be applied to nearshore sediments on account of their higher crystallinity.

For the clay mineralogy, we used the method discussed by Biscaye (1965). The factors in Table 4 were multiplied by the peak area, determined planimetrically; the sum of these was 100 per cent. The kaolinite/chlorite peak at 12.3Å = 2θ was divided by peak splitting at 24 to 25° = 2θ — a factor obtained from the ratio:

$$\frac{3.58\text{ Å peak area}}{3.58\text{ Å} + 3.54\text{ Å peak area}}$$

The carbonate contents were determined gasometrically by carbonate bomb (Müller and Gastner, 1971). X-ray numerical data for all holes are presented in tabular form on the core barrel sheets following the site report chapters. Mineral identifications were made manually and peak areas measured with the aid of a template having graduated triangles. The amount of amorphous material was not determined quantitatively.

RESULTS

X-ray results are listed in Tables 1 and 2. A graphic representation in Figures 3 through 5 places the samples at their proper stratigraphic depths.

Unit 1 and 2 pelagic clays are characterized mainly by a chlorite component in the dominant clay universal spectrum. Rhodochrosite and dolomite appear in the base of Unit 2 above the first clinoptilolite occurrences in Unit 1. Palygorskite occurs in the nonzeolitic interval of mid-Eocene radiolarian clays. Multicolored Cretaceous clays are rich in clinoptilolite and cristobalite from former radiolarian tests.

Palygorskite increases in abundance downhole in the Upper Cretaceous. In the Middle Cretaceous black clay facies, the clay-mineral assemblage changes to dominantly mixed-layer varieties; illite peaks are asymmetric; zeolites plus cristobalites disappear; and quartz (and, periodically, calcite) becomes an important constituent. Several authigenic phases were detected, including pyrite, gypsum, barite, and apatite (phosphates).

REFERENCES

Biscaye, P. E., 1965. Mineralogy and sedimentation of recent deep-sea clay in the Atlantic Ocean and adjacent seas and oceans, *Geol. Soc. Am. Bull.*, v.76, no. 7, p. 803-832.

Müller, G. and Gastner, M., 1971. The "Carbonate Bomb," a simple device for the determination of the carbonate content in sediments, soils, and other materials, *N. Jb. Mineral.*, v. 10, p. 466-469.

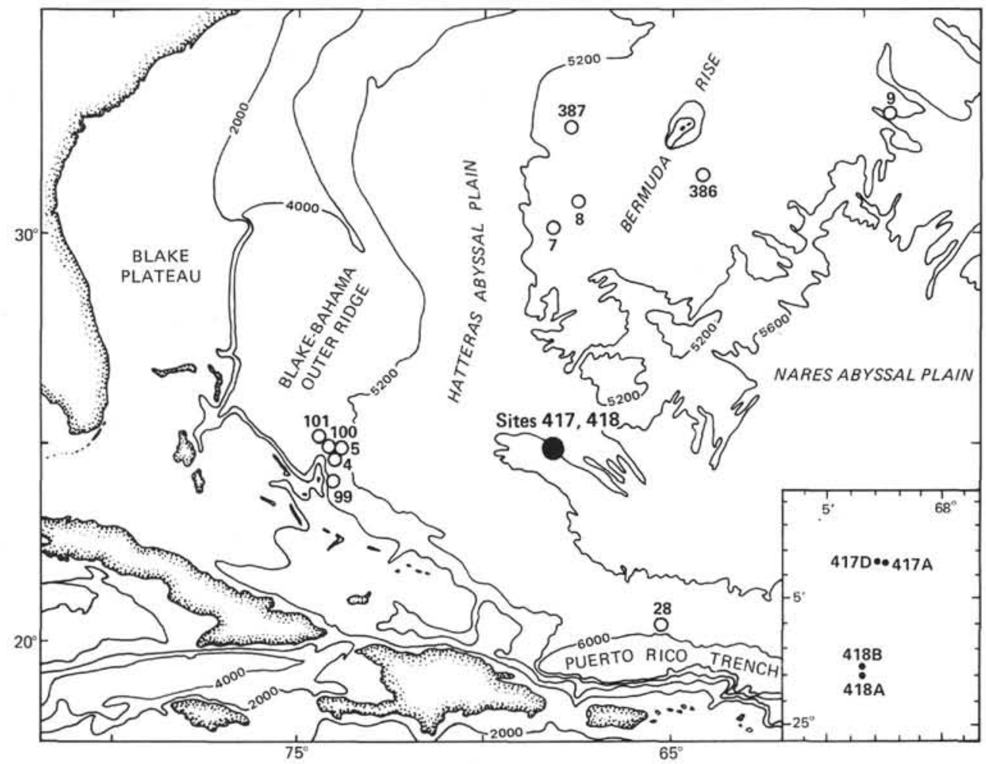


Figure 1. *Location of Sites 417 and 418.*

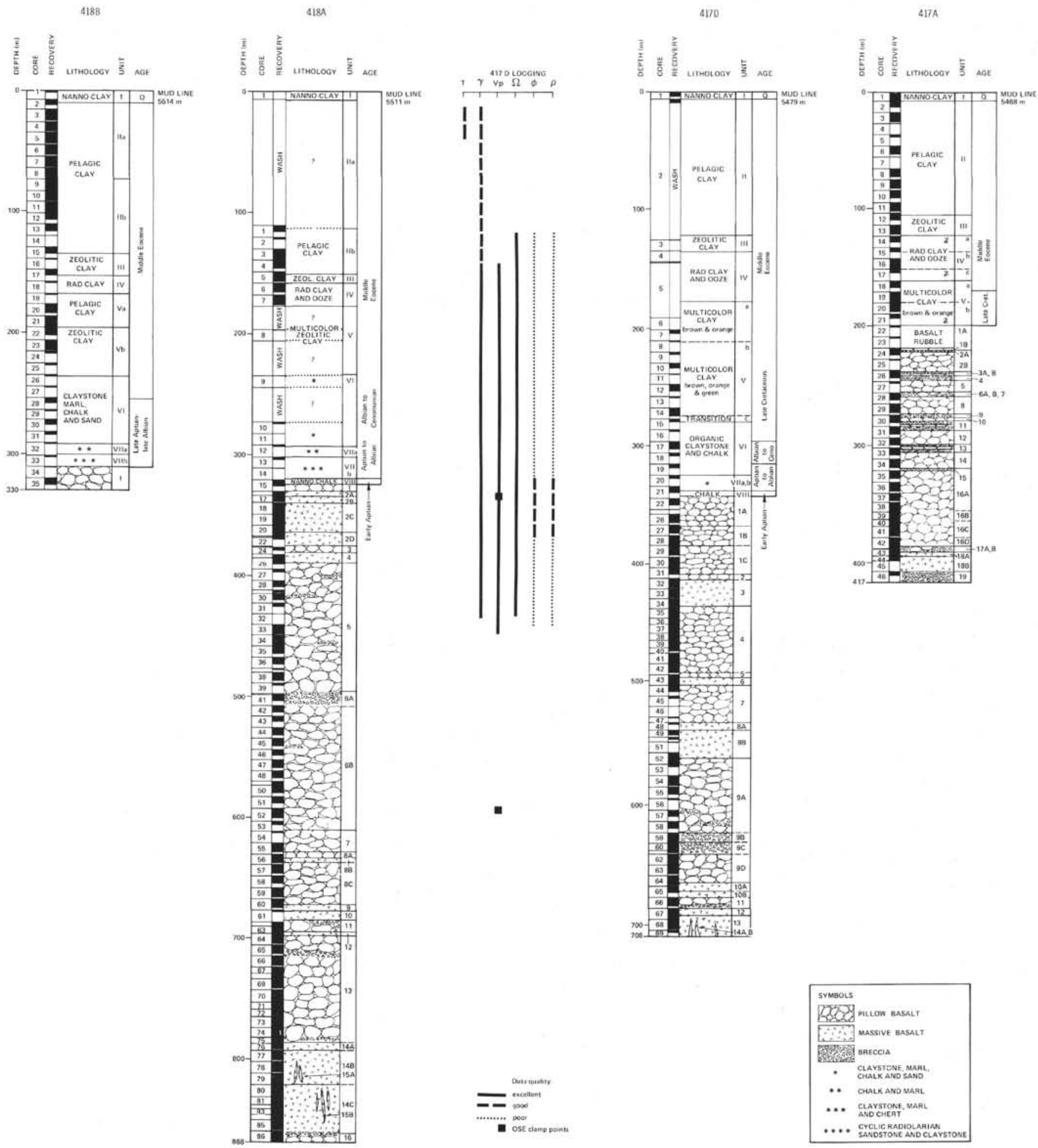


Figure 2. *Stratigraphy of sediment and basement sections of Sites 417 and 418.*

TABLE 1
X-Ray Mineralogical Analysis, Site 417, Holes 417A and 417D

				Bulk Mineralogy = 100%											Carbonates		Clay Mineralogy = 100%							Mixed Layer = 100%		
X-Ray Number	Core	Section	Interval (cm)	Clay minerals	Quartz	Feldspar	Pyroxene	Hornblende	Cristobalite	Clinoptilolite	Pyrite	Gypsum	Other	Total carbonate[a]	Calcite	Other	Smectite	Chlorite	Illite	Kaolinite	Palygorskite	Other	Mixed layer	Smectite part	Illite part	Assym. illite
Hole 417A																										
1	1	3	40-42	88	9	2	1										45	7	32	16						
2	1	3	88-90	82	14	3	1										33	6	51	10						
3	1	5	30-32	85	12	2	1										39	6	36	19						
4	2	3		85	12	2	1										39	8	35	18						
5	3	3		83	13	2	1	1									41	5	34	20						
6	3	5		86	11	2	1										50	2	28	20						
7	5	2		85	11	2	2										49	6	27	18						
8	6	3		87	10	2	1										39	5	24	32						
9	6	5		89	9	1		1									40	2	25	33						
10	8	3		82	13	3							Apatite 2				42	3	18	37						
11	8	5		89	10	1											57	5	14	24						
12	9	3	59-61	86	10	2							Apatite 2				50	6	20	24						
13	9	3	91-93	87	10	2	1		1								47	3	25	25						
14	9	5		88	8	1	1	1								Dolomite 1	46	5	21	28						
15	10	3		80	10	3	2	1					Apatite 1			Rhodochrosite 3	37	5	31	27						
16	11	3		84	10	2	1		?				Apatite ?			Dolomite 1 Rhodochrosite 2	41		17	42						
17	11	5		88	9	1	1									Dolomite? Rhodochrosite 1	56		18	26						
18	12	3		87	9	2			1				Apatite ?		1		73		8	18						
19	13	1		83	10	2	1		1				Apatite 1			Rhodochrosite 2	43		23	24						
20	13	3		84	8	2			2	2							64		13	22		Talc 1				
21	13	4		87	8	2			1	2							53		19	28						
22	13	5		88	9	2				1							59		14	7						
23	14	3		88	7	2				3							73		10	17						
24	15	3		83	9	2		1		4			Apatite 1				67		16	17						
25	16	3		84	9	2	1			4							72		9	17	1	Talc 1				
26	17	1		87	5	2	2		?	4							10		51	5	29	Sepiolite 5				
27	18	2		90	8	2											33[b]		26	39		Talc 2				
28	18	3		87	10	2		1		?							42[b]		28	27	1	Talc 2				
29	19	2		86	11	2	1										32[b]		24	44						
30	19	3		83	12	2	2						Apatite?			Dolomite 1 Rhodochrosite?	47[b]		23	30						
31	20	3		86	9	3	1									Rhodochrosite 1	51[b]		22	26	1					
32	20	5		88	8	2	2										40		31	27	2					
33	21	3		84	7	2	2			5							52		31	15	2					
34	22	1		84	8	2	1			5							54		30	24						
35	23	1		85	8	2	1			4							46		30	24						
Hole 417D																										
36	7	2		85	8	3	1	1		2							53		21	25	1					
37	8	1		75	6	2	2		4	11							63	3	26	8						
38	9	1		85	7	2	1		2	3							39		39	22						
39	9	2		82	8	1	1		3	5							51		33	16						
40	10	2		82	8	2	1	2	2	3							40		24	36						
41	10	3		83	8		2		2	4			Apatite 1				64		14	22						
42	12	2		86	7		2		2	3							62		16	22						
43	12	3		85	7	2	1		2	3							59		18	23						
44	13	1	25-26	85	7		2		2	3						Dolomite 1	61		14	23	1	Talc 1				
45	13	1	27-28	80	7	2	2		3	5			Apatite 1				58		19	25	1					
46	13	1	47-49	83	7	3	1		2	4						Rhodochrosite?	55		19	25	1					
47	14	1		79	6	2	2		3	8							32		53	13	2					
48	14	3	40-41	75	4	2			8	11							41		51	5	3					
49	14	3	72-73	82	6	2			3	7							43		44	11	2					
50	14	3	129-131	85	8	3	1			3							46		33	20	1					
51	14	5	63-64	74	6				5	15							55		43	1	1					
52	14	5	89-92	81	6	2	2		2	7							59		31	8	2					
53	15	1	43-44	76	7	2	2		2	11							57		41		2					
54	15	1	44-45	80	7		1		2	10							81		16	1	2					
55	16	1		79	5	2		2		2				10		Dolomite 9 Rhodochrosite 1	77		21	1	1					
56	17	3		70	11				1					18	18		30		58	1	11					
57	17	4		82	13	2			1				Barite 1 Apatite 1				54		42		4					
58	18	1	65-66	79	13	2	2		2				Barite 1 Apatite 1					3	50		47					
59	18	1	105-106	76	18	2	1		1				Barite 1 Apatite 1				15	2	54		29					
60	18	2	7-9	78	18	1			1				Barite 2				21	2	51		26					
61	18	2	45-47	76	19	2			1				Barite 2				28		64		8					
62	18	2	56-58	76	18	2	1		1				Barite 2				16	2	62		20					
63	19	1	67-69	68	29	1							Barite 2				31		67			Sepiolite 2?				
64	19	1	68-69	65	31	1							Barite 3										100	43	57	
65	19	1	127-128	62	35	1							Barite					1					99	9	91	
66	19	2		70	23	1	1						Barite 2 Apatite 3					4					96	29	71	
67	20	1		72	15	1							Barite 1	11	11								100	21	79	
68	20	2	45-47	44	13								Barite 1	42	32								100	19	81	
69	20	2	118-119	34	60								Barite 1	5	5								100	12	88	
70	21	1		30	7								Barite 1	62	62			7					93	21	79	
71	21	2	6-7	75	21								Barite 1													100
72	21	2	76-77	47	16	1							Barite 4	32	32											100
73	21	3	4-5	48	7	1							Barite 1 Apatite 1	33	42	Dolomite 1		3					97			100
74	21	3	30-31	38	9									53	53											100
75	21	3	70-73	76	14	1	1				4	4						2					98	1	99	
76	21	3	84-86	61	12	1					7	7	Apatite 2	10	10			4					96	3	97	
77	21	3	124-146	26	4						3	3		64	64											100
78	21	4		8	2						2	2		86	86											100

[a] If > 3 per cent.
[b] Smectite with shoulders.

TABLE 2
X-Ray Mineralogical Analysis, Site 418, Holes 418A and 418B

				Bulk Mineralogy = 100%											Carbonates		Clay Mineralogy = 100%							Mixed Layer = 100%		
X-Ray Number	Core	Section	Interval (cm)	Clay minerals	Quartz	Feldspar	Pyroxene	Hornblende	Cristobalite	Clinoptilolite	Pyrite	Gypsum	Other	Total carbonate[a]	Calcite	Other	Smectite	Chlorite	Illite	Kaolinite	Palygorskite	Other	Mixed layer	Smectite part	Illite part	Assym. illite
Hole 418A																										
1	1	1	65-67	77	14	4P/2K	1						Apatite 1			Dolomite 1	27	10	52	11						
2	1	4	60-62	79	13	4P/2K	1									Dolomite 1	25	9	56	10						
3	1	2	83-85	88	9	2	1										57		21	22						
4	2	1	14-16	87	10	2	1										49		28	23						
5	3	2	35-36	85	10	3	1	1									51		22	27						
6	3	4	54-56	86	9	2	1	1								Rhodochrosite 1	50		21	29						
7	3	6	11-13	75	9	5P/7K			2				Apatite 1			Rhodochrosite 1	62		15	23						
8	3	6	44-46	84	10	2							Apatite 1			Rhodochrosite 2	43[b]	25								
9	1	1	69-71	86	11	2										Rhodochrosite 1	45[b]	23	32							
10	4	5	47-49	87	10	2			1								40	29	31							
11	5	1	18-20	87	9	2			1							Rhodochrosite 1	43	22	33			Sepiolite 2				
12	5	3	67-69	88	9	2			1								62	13	25							
13	5	4	28-30	85	9	2	1	1	1							Rhodochrosite 1	63	17	20							
14	5	4	109-111	86	9	2	1	1	1								54	20	26							
15	6	1	67-70	85	7	2			2	4							63	21	16							
16	7	2	63-65	84	5	2	1		1	7							73	16	8	1		Talc 2				
17	7	4	28-30	81	9	2			1	7							73	16	8	1		Talc 2				
18	7	5	46-48	89	5	2			2				Apatite 1		1		5		39	trace	61	Sepiolite 5				
19	8	1	144-146	90	7	2	1										61		16	21	1	Talc 1				
20	10	1	109-111	71	10	2			4		4		Barite 4				16	trace	75		9					
21	12	1	69-71	62	22	1			1				Apatite 5 Barite 1	13	13		65		35							
22	13	1	62-64	37	15									48	48								100	7	93	
23	13	2	15-18	72	26	2																	100	5	95	
24	13	2	109-110	73	24	1							Barite 1 Apatite 1										100	3	97	
Hole 418B																										
1	1	1	141-143	60	17	5	2	2						14	12	Dolomite 2	30	13	36	21						
2	2	1	51-53	74	20	4	2										31	5	40	24						
3	3	1	67-69	73	23	2	2										36	6	39	19						
4	3	3	67-69	73	22	3	2										41	6	33	20						
5	4	1	82-84	76	10	3	1										45	5	36	14						
6	5	1	74-76	77	19	3	1										42	4	30	24						
7	6	6	36-38	83	16	2	1										46	4	25	25						
8	7	6	56-58	81	16	2	1										47	3	26	24						
9	8	1	77-79	81	16	2	1										42	4	23	31						
10	8	4	6-8	83	14	2	1										46		17	27						
11	9	1	72-74	80	17	2	1										45		28	27						
12	9	6	52-54	86	10	1	1									Rhodochrosite 2	62		18	20						
13	10	1	71-73	86	12	2											71		13	16						
14	10	3	133-134	88	8	2										Rhodochrosite 2	62		21	17						
15	11	2	85-87	83	13	2	2										68		15	17						
16	11	3	85-87	82	14	2	2										72		16	12						
17	13	1	65-67	77	19	2	2										54		21	22						
18	15	2	78-80	81	15	2		2									49		22	29						
19	16	1	20-22	87	12	1											56		18	26						
20	17	1	92-94	83	13	2	2						Apatite?			Rhodochrosite?	61		14	25						
21	18	1	109-111	80	11	2	2		1	4						Rhodochrosite?	64		13	23		Sepiolite				
22	19	2	23-25	81	8	2	2		1	5			Apatite 1				12		50	10	21	Sepiolite 6 Talc 1				
23	20	2	77-79	83	12	2	2						Apatitie 1				40		30	25	2	Talc 3				
24	21	6	49-50	87	8	2	2						Apatitie 1				64		12	20	1	Talc 3				
25	22	1	22-24	81	9	2	2	1		5			Barrite?				41		31	24		Talc 4				
26	22	2	18-20	76	13	2	2			7							43		26	31						
27	23	1	15-17	78	10	1	1			10							47		31	22						
28	25	2	78-80	85	10	2	1			2							46		28	26						
29	26	1	80-82	76	5	3	2			5	3	4	Apatitie 2				95		5							
30	26	1	146-148	86	9	1	1			3							37		36	23	4					
31	27	1	5-7	78	6	2			1	1				12	12		69		25		6					
32	29	1	55-57	78	7	1			4		2	2	Apatite 2 Barrite?	4	4		60		34		6					
33	30	2	84-85	69	20				11				Barrite?										100	19	81	
34	32	1	85-87	58	36									16	16								100	2	98	
35	32	1	119-121	67	16	1								16	16								100	12	88	

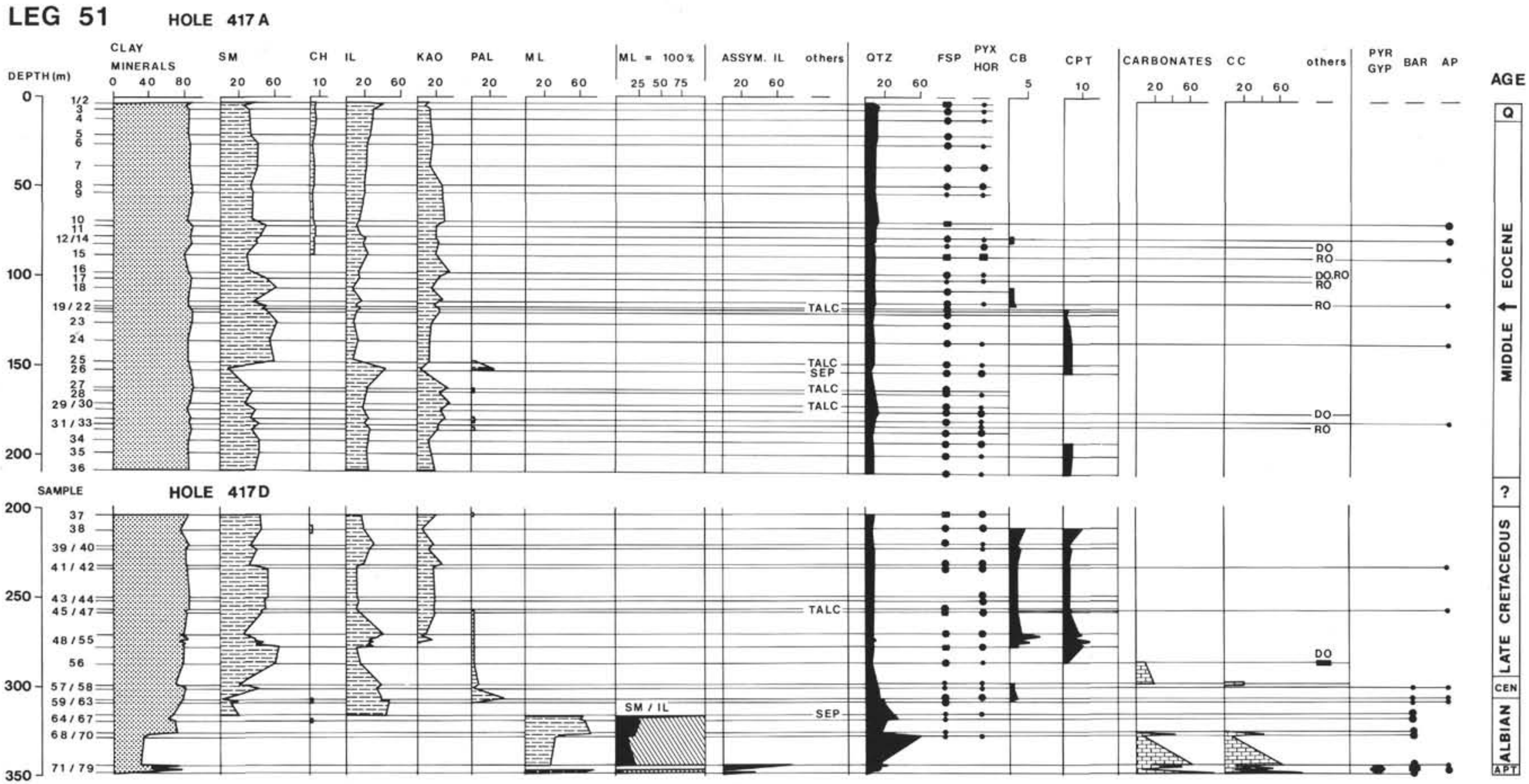
Note: P = plagioclase; K = potassium feldspar.
[a]If > 3 per unit.
[b]Smectite with shoulder.

TABLE 3
Factor for Minerals Investigated, Bulk Mineralogy

Mineral	Peak 2 θ (in degrees)	d (in Å)	Factor
Quartz	26.7	3.34	1.3
Feldspar	27.4-28.0	3.25-3.18	2.0
Pyroxene	29.9	2.99	2.0
Hornblende	10.5	8.42	2.0
Cristobalite	21.5-21.9	4.15-4.05	1.5
Clinoptilolite	9.8	8.99	2.0
Pyrite	33.0	2.71	2.0
Gypsum	11.7	7.56	2.0
Rhodochrosite	31.4	2.85	2.0
Barrite	25.9	3.44	2.0
Apatite	32.2	2.78	2.0

TABLE 4
Factors for Minerals Investigated, Clay Mineralogy

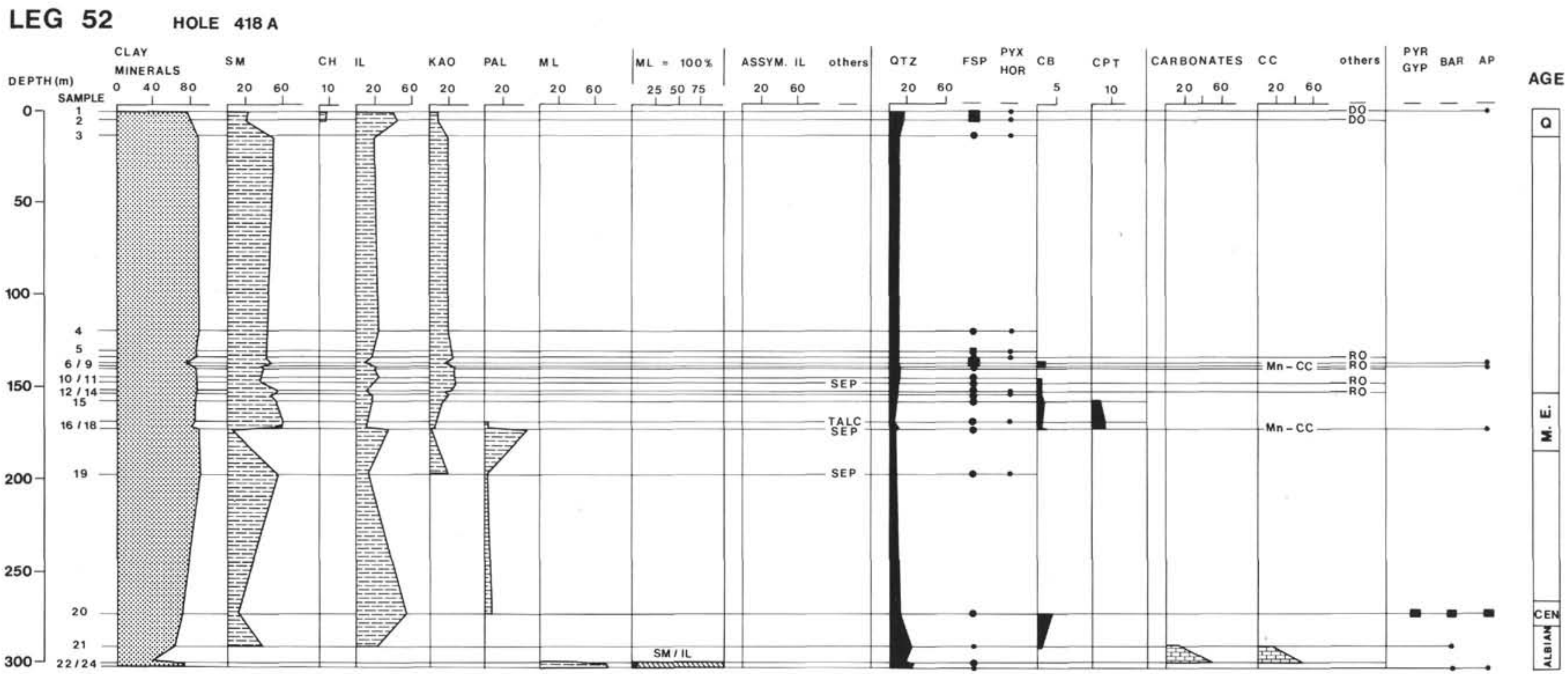
Mineral	Peak 2 θ (in degrees)	d (in Å)	Factor
Smectite	5.2	17.0	1
Chlorite	12.3	7.2	2
Illite	8.8	10.0	4
Kaolinite	12.3	7.2	2
Palygorskite	8.4	10.5	1
Talc	9.4	9.3	1
Sepiolite	7.4	12.0	1
Mixed layer	Same as its parts		



ABBREVIATIONS :

- SM – SMECTITE
- CH – CHLORITE
- IL – ILLITE
- KAO – KAOLINITE
- PAL – PALYGORSKITE
- ML – MIXED LAYER
- SEP – SEPIOLITE
- QTZ – QUARTZ
- FSP – FELDSPAR
- PYX – PYROXENE
- HOR – HORNBLENDE
- CB – CRISTOBALITE
- CPT – CLINOPTILOLITE
- CC – CALCITE
- PYR – PYRITE
- GYP – GYPSUM
- BAR – BARITE
- AP – APATITE
- DO – DOLOMITE
- RO – RHODOCHROSITE

Figure 3. *X-ray diffraction data, Hole 417A.*



ABBREVIATIONS :

SM – SMECTITE
CH – CHLORITE
IL – ILLITE
KAO – KAOLINITE
PAL – PALYGORSKITE
ML – MIXED LAYER
SEP – SEPIOLITE
QTZ – QUARTZ
FSP – FELDSPAR
PYX – PYROXENE
HOR – HORNBLENDE
CB – CRISTOBALITE
CPT – CLINOPTILOLITE
CC – CALCITE
PYR – PYRITE
GYP – GYPSUM
BAR – BARITE
AP – APATITE
DO – DOLOMITE
RO – RHODOCHROSITE

Figure 4. *X-ray diffraction data, Hole 418A.*

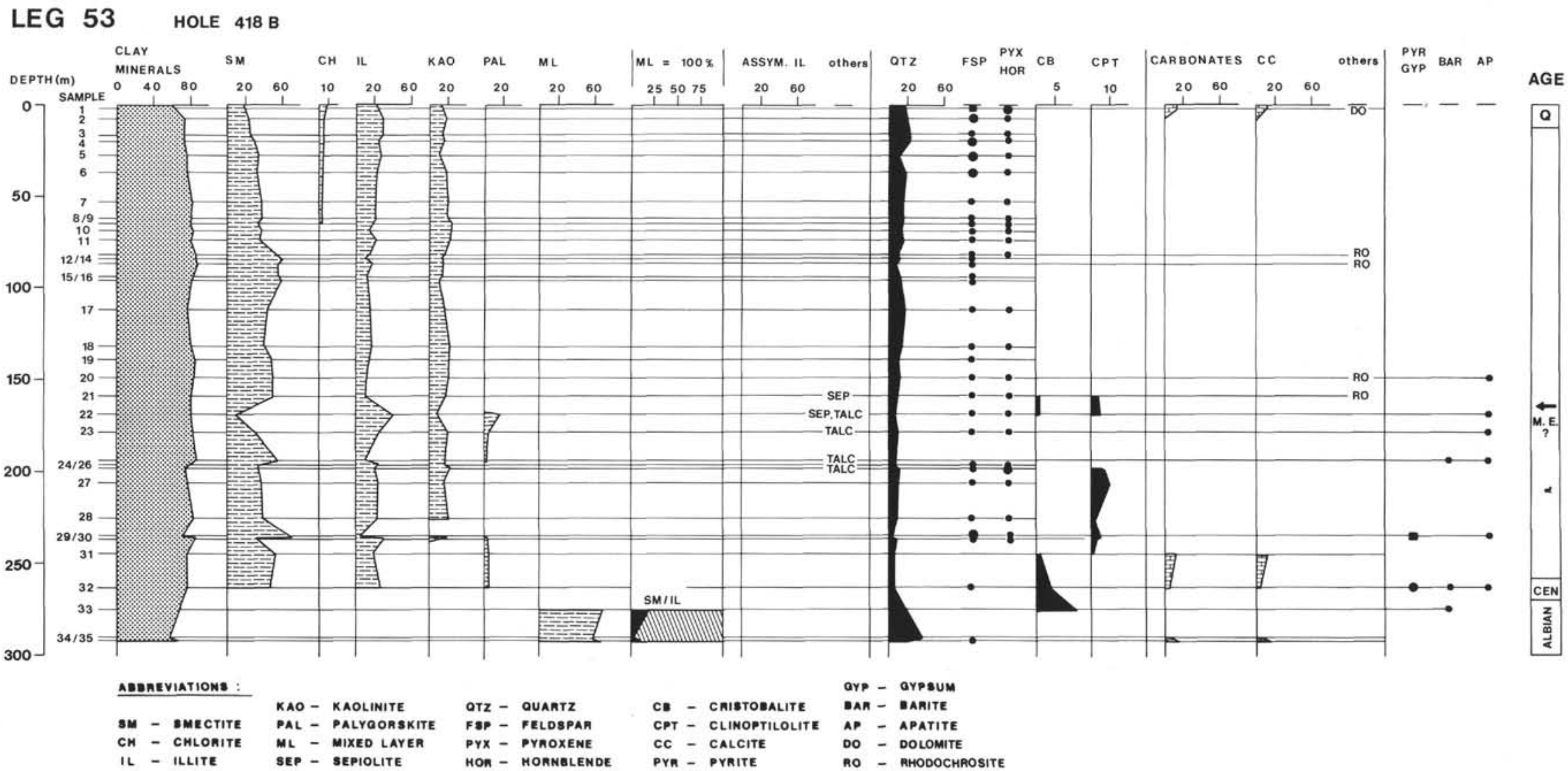


Figure 5. *X-ray diffraction data, Hole 418B.*