

12. X-RAY MINERALOGY OF DSDP LEGS 44 AND 44A, WESTERN NORTH ATLANTIC: LOWER CONTINENTAL RISE HILLS, BLAKE NOSE, AND BLAKE-BAHAMA BASIN

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METHODS

Bulk samples were analyzed with an X-ray diffractometer in order to obtain semiquantitative determinations of the mineral composition of the sediments sampled. The analyses were performed in the manner of Cook et al., 1975.

Briefly, the method was as follows. Bulk samples were washed with distilled water to remove sea salts and ground to less than 10 μm under butanol. They were then treated with trihexylamine acetate to expand smectite minerals and X-rayed as random powders. Bulk samples were subjected to Cu-K α radiation at 2° 2 θ /minute. A 1° divergence slit and a 0.001 inch receiving slit with a curved crystal monochromator were used. Diffraction patterns were recorded on chart paper at 1 inch/minute with a full-scale reading of 1000 counts per second. Due to equipment failures and time constraints, three different X-ray diffraction units were used during the course of this study. Identical samples run on all three machines showed relative peak intensities which were within the limits of the technique. Standard rate-meter techniques were used with a time constant of 0.5 second.

Mineral identifications were made manually on the basis of a peak present within one of the windows indicated by Cook et al., 1975, and verified by the presence of secondary peaks. Diffraction traces were manually smoothed and the diagnostic peak heights were measured. Secondary peaks were used to calculate the diagnostic peak height if the diagnostic peak was off-scale. Peak heights were corrected for interfering peaks of other minerals present in the sample, and mineral weights were calculated by the method of mutual ratios (Cook et al., 1975). The total of all minerals identified was set equal to 100% and relative mineral composition computed with abundances reported to the nearest percent. The amount of amorphous material was not determined quantitatively.

Several factors combine to limit the accuracy and precision of the measurements made here. The limitation on accuracy is mainly in the use of the weighting factors (derived by Cook et al., 1975). As they pointed out, these factors were determined by ratioing the diagnostic peak of the mineral in question to the major quartz peak in mixtures of known composition. Differences in crystallinity between the mineral standards and the mineral samples and the interference from other diffraction peaks often keep the accuracy of the method below the implied precision. Zemmels and Cook (1976) reported that the errors

could be as much as $\pm 50\%$ for smectites; $\pm 20\%$ for micas, chlorites, cristobalite, tridymite, and goethite; $\pm 10\%$ for kaolinite, amphibole, augite, feldspar, zeolite, palygorskite, sepiolite, and apatite and $\pm 5\%$ for minerals which have stable crystal lattices and are not members of solid solution series (or typically have limited crystal-lattice substitution in the sedimentary environment) such as quartz, low-magnesian calcite, aragonite, dolomite, rhodochrosite, siderite, gibbsite, talc, barite, anatase, gypsum, anhydrite, halite, pyrite, hematite, and magnetite.

Strictly speaking, the weighting factors are only valid when used with the X-ray diffraction system for which they were derived. However, because of the similarity of the instruments involved, these factors were applied in this work. The use of these weighting factors, as well as the use of three X-ray diffraction units during the course of the study, also reduce the accuracy below the implied precision.

The sensitivity of the method is limited mainly by the effectiveness of the random background noise in masking the diagnostic and secondary peaks of a mineral. In general, a mineral has to comprise 1%-2% of a sample before it will be recorded on an X-ray diffractogram.

In using these data one should bear in mind that the reported values are not absolute concentrations, i.e., some adjustment must be made for the amount of amorphous material and any unquantified minerals. Moreover, the trends seen within a homogeneous set of minerals are valid, but, in order to compare mineral concentrations between lithologic units or geographical regions, information on the crystallinity is required.

RESULTS

Site 388

Hole 388A was drilled in the lower continental rise hills found at the base of the continental rise on the western Atlantic continental margin. The purpose of this hole was to determine the origin of these hills. Two sedimentary units were recognized by the shipboard scientists. Table 1 summarizes the X-ray diffraction data for this hole.

Unit 1

Unit 1 consists of Recent to lower Pleistocene terrigenous sediments ranging from coarse sand and silty clay to clay. Five samples were X-rayed from this unit. Carbonates are present with calcite comprising 16%-42% of the samples and dolomite accounting for

TABLE 1
X-Ray Mineralogy Summary, Hole 388A

Sample (Interval in cm)	Depth (m)	Unit	Calc.	Dolo.	Side.	Quar.	K-Fe.	Plag.	Mica	Mont.	Kaol.	Chlo.	Pyri.	Hema.	Amph.
1-3, 99-101	4.0	1	41	2	—	29	6	12	6	—	3	—	—	—	—
1-4, 100-102	5.5	1	23	2	—	43	11	12	8	—	2	—	—	—	—
2-1, 126-128	38.3	1	22	2	—	27	14	21	8	—	3	—	—	2	2
2-2, 99-101	39.5	1	42	1	—	31	6	9	6	—	3	—	—	3	—
2-3, 100-102	41.0	1	16	1	—	33	5	8	23	—	10	2	—	3	—
5-1, 100-102	247.0	2	—	—	—	43	8	9	19	4	8	2	6	—	—
5-3, 100-102	250.0	2	—	—	—	47	7	7	19	10	8	3	—	—	—
5-6, 88-90	254.4	2	—	—	—	53	8	7	16	5	7	—	—	3	—
6-2, 90-91	286.4	2	15	—	30	25	—	—	10	10	—	—	—	11	—
7-2, 99-101	296.0	2	—	—	—	66	4	6	14	5	5	—	—	—	—
7-3, 104-106	297.6	2	—	—	—	49	7	12	15	8	6	3	—	—	—
8-1, 108-110	304.1	2	—	—	2	43	6	9	24	9	6	—	—	—	—
9-3, 108-110	316.6	2	—	—	3	42	7	10	21	10	7	—	—	—	—
9-4, 42-44	317.4	2	11	—	—	35	7	7	19	9	9	—	—	3	—
9-5, 68-70	319.2	2	—	—	—	62	6	5	15	5	5	—	—	—	—
10-1, 128-130	323.3	2	—	—	1	42	9	8	24	9	8	—	—	—	—
11-2, 12-14	333.1	2	28	—	4	28	5	8	15	5	6	—	—	—	—
11-2, 26-28	333.3	2	2	—	3	48	6	9	18	6	8	—	—	—	—

1%-2%. Silicate minerals are abundant with quartz accounting for 27%-43%, total feldspar for 13%-35%, clay minerals for 9%-33%, and amphibole (0%-2%) is present in trace amounts. Plagioclase (8%-21%) is more abundant than K-feldspar (5%-14%), and mica (6%-23%) is the dominant clay mineral with kaolinite (2%-10%) secondary and chlorite (0%-2%) present in trace amounts. The major peak for hematite was seen (0%-3%) but no secondary peaks were detected.

Unit 2

Unit 2 is late to middle Miocene clay and silty clay. Thirteen samples were analyzed from this unit. Carbonate minerals present are calcite (0%-28%) and siderite (0%-4%). Silicates include quartz (28%-66%), feldspars (10%-19%), and clay minerals (21%-40%). Plagioclase (5%-12%) and K-feldspar (4%-9%) are almost equally abundant, and mica is the dominant clay mineral (10%-24%) with montmorillonite (4%-10%), kaolinite (0%-9%), and chlorite (0%-3%) also present. Pyrite was seen to form 6% of one sample. A siderite nodule at Sample 6-2, 90-91 cm contained 15% calcite, 30% siderite, 25% quartz, 10% mica, 10% montmorillonite, and 11% hematite. Hematite (0%-3%) was also scattered throughout this unit.

Site 390

Holes 390 and 390A were drilled on the Blake Nose to study the Cretaceous reef complex and the overlying Tertiary sequence. Eight lithologic units were recognized by the shipboard scientists. No samples from unit 1 were analyzed. Tables 2 and 3 summarize the X-ray diffraction data from these two holes.

Unit 2

Unit 2 is zeolitic, white nannofossil ooze of middle Eocene age. The five samples of this unit which were X-rayed showed 98%-99% calcite, 1% quartz, and 0%-1% clinoptilolite.

TABLE 2
X-Ray Mineralogy Summary, Hole 390

Sample (Interval in cm)	Depth (m)	Unit	Calc.	Quar.	K-Fe.	Plag.	Mica	Kaol.
1-2, 126-128	2.8	2	99	1	—	—	—	—
3-2, 89-91	135.4	7	41	23	8	10	14	4
3-3, 70-72	136.7	7	68	12	3	5	10	2
4-1, 136-138	143.9	7	49	18	7	11	13	2
4-2, 89-91	144.9	7	58	14	5	7	14	2
5-2, 78-79	154.3	7	86	3	2	2	5	1
9-1, 96-98	191.0	8	100	—	—	—	—	—

Unit 3

Unit 3 is pale brown and yellow nannofossil ooze of middle Eocene to middle Paleocene age which has been broken into two sub-units. Sub-unit 3a is siliceous nannofossil ooze which shows, in four samples, 97%-99% calcite, 1%-2% quartz, and 0%-1% clinoptilolite. Sub-unit 3b is cherty nannofossil limestone which, in two samples, is 93%-95% calcite, 4%-6% quartz and, 1% clinoptilolite.

Unit 4

Unit 4 is Danian zeolitic nannofossil ooze which, in three samples, is 93%-95% calcite, 3%-4% quartz, 0%-3% mica, and 0%-1% clinoptilolite.

Unit 5

Unit 5 is Maestrichtian nannofossil ooze. Three samples in the marly upper part of this unit (sub-unit 5a) show 93%-97% calcite, 3% quartz, 0%-2% K-feldspar, and 0%-2% mica. Two samples in the homogeneous, higher carbonate sub-unit (5b) show 98%-99% calcite, 1% quartz, and 0%-2% K-feldspar.

Unit 6

One sample in unit 6, Maestrichtian-Campanian nannofossil ooze has 99% calcite and 1% quartz.

TABLE 3
X-Ray Mineralogy Summary, Hole 390A

Sample (Interval in cm)	Depth (m)	Unit	Calc.	Quar.	K-Fe.	Mica	Clin.
1-1, 124-126	10.8	2	98	1	—	—	1
2-2, 93-95	21.4	2	99	1	—	—	—
3-2, 100-102	31.0	2	99	1	—	—	—
4-4, 73-75	43.2	2	99	1	—	—	—
5-2, 88-90	49.9	3a	97	1	—	—	1
6-1, 104-106	58.1	3a	99	1	—	—	—
6-4, 115-117	62.7	3a	99	1	—	—	—
7-4, 41-43	71.4	3a	99	2	—	—	—
8-2, 108-110	78.6	3b	95	4	—	—	1
9-1, 136-138	86.9	3b	93	6	—	—	1
10-1, 113-115	96.1	4	95	4	—	—	1
10-2, 15-17	96.7	4	93	3	—	3	1
11-2, 106-108	107.1	4	94	4	—	2	—
11-6, 114-116	113.1	5a	95	3	—	2	—
12-4, 100-102	119.5	5a	97	3	—	—	—
12-6, 101-103	122.5	5a	93	3	2	1	—
13-2, 113-115	126.1	5b	98	1	2	—	—
13-6, 95-97	132.0	5b	99	1	—	—	—
14-4, 97-99	138.5	6	99	1	—	—	—

Unit 7

Unit 7 is a variegated marly nannofossil ooze of Aptian, Albian, and Barremian? age. Five samples from different lithologies were analyzed. The range of calcite is from 86% in a nannofossil chalk to 41% in a clay layer. Respective variations in other minerals are 3%-23% for quartz, 4%-18% for feldspars (plagioclase 2%-11%, K-feldspar 2%-8%), and 6%-18% for clay minerals (mica 5%-14%, kaolinite 1%-4%).

Unit 8

Unit 8, a Barremian or older limestone, was found on the basis of one sample of Core 390-9, to be 100% calcite.

Site 391

Holes 391, 391A, 391B, and 391C were drilled in the Blake-Bahama Basin. Hole 394A was drilled at this site on Leg 44A. The X-ray results of samples from Hole 394A are discussed later. Shipboard scientists distinguished five major lithologic units extending in age from Quaternary to early Tithonian. These units have been further divided into a total of 14 sub-units. Tables 4 through 7 summarize the X-ray diffraction data from these four holes.

Unit 1

Unit 1 is a Quaternary silty clay. Nine samples were X-rayed and carbonate minerals range between 12%-37% for calcite and 2%-4% for dolomite. Aragonite (11%) was seen in Sample 391A-1-5, 91-93 cm. Quartz ranges from 22% to 43%, total feldspar from 12% to 30%, total clay minerals from 20% to 39%, and amphibole from 0% to 3%. Plagioclase (8%-26%) is more abundant than K-feldspar (4%-13%). Clay minerals present are mica (8%-26%), kaolinite (2%-8%), chlorite (0%-6%), and montmorillonite (0%-2%). Pyrite (1%) was detected in one sample.

Unit 2

Unit 2 is a complex unit including zones of intraclastic chalk, mudstone, and carbonate silt of early to late Miocene age. This unit has been broken into five sub-units. Sub-unit 2a is a white calcareous silt. Two samples of this sub-unit were X-rayed which showed the chalk to be composed entirely of carbonate minerals. The carbonate mineral composition is 48%-52% calcite, 5%-6% dolomite and 43%-47% aragonite.

Sub-unit 2b is marly chalk at the top of the sub-unit and light gray intraclastic chalk with greenish gray clasts at the bottom. The marly chalk (five samples) consists of 67%-72% calcite, 3%-6% dolomite, 23%-28% aragonite, and 1%-2% quartz. The intraclastic chalk (three samples) has 79%-85% calcite, 1%-3% dolomite, 13%-18% aragonite, and 1% quartz.

Sub-unit 2c is a middle Miocene dark olive-gray radiolarian mudstone. The four samples of this sub-unit analyzed show relatively varied mineral contents. In general, the samples range from 16%-55% calcite, 42% quartz, and 21%-36% clay minerals. Five per cent pyrite was detected in one sample and 14% feldspar in another (plagioclase 7%, K-feldspar 7%). The clay minerals are varied, with palygorskite (21%-29%) present in the two samples along with sepiolite (2%) and montmorillonite (1%) in one of these. Mica (10%-20%) and montmorillonite (8%-10%) are present in the other two samples. Kaolinite (2%-6%) is present in all four samples.

Sub-unit 2d is an intraclastic chalk. Nine samples were analyzed from this sub-unit. Eight of these samples showed 95%-98% calcite, 0%-2% dolomite, and 2%-4% quartz. One Sample (391A-12-6, 45-47 cm), from a turbidite, showed 66% calcite, 1% dolomite, 32% aragonite, and 1% quartz.

Sub-unit 2e is a deposit with interbedded mudstones and chinks. The chinks are intraclastic near the base of the unit. Fourteen samples were X-rayed and the compositions fell into four groups. First, chinks and marly chinks (seven samples) are 96%-99% calcite, 1%-3% dolomite, and 1%-3% quartz. One sample of an intraclastic chalk comprises the second group with 82% calcite, 2% dolomite, 11% aragonite, 3% quartz, and 2% montmorillonite. The third group are the mudstones in Core 391A-13. Two samples showed 53%-56% calcite, 3%-5% dolomite, 0%-7% aragonite, 9%-10% quartz, 23%-33% clay minerals (palygorskite 19%-27%, sepiolite 4%-6%), and 0%-2% pyrite. Mudstones and claystones from the rest of the sub-unit compose the fourth group. Four samples show no calcite, 31%-49% quartz, 11% plagioclase in one sample, 46%-65% clay (montmorillonite 19%-49%, mica 9%-19%, kaolinite 5%-6%, chlorite 0%-10%), and 2%-5% pyrite.

Unit 3

Unit 3 is a claystone unit of Late Cretaceous to Aptian age. Two sub-units have been distinguished. Sub-unit 3a consists of dark greenish gray, olive-gray, and black claystones. The analysis of 11 samples indicates a composition of 30%-58% quartz, 4%-24%

TABLE 4
X-Ray Mineralogy Summary, Hole 391

Sample (Interval in cm)	Depth (m)	Unit	Calc.	Dolo.	Quar.	K-Fe.	Plag.	Mica	Kaol.	Chlo.	Amph.
1-2, 94-96	2.4	1	32	2	27	8	11	10	4	5	2

feldspars (plagioclase 4%-18%, K-feldspar 0%-9%), and 30%-57% clay minerals (mica 17%-24%, montmorillonite 0%-32%, kaolinite 1%-11%, chlorite 1%-2%). Pyrite is sometimes seen (0%-5%). One sample shows 2% calcite.

Sub-unit 3b is a dark gray calcareous claystone with sparse interbeds of limestone. Two samples from this sub-unit have a wide variation in mineral percentages. One sample is 85% calcite, 7% quartz, 3% plagioclase, and 5% montmorillonite. The other sample is 15% calcite, 34% quartz, 7% mica, 19% montmorillonite, and 25% pyrite.

Unit 4

Unit 4 consists of a variety of limestones, mudstones, and shales of (Barremian?) Hauterivian to late Tithonian age. This unit has been divided into four sub-units. Sub-unit 4a is characterized by limestones and mudstones containing, in part, quartz sand and silt. A relatively wide range of mineral composition is found in this sub-unit. A sample of clayey limestone from Core 391C-14 contains 45% calcite, 22% quartz, and 33% clay minerals (mica 18%, montmorillonite 13%, kaolinite 2%). A calcareous claystone in Core 391C-15 contains 59% calcite, 17% quartz, 7% feldspar (K-feldspar 4%, plagioclase 3%), and 17% clay minerals (mica 7%, montmorillonite 7%, kaolinite 3%). A sandy layer at 391C-16-3, 129-131 cm has 39% calcite, 24% quartz, and 28% feldspar (K-feldspar 24%, plagioclase 14%). Two samples of sandy limestone from Cores 391C-17 and 20 show 60%-61% calcite, 16%-20% quartz, and 20%-23% feldspar (K-feldspar 11%-12%, plagioclase 9%-11%). A calcareous claystone from Core 391C-21 shows 93% calcite, 3% quartz, and 4% mica.

Sub-unit 4b is a series of interbedded limestones and shales. The 13 samples analyzed from this sub-unit appear to fall into three groups. The first group consists of 10 limestone samples which contain 94%-99% calcite, 1%-4% quartz, and, in three of these samples, 2%-3% montmorillonite. In the second group two samples of clayey limestone show 77%-81% calcite, 7%-8% quartz, 1%-2% plagioclase, and 9%-15% clay minerals (montmorillonite 5%-13%, mica 2%-4%). One sample of a shale layer falls in the third group with 35% calcite, 36% quartz, 2% plagioclase, and 27% clay minerals (montmorillonite 17%, mica 8%, kaolinite 2%).

Sub-unit 4c is a limestone unit which four samples show to be 86%-97% calcite, 3%-6% quartz, and 0%-8% montmorillonite.

Sub-unit 4d is a limestone with clay stringers. Nine limestone samples show 90%-98% calcite and 2%-10% quartz. Six samples of the clay stringers show a range of 57%-84% calcite, 7%-28% quartz, 0%-4% plagioclase, and 4%-12% clay minerals (mica 0%-8%, montmorillonite 2%-4%, kaolinite 0%-2%).

Unit 5

Unit 5 consists of early Tithonian red limestone and calcareous claystone which has been divided into two sub-units. Sub-unit 5a is a group of variegated argillaceous limestones. Five samples of the argillaceous zones show 60%-80% calcite, 14% aragonite in one sample, 16%-22% quartz, 0%-3% plagioclase, and 7%-15% clay minerals (montmorillonite 2%-7%, mica 4%-7%, kaolinite 0%-1%). Two samples of the limestones show 91%-99% calcite and 1%-9% quartz.

Sub-unit 5b consists of a red marl. Four samples indicate 29%-58% calcite, 3%-35% aragonite, 14%-17% quartz, 3%-12% feldspar (plagioclase 3%-8%, K-feldspar 0%-4%), and 9%-40% clay minerals (montmorillonite 4%-25%, mica 4%-15%, kaolinite 1%-4%).

Site 392

Holes 392 and 392A were drilled on the Blake Nose to penetrate into the Cretaceous reef and examine the sediments above the reef. Four units have been recognized. Table 8 summarizes the X-ray diffraction data from Hole 392A. No samples from Hole 392 were X-rayed.

Unit 1

Unit 1 is a sequence of Campanian to Barremian nanofossil oozes and nanofossil clays. Core 392A-1 penetrated a nanno ooze. A sample from this core contains 99% calcite and 1% quartz. Cores 392A-2 through 3 cored marly nanofossil ooze which contains 58%-74% calcite, 0%-10% aragonite, 9%-12% quartz, 5%-8% feldspar (plagioclase 3%-5%, K-feldspar 0%-4%), and 8%-15% clay minerals (mica 5%-8%, montmorillonite 3%-5%, kaolinite 0%-2%). Cores 392A-3 through 4 cored nanofossil ooze which showed 88%-92% calcite, 0%-2% dolomite, 3%-6% quartz, and 3%-6% feldspar (K-feldspar 2%-3%, plagioclase 0%-3%).

Unit 2

Unit 2 is a fenestral limestone of unknown age. Two samples of this unit showed it to be 100% calcite. No samples of units 3 or 4 were analyzed.

Site 394 (Leg 44A)

Hole 394A was drilled at the location of Site 391 (Leg 44). Six samples from two cores were analyzed during the X-ray diffraction work (Table 9). Cores 394A-5 and 6 appear to be from unit 2 of Miocene age described at Site 391. Two samples from Core 394A-5, a chalk breccia, contain 82%-90% calcite, 1% dolomite, 9%-14% aragonite, and 1%-3% quartz. Three of the samples from Core 394A-6, a marly chalk breccia, has 65%-88% calcite, 1% dolomite, 9%-34% aragonite, and 0%-1% quartz. One sample (394A-6-6, 90-92 cm) is of a large olive-gray siliceous clay clast and contains 38% calcite, 26% quartz, 3% plagioclase, 29% clay minerals (palygorskite 20%, montmorillonite 5%, kaolinite 4%), and 3% pyrite.

TABLE 5
X-Ray Mineralogy Summary, Hole 391A

Sample (Interval in cm)	Depth (m)	Unit	Calc.	Dolo.	Arag.	Quar.	K-Fe	Plag.	Mica	Mont.	Kaol.	Chlo.	Paly.	Sepi.	Pyri.	Amph.
1-2, 123-125	88.7	1	19	2	—	31	7	17	8	3	3	6	—	—	—	2
1-5, 91-93	92.9	1	37	1	11	22	4	8	10	2	3	3	—	—	—	—
1-6, 116-118	94.7	1	—	1	—	43	12	18	16	—	8	—	—	—	—	3
2-2, 118-120	34.2	1	30	2	—	28	11	15	9	—	5	—	—	—	—	—
2-4, 104-106	37.1	1	29	1	—	30	10	14	12	—	4	—	—	—	—	—
3-3, 81-83	149.3	2A	48	5	47	—	—	—	—	—	—	—	—	—	—	—
3-5, 83-85	152.3	2A	52	6	43	—	—	—	—	—	—	—	—	—	—	—
4-2, 104-106	205.1	2B	68	6	25	2	—	—	—	—	—	—	—	—	—	—
4-4, 92-94	207.9	2B	67	3	28	2	—	—	—	—	—	—	—	—	—	—
5-2, 92-94	261.9	2B	72	3	23	2	—	—	—	—	—	—	—	—	—	—
5-4, 92-94	264.9	2B	68	3	26	2	—	—	—	—	—	—	—	—	—	—
5-6, 85-86	267.9	2B	67	3	28	1	—	—	—	—	—	—	—	—	—	—
6-2, 99-101	319.0	2B	79	2	18	1	—	—	—	—	—	—	—	—	—	—
6-4, 99-101	322.0	2B	81	3	15	1	—	—	—	—	—	—	—	—	—	—
6-5, 123-125	323.7	2B	85	1	13	1	—	—	—	—	—	—	—	—	—	—
7-1, 123-125	327.2	2C	34	—	—	31	7	7	10	8	3	—	—	—	—	—
7-4, 114-116	331.6	2C	48	—	—	21	—	—	—	—	2	—	29	—	—	—
7-5, 92-94	332.9	2C	55	—	—	20	—	—	—	1	2	—	21	2	—	—
8-1, 118-120	336.7	2C	16	—	—	42	—	—	20	10	6	—	—	—	5	—
9-2, 86-88	357.0	2D	97	1	—	2	—	—	—	—	—	—	—	—	—	—
9-4, 108-110	360.1	2D	95	1	—	3	—	—	—	—	—	—	—	—	—	—
10-4, 85-87	378.9	2D	96	2	—	2	—	—	—	—	—	—	—	—	—	—
10-6, 96-88	381.9	2D	97	1	—	3	—	—	—	—	—	—	—	—	—	—
11-1, 80-82	412.3	2D	96	1	—	2	—	—	—	—	—	—	—	—	—	—
11-4, 59-61	416.6	2D	95	1	—	4	—	—	—	—	—	—	—	—	—	—
12-2, 146-148	471.5	2D	96	2	—	3	—	—	—	—	—	—	—	—	—	—
12-6, 45-47	476.5	2D	66	1	32	1	—	—	—	—	—	—	—	—	—	—
12-6, 63-65	476.6	2D	98	—	—	2	—	—	—	—	—	—	—	—	—	—
13-1, 64-66	526.1	2E	56	3	7	9	—	—	—	—	—	—	19	4	2	—
13-2, 93-95	527.9	2E	96	3	—	2	—	—	—	—	—	—	—	—	—	—
13-5, 113-115	532.6	2E	53	5	—	10	—	—	—	—	—	—	27	6	—	—
16-2, 87-89	556.4	2E	—	—	—	41	—	11	12	19	5	10	—	—	2	—
17-2, 65-67	565.7	2E	98	1	—	1	—	—	—	—	—	—	—	—	—	—
17-4, 62-64	568.6	2E	98	1	—	1	—	—	—	—	—	—	—	—	—	—
19-1, 133-135	583.8	2E	—	—	—	31	—	—	18	41	6	—	—	—	5	—
19-2, 85-87	584.9	2E	96	2	—	3	—	—	—	—	—	—	—	—	—	—
19-4, 128-130	588.3	2E	99	—	—	1	—	—	—	—	—	—	—	—	—	—
20-1, 90-92	640.4	2E	—	—	—	31	—	—	9	49	6	—	—	—	5	—
20-2, 60-62	641.6	2E	—	—	—	49	—	—	19	22	5	—	—	—	5	—
20-4, 72-74	644.7	2E	82	2	11	3	—	—	—	2	—	—	—	—	—	—
21-1, 57-59	649.6	3A	—	—	—	41	6	11	28	—	10	—	—	—	5	—
21-3, 58-60	652.6	3A	—	—	—	42	—	4	27	15	11	—	—	—	—	—
21-5, 62-64	655.6	3A	—	—	—	44	4	5	22	17	7	—	—	—	—	—

DISCUSSION AND CONCLUSIONS

Carbonates occur frequently throughout the sections cored; calcite is ubiquitous. Dolomite is commonly lower Aptian-Barremian age at Site 392 (Blake Nose). Siderite is found (up to 30%), sometimes associated with hematite, in the gas-bearing Miocene sediments at Site 388 (lower continental rise hills). Aragonite is quite common (up to 47%) in sediments from Sites 391 (Blake-Bahama Basin) and 392 (Blake Nose).

Aragonite, present in the Quaternary sediments and in the Miocene turbidite sequences at Sites 391 and 394 (Blake-Bahama Basin), indicates the contribution of aragonitic sediments from nearby shallow-water carbonate platforms where aragonite is abundant (Hathaway, 1972). This contribution is probably from turbidity currents. Aragonite is also present at this site in the argillaceous zones of sub-unit 5a and throughout sub-unit 5b (early Tethonian) where shipboard scientists found aragonitic fossils. These sediments may

have been deposited above the aragonite compensation depth. Some aragonite is also present in Site 392 (Blake Nose) in the early Albian-late Aptian marly nannofossil oozes.

Silicate minerals are quite abundant in these sediments. Quartz (up to 66%) is, except in three units, present (up to 6%) in unit 1 of Site 388 (lower continental rise hills), units 1 and 2 of Sites 391 and 394 always present. Feldspars (up to 30%) and clay minerals (up to 60%) are often present. Amphibole (up to 3%) was found only in the Quaternary sediments of Sites 388 (lower continental rise hills) and 391 (Blake-Bahama Basin). The zeolite clinoptilolite (up to 1%) was found in three units of Site 390 (Blake Nose).

Plagioclase is, in general, the dominant feldspar. However, K-feldspar is dominant in three units or sub-units of Cretaceous age. At Site 391 (Blake-Bahama Basin) K-feldspar is dominant in the sandy limestones and in a calcareous claystone of sub-unit 4a (Barremian?, Hauterivian to late Valaginian). On the

TABLE 6
X-Ray Mineralogy Summary, Hole 391B

Sample (Interval in cm)	Depth (m)	Unit	Calc.	Dolo.	Quar.	K-Fe.	Plag.	Mica	Mont.	Kaol.	Chlo.	Pyri.	Amph.
1-2, 91-93	2.4	1	19	4	24	7	9	26	2	8	2	—	1
1-4, 117-119	5.7	1	12	3	33	6	13	22	—	8	—	—	2
1-6, 95-97	8.5	1	17	1	30	13	26	9	—	2	—	1	2

TABLE 7
X-Ray Mineralogy Summary, Hole 391C

Sample (Interval in cm)	Depth (m)	Unit	Calc.	Dolo.	Arag.	Quar.	K-Fe.	Plag.	Mica	Mont.	Kaol.	Chlo.	Pyri.
2-1, 2-4	611.0	2E	96	1	—	3	—	—	—	—	—	—	—
2-3, 120-122	615.2	2E	97	1	—	2	—	1	—	—	—	—	—
4-1, 90-92	668.9	3A	—	—	53	7	6	17	13	4	—	—	—
5-1, 99-101	678.5	3A	—	—	58	—	13	24	—	6	—	—	—
6-4, 104-106	692.6	3A	—	—	48	8	15	18	3	5	2	—	—
7-2, 60-62	727.1	3A	2	—	30	6	11	21	27	3	—	—	—
8-2, 31-33	783.8	3A	—	—	29	5	7	21	32	4	—	2	—
9-1, 112-114	830.6	3A	—	—	45	—	18	19	12	5	—	—	—
10-2, 132-134	898.8	3A	—	—	41	8	16	23	9	2	—	—	—
10-3, 70-72	899.7	3A	—	—	45	9	12	19	13	1	—	—	—
11-3, 108-110	928.6	3B	85	—	7	—	3	—	5	—	—	—	—
12-1, 63-65	935.6	3B	15	—	34	—	—	7	19	—	—	—	25
14-1, 122-124	1001.7	4A	45	—	22	—	—	18	13	2	—	—	—
15-1, 127-129	1011.3	4A	59	—	17	4	3	7	7	3	—	—	—
16-3, 129-131	1023.8	4A	39	—	24	24	14	—	—	—	—	—	—
17-2, 94-95	1031.4	4A	60	—	20	11	9	—	—	—	—	—	—
20-1, 112-114	1058.6	4A	61	—	16	12	11	—	—	—	—	—	—
21-4, 110-112	1091.6	4A	93	—	3	—	—	4	—	—	—	—	—
24-2, 60-62	1126.1	4B	99	—	1	—	—	—	—	—	—	—	—
25-2, 91-93	1135.9	4B	9	—	1	—	—	—	—	—	—	—	—
26-2, 82-83	1145.3	4B	98	—	2	—	—	—	—	—	—	—	—
26-4, 96-98	1148.5	4B	97	—	3	—	—	—	—	—	—	—	—
27-4, 65-67	1157.7	4B	35	—	36	—	2	8	17	2	—	—	—
27-4, 91-93	1157.9	4B	96	—	2	—	—	—	2	—	—	—	—
28-4, 62-64	1167.1	4B	96	—	2	—	—	—	2	—	—	—	—
29-3, 103-105	1175.5	4B	94	—	2	—	—	—	3	—	—	—	—
30-4, 80-82	1186.3	4B	98	—	2	—	—	—	—	—	—	—	—
31-2, 65-67	1192.7	4B	99	—	1	—	—	—	—	—	—	—	—
31-6, 8-9	1198.1	4B	81	—	8	—	2	4	5	—	—	—	—
32-2, 144-145	1202.9	4B	77	—	7	—	1	2	13	—	—	—	—
33-3, 56-58	1213.1	4B	96	—	4	—	—	—	—	—	—	—	—
34-4, 61-63	1224.1	4C	93	—	4	—	—	—	3	—	—	—	—
35-2, 57-59	1230.6	4C	86	—	6	—	—	—	8	—	—	—	—
36-4, 55-57	1243.1	4C	91	—	5	—	—	—	4	—	—	—	—
37-2, 111-113	1250.1	4C	97	—	3	—	—	—	—	—	—	—	—
38-1, 100-102	1258.0	4D	95	—	5	—	—	—	—	—	—	—	—
38-3, 14-16	1260.1	4D	98	—	2	—	—	—	—	—	—	—	—
39-2, 121-123	1269.2	4D	84	—	7	—	—	4	4	2	—	—	—
39-4, 87-89	1271.9	4D	97	—	3	—	—	—	—	—	—	—	—
39-5, 18-20	1272.7	4D	79	—	12	—	3	3	2	1	—	—	—
40-2, 73-75	1278.2	4D	73	—	19	—	4	3	1	—	—	—	—
41-1, 23-25	1285.7	4D	90	—	10	—	—	—	—	—	—	—	—
41-3, 61-63	1289.1	4D	96	—	4	—	—	—	—	—	—	—	—
42-2, 95-97	1297.5	4D	96	—	4	—	—	—	—	—	—	—	—
43-3, 109-111	1308.6	4D	96	—	4	—	—	—	—	—	—	—	—
43-4, 27-29	1309.3	4D	57	—	28	—	4	8	2	2	—	—	—
44-2, 79-81	1316.3	4D	93	—	7	—	—	—	—	—	—	—	—
44-4, 100-102	1319.5	4D	88	—	8	—	—	—	4	—	—	—	—
44-6, 106-108	1322.6	4D	95	—	5	—	—	—	—	—	—	—	—
45-1, 137-139	1324.9	4D	69	—	22	—	1	3	3	1	—	—	—
45-2, 77-79	1325.8	5A	91	—	9	—	—	—	—	—	—	—	—
46-1, 72-74	1333.7	5A	80	—	13	—	—	5	2	—	—	—	—
46-1, 128-130	1334.3	5A	63	—	22	—	3	5	7	—	—	—	—
47-1, 133-135	1343.8	5A	68	—	16	—	1	7	7	1	—	—	—
48-2, 131-133	1354.8	5A	57	—	14	17	—	2	4	4	1	—	—
49-2, 42-44	1363.4	5A	66	—	20	—	2	7	4	—	—	—	—
49-2, 99-101	1364.0	5A	99	—	1	—	—	—	—	—	—	—	—
50-1, 36-38	1371.4	5B	58	—	3	17	—	3	9	10	—	—	—
51-2, 114-116	1383.1	5B	38	—	35	14	—	4	4	4	1	—	—
52-2, 93-95	1392.4	5B	39	—	10	15	—	5	15	15	4	—	—
52-4, 73-75	1395.2	5B	29	—	4	15	4	8	13	25	2	—	—

Blake Nose, K-feldspar is dominant in the late Aptian-Barremian nannofossil ooze of Site 392 and is the only feldspar present in the Maestrichtian nannofossil oozes (unit 5) of Site 390.

Mica or montmorillonite are often the dominant clay mineral of these samples with kaolinite usually present in lesser amounts. Two areas of interest were delineated on the basis of clay minerals.

Chlorite occurs scattered throughout the Pleistocene and Miocene of Site 388 (lower continental rise hills)

TABLE 8
X-Ray Mineralogy Summary, Hole 392A

Sample (Interval in cm)	Depth (m)	Unit	Calc.	Dolo.	Arag.	Quar.	K-Fe.	Plag.	Mica	Mont.	Kaol.	
1-1, 118-120	51.7	1	99	—	—	1	—	—	—	—	—	—
2-1, 98-100	67.0	1	58	—	10	12	—	5	8	5	2	—
2-3, 96-98	70.0	1	74	—	—	10	4	4	5	3	—	—
3-1, 102-104	80.0	1	68	—	5	9	2	3	5	5	2	—
3-2, 127-129	81.8	1	92	2	—	3	2	1	—	—	—	—
3-3, 111-113	83.1	1	92	1	—	4	3	—	—	—	—	—
4-1, 128-130	89.8	1	88	—	—	6	3	3	—	—	—	—
5-1, 145-147	99.5	2	100	—	—	—	—	—	—	—	—	—
6-1, 131-132	108.8	2	100	—	—	—	—	—	—	—	—	—

TABLE 9
X-Ray Mineralogy Summary, Hole 394A

Sample (Interval in cm)	Depth (m)	Unit	Calc.	Dolo.	Arag.	Quar.	Plag.	Mont.	Kaol.	Paly.	Pyri.
5-1, 70-73	279.7	2	82	1	14	3	—	—	—	—	—
5-3, 113-116	283.1	2	90	1	9	1	—	—	—	—	—
6-1, 90-92	355.9	2	70	1	28	1	—	—	—	—	—
6-3, 90-92	358.9	2	65	1	34	—	—	—	—	—	—
6-4, 90-92	360.4	2	88	1	9	1	—	—	—	—	—
6-6, 90-92	363.4	2	38	—	—	26	3	5	4	20	3

and in the Quaternary, early Miocene, and Late Cretaceous of Site 391 (Blake-Bahama Basin). Amphibole occurs only in the Quaternary sediments of these sites. Chlorite and amphibole are part of Hathaway's (1972) northern mineral assemblage and indicate a northern (north of Cape Hatteras) provenance for the Quaternary sediments of these sites. At Site 391, deep, southward-flowing contour currents have carried these minerals to their present position south of Cape Hatteras (Tucholke, 1975; Hathaway, 1972). The northern mineral assemblage—a result of glacial erosion of Paleozoic and older sedimentary and metamorphic rocks of the northern Appalachian region—contains illite, chlorite, finely divided quartz, feldspar, and accessory minerals such as hornblende. As such, this mineral assemblage is a valid indicator of a northern source only after the onset of North American continental glaciation, approximately three million years ago.

Palygorskite and sepiolite are present in the middle Miocene radiolarian mudstone (sub-unit 2c), in the early Miocene mudstone (sub-unit 2e) of Site 391 (Blake-Bahama Basin), and in a clast from the Miocene sediments drilled at Site 394 (Blake-Bahama Basin). The presence of palygorskite and sepiolite of Miocene age was also detected at Site 12 (DSDP Leg 2, Cape Verde Basin, Peterson et al., 1970); in drill holes on the Florida continental margin (Hathaway et al., 1970); and in rocks of the southern coastal plain (Gremillion,

1965). Gremillion (1965) concluded that the Miocene palygorskite and sepiolite of Florida, Georgia, and South Carolina formed from the lateration of volcanic ash in a nearshore marine environment. The palygorskite and sepiolite found at Site 391 could either have formed in place in the deep sea, as may be indicated by the mudstones of sub-units 2c or 2e, or they could have slumped in from shallower sedimentary environments, as may be indicated by the sediments cored at Site 394.

Clinoptilolite is present in the middle Eocene to late Paleocene samples of Site 390 (Blake Nose). Clinoptilolite has previously been found in Oligocene to Paleocene sediments sampled by drill holes on the Florida continental margin (Hathaway et al., 1970). Hathaway et al. (1970) discuss the origin of clinoptilolite as an alteration product of volcanic ash. They also discuss other lower Tertiary occurrences of volcanic ash and its alteration products on the Gulf Coastal Plain and in Alabama, Mississippi, and Texas.

Pyrite (up to 24%) is often present in the clays, claystones, and mudstones of Site 388 (lower continental rise hills) and Sites 391 and 394 (Blake-Bahama Basin). Hematite (0%-3%) was scattered throughout the Site 388 sediments (lower continental rise hills).

ACKNOWLEDGMENTS

Drs. Frederick Sayles and John Hathaway kindly allowed me to use their X-ray diffraction units. Dr. P.D. Johnson provided information on the appropriate techniques and Ms. Robin Hollister and Messers. Peter George and Ned

Goddard aided substantially in the sample preparation. During this project, the author was supported by the Massachusetts Institute of Technology-Woods Hole Oceanographic Institution Joint Program in Oceanography. Dr. C.D. Hollister critically reviewed the manuscript.

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