14. GEOCHEMISTRY OF SEDIMENTS IN THE WESTERN CENTRAL ATLANTIC, DSDP LEG 39

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INTRODUCTION

Twenty chemical elements were studied and $CaCO_3$, CO_2, and C (organic) were determined by the modified volumetric chemical method (Sokolov and Sokolova, 1975). Other samples were decomposed to determine Fe, Mn, Ti, Na, O, K_2O, Zn, Cu, Ni, Co, Cr, and Cd. Decomposition of the sample (0.25 gr) was accomplished with acid (with the application of HCl, HNO_3, and HF) in platinum crucibles. The concentrations of Na_2O and K_2O were measured by flame photometry (M-3, FRG), Ti was measured by the photoelectrocolorimeter (FEK-56, U.S.S.R.), and all other elements were analyzed using the atomic-absorption spectrophotometer "Saturn" (U.S.S.R.). Phosphorus was analyzed in a separate sample (0.5 gr), decomposed in aqua regia, i.e. a mixture of HCl (3 parts) and HNO_3 (1 part). The concentration of P was determined photocolorimetrically by FEK-56. Ba, Zr, V, Sn, Mo, Be, Ge, Ni, and Cr were analyzed by the quantitative spectral method (Meyshtas, 1970) using the ISP-28 (U.S.S.R.). All samples were analyzed twice. Control of analysis quality was carried out by means of the Soviet geological standards SGD-1, SG-1, and ST-1, and standards of the German Democratic Republic. Intralaboratory geological standards were also used. Accuracy and quality of the analyses are thought to be good. Analyses were performed in the Laboratory of Atlantic Geology, Atlantic Branch, P.P. Shirshov Institute of Oceanology, Academy of Sciences of the U.S.S.R., under the author's guidance (analysts Yu. O. Shaydurov, G.S. Khandros, Z. Yablunovskaya, T.I. Khomina, and N.G. Kudryavtsev).

Silicate analyses were carried out by conventional chemical methods in the laboratory of the Geological Survey of Western Siberia (Novokuznetsk).

The comparative data on Recent and late Quaternary sediments near Leg 39 drill sites (Figure 1) is also included.

CARBONATES

$CaCO_3$ content varies considerably, ranging from 0.0 up to 92.52% (Tables 1, 2, 3).

Site 353

The carbonate content in sediments from the Vema Fracture Zone is low. This is due to two reasons: (1) dilution of carbonate by terrigenous sediment from the Amazon River (Bader et al., 1970); and (2) depth of the site at or near the level of carbonate compensation depth (the compensation depth in the Guiana Basin is 5500 meters [Lisitzin, 1971; Emelyanov et al., 1975]).

Carbonates are mainly biogenic remains. Low-magnesian calcite is the dominant mineral. Authigenic carbonates occur as single grains (Tables 4, 5).

Site 354

$CaCO_3$ content varies from 8.75 to 85.05%. The minimum content of $CaCO_3$ (8.75%) was found in the sediments of Pleistocene age as a result of strong dilution by terrigenous input from the Amazon River; carbonate content is considerably higher in the older sediments (37.02-85.05%). Variations of $CaCO_3$ content over such a wide range may be caused by one or more of the following: (1) variations of the rate of supply of biogenic carbonates to bottom sediments; (2) irregular supply of terrigenous material from the Amazon River drainage; (3) variations of the depth carbonate dissolution. The Ceará Rise site was presumably situated below the lysocline between late Eocene and middle Oligocene, a time when the lysocline might have been shallower than at present. After middle Oligocene, the content of $CaCO_3$ increased slightly, which could be related to a subsidence of the lysocline or shoaling of the site. The high content of $CaCO_3$ indicates that the site was above the carbonate compensation depth for most or all of the Tertiary.

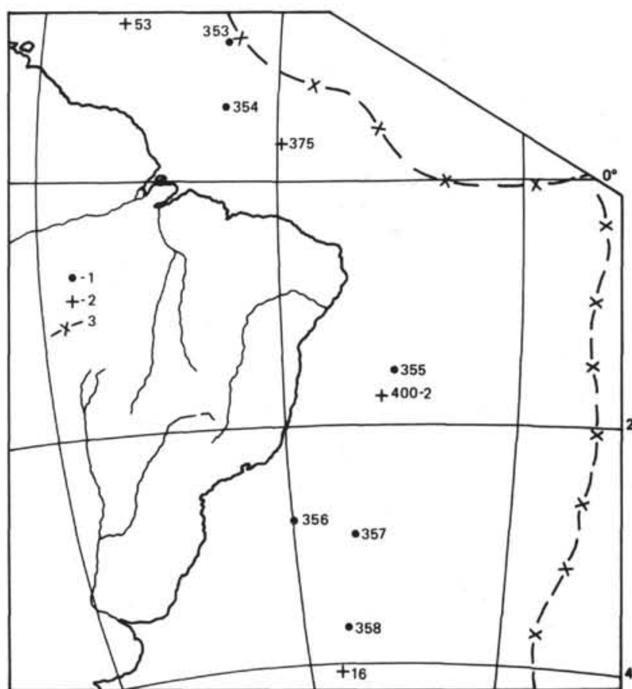

Figure 1. *Location of DSDP and other sites. 1 = Leg 39 sites, 2 = other sites, 3 = Mid Atlantic Ridge.*

TABLE 1
Range of Contents of Elements in the Sediments from Leg 39

Type of Sediments	Content, (%) $CaCO_3$	C_{org}	Fe	Mn	Ti	P	Na_2O	K_2O	Zn
Sites 353-358									
All types	0.00-92.52	0.03-1.35[a]	0.30-7.32 (1.58-28.58)	0.003-0.70 (0.02-2.39)	0.01-1.05 (0.05-2.00)	0.01-0.65 (0.01-2.17)	0.37-3.10	0.30-3.77	<4-231 (<17-554)
Site 359									
All types	3.25-90.96	0.15-0.66	0.12-6.07	0.01-0.15	0.006-1.58	0.01-0.26	0.86-4.73	0.07-4.38	<2-223

Note: Content given for dry sediment and for carbonate-free sediment (in brackets).
[a]In one sample 9.81%.

The carbonate consists mostly of coccoliths, with lesser foraminifers. Low magnesian calcite is the dominant mineral (Table 4). About 2% dolomite is found in sediments of Eocene, Oligocene, and Miocene age and 15 to 20% authigenic carbonate is present. Up to 6% dolomite and 4% siderite (Table 4) occur in the ferruginous marly nannofossil oozes.

Site 355

The site is below the present carbonate compensation depth (4600-4800 m) and is located in the zone of Recent red clays deposition in the Brazil Basin. Therefore, carbonate content is very low in the upper part of the core (lower Eocene-Pleistocene), which is characterized by terrigenous muds (and red clays) and by zeolitic pelagic muds. In the lower part of the core, in nannofossil oozes of Late Cretaceous age, the content of $CaCO_3$ is high, being up to 60.79 to 89.12%. On the basis of the smear slides study, the carbonate is represented by the remains of coccoliths (40% on the average) and authigenic calcite (50% on the average). Calcite occasionally forms hydrothermal veins with a thickness of 3-13 mm. These veins are associated with the brown-reddish ferruginous nannofossil muds. The degree of iron enrichment (oxidized form of Fe prevails; Table 3) increases with depth. Grains of dolomite were found in the upper part of the coccolith muds. On the basis of X-ray analyses calcite (only authigenic?) in the Cretaceous sediments contains 4-6 mol. % $MgCO_3$ in its lattice.

The carbonate data indicate that in the Late Cretaceous the bottom of the Brazil Basin (Site 355) was much shallower and was situated above the compensation depth. Site 355 in the Cretaceous was probably located within the limits of the Mid-Atlantic Ridge. In the early Maestrichtian the site subsided below the compensation depth (Sclater et al., 1971), and carbonate dissolution began.

Site 356

The content of $CaCO_3$ varies in the range of 1.75 to 85.80% (40% on the average). The highest carbonate content was found in the sediments of early Miocene-Pleistocene age, from 48.78% up to 85.80%. Carbonates are represented by coccoliths and foraminifers. In Units II and III (Core 16, Section 1 up to Core 6, Section 4), represented by siliceous-calcareous muds (coccoliths and foraminifers, mainly), the content of $CaCO_3$ is 21.76 to 37.74% and 19.02 to 41.78%, respectively. The dominant carbonate mineral is biogenic low-magnesian calcite. Dolomite is detected in the sediments of early Eocene age and authigenic calcite is present.

Unit IV (Core 26, Section 2 up to Core 19, Section 4) is represented by nannofossil muds (marly mud) with a $CaCO_3$ content from 41.78 to 57.54%. Interbeds of terrigenous and terrigenous-siliceous (?) muds with a low content of $CaCO_3$ (14.76 and 18.51%) are present in two cores of this unit (Core 17, Section 4 and Core 29, Section 2). Carbonates are represented by coccoliths, foraminifers, and authigenic calcite which contains about 5 mol. % $MgCO_3$.

Unit V is represented by marly nannofossil muds (chalk), slightly cemented by authigenic calcite. It contains 39.02 to 45.28% $CaCO_3$. There is a considerable admixture of dolomite, increasing downward.

Unit VI (Core 40, Section 6 and Core 39, Section 5, clayey conglomerates and mudstones) contains low quantities of $CaCO_3$, from 1.75 to 6.25%. Carbonates are represented by coccoliths and authigenic calcite.

Unit VII (Core 44, Section 3 and Core 41, Section 3) consists of marly dolomitized limestones (32.02-37.27% of $CaCO_3$). The limestones are recrystallized carbonates (calcite) and are dolomitized. Coccoliths and foraminifers are in neglibible quantities.

Thus, judging from the carbonate studies, all sediments at Site 356 accumulated under pelagic conditions, but above the carbonate compensation depth. Active biogenic pelagic accumulation of carbonates took place (deposition of coccoliths, foraminifers) followed by the consequent recrystallization of these biogenic carbonates and diagenetic formation of calcite and dolomite.

Site 357

This site is on the Rio Grande Rise and the $CaCO_3$ content in the sediments is high, up to 92.56%. Although there are interlayers with very low content, from 1 to 3% (Table 2), at this site the depth was always moderate (1000 m in the Cretaceous and 2100 m at present).

Unit I (foraminiferal-coccolith muds) is richest in $CaCO_3$ being from 84.10 to 92.56%. Planktonic foraminifers and coccoliths are dominant and pteropods and benthic foraminifers are found in negligible quantities.

The sediments of Unit II consist mainly of coccolith ooze and contain from 70.04 to 92.56% $CaCO_3$. It differs from the first unit by: (1) the presence of

TABLE 1 – *Continued*

Content (10^{-4}%)										
Cu	Ni	Co	Cr	Ba	Zr	V	Mo	Be	Ge	Cd
6-232 (20-543)	<6-354 (<13-864)	<4-65 (<4-159)	7-513 (7-796)	<200-1300 (<200-3589)	<40-600 (66-1138)	13-870 (46-883)	<5-13 (<5-120)	<1-4 (<1-8)	<50 (<50-334)	<6 <6
<6-18	<6-20	<6-26	4-28	–	–	–	–	–	–	<6

TABLE 2
Chemical Composition of Sediments From Leg 39

Sample (Interval in cm)	$CaCO_3$	C_{org}	Fe	Mn	Ti	P	Na_2O	K_2O	Zn	Cu	Ni	Co	Cr	Cd
	(%)								(10^{-4} %)					
Hole 353														
2-2, 30-32	4.75	0.36	4.65	0.087	0.50	0.05	1.75	2.62	108	37	50	22	66	4.0
Hole 353A														
1-1, 102-105	4.25	0.48	5.30	0.070	0.47	0.05	1.76	2.84	120	19	48	<20	42	<4.0
Site 354														
1-1, 115	19.51	0.18	4.63	0.675	0.40	0.05	2.02	2.25	95	53	65	36	70	4.0
1-2, 119	8.75	0.36	4.95	0.107	0.50	0.05	2.30	2.50	102	60	61	22	76	<4.0
3-1, 120	46.53	0.12	2.53	0.065	0.24	0.03	1.43	1.56	76	30	44	22	38	4.5
4-1, 40-42	43.78	0.06	2.95	0.070	0.28	0.03	1.38	1.64	88	68	41	22	52	<4.0
4-2, 40-42	61.04	0.06	1.97	0.094	0.16	0.03	1.03	1.17	64	22	31	22	46	<4.0
5-2, 71-73	40.78	0.06	3.50	0.084	0.29	0.03	1.18	1.76	73	39	53	22	58	<4.0
6-3, 91	67.02	0.06	1.25	0.087	0.19	0.02	0.88	0.76	42	110	43	<20	38	<4.0
6-2, 107	56.54	0.03	1.90	0.077	0.19	0.03	1.09	1.30	46	30	51	<20	42	<4.0
7-1, 137	73.05	0.03	1.20	0.160	0.08	0.03	1.30	0.60	38	28	35	<20	32	<4.0
7-3, 16	47.28	0.03	2.73	0.092	0.24	0.05	1.04	1.07	90	30	60	<20	62	<4.0
8-2, 30	51.28	0.15	2.37	0.071	0.21	0.04	1.05	0.83	66	46	38	<20	58	<4.0
9-3, 112	54.78	0.15	2.40	0.051	0.17	0.03	0.97	0.90	80	92	46	28	54	<4.0
10-2, 98	85.05	0.18	1.08	0.041	0.16	0.03	0.83	0.52	44	60	27	<20	26	<4.0
11-5, 25	67.54	0.15	3.17	0.032	0.12	0.03	0.80	1.05	64	54	22	10	36	<4.0
12-4, 11	55.03	0.18	2.90	0.032	0.11	0.02	0.90	0.86	60	200	76	21	27	<4.0
13-6, 125	67.54	0.15	2.77	0.050	0.12	0.03	0.58	0.81	23	36	10	8	30	<4.0
14-1, 106	71.55	0.12	2.02	0.051	0.08	0.02	0.71	0.47	16	28	10	8	24	<4.0
15-2, 45	63.79	0.12	0.99	0.100	0.02	0.03	0.44	0.34	25	17	12	10	21	<4.0
15-3, 84	64.29	0.15	1.83	0.073	0.08	0.02	0.68	0.74	19	194	6	8	26	<4.0
17-2, 117	53.78	0.15	3.32	0.069	0.21	0.04	0.54	1.08	27	58	6	8	50	<4.0
18-1, 130	52.78	0.21	1.54	0.073	0.19	0.04	0.83	1.00	37	12	15	14	38	<4.0
18-4, 128	37.02	0.27	1.90	0.040	0.29	0.06	0.42	0.91	56	34	8	8	52	<4.0
Site 355														
1-2, 69-71	0.25	0.24	5.47	0.27	0.63	0.05	2.32	2.65	14	88	75	35	53	<6
1-6, 80-82	1.00	0.27	5.33	0.67	0.56	0.04	2.54	2.54	138	85	72	20	54	<6
2-3, 130-132	1.25	0.30	5.54	0.30	0.59	0.05	2.06	2.82	132	84	56	25	52	<6
2-5, 135-137	0.75	0.21	6.01	0.10	0.52	0.06	1.88	3.34	146	76	84	20	50	<6
3-2, 88-90	8.50	0.51	4.91	0.13	0.48	0.05	2.11	2.26	130	56	75	15	54	<6
3-5, 58-60	0.75	0.54	5.55	0.24	0.59	0.05	2.14	2.35	152	94	86	31	44	<6
4-3, 110-112	0.00	0.36	6.07	0.09	0.67	0.06	1.53	2.24	166	73	78	25	69	<6
5-1, 40-42	0.50	0.39	5.32	0.08	0.59	0.06	1.88	2.21	135	46	56	15	54	<6
5-4, 98-100	0.24	0.45	4.65	0.15	0.56	0.04	2.11	2.35	111	33	57	15	55	<6
6-2, 100-102	5.00	0.63	5.63	0.07	0.59	0.05	2.12	2.21	123	42	45	15	54	<6
7-2, 90-92	2.50	0.30	5.14	0.05	0.59	0.05	1.90	2.40	122	40	107	31	63	<6
7-3, 100-102	4.50	0.51	6.26	0.18	0.63	0.06	1.70	2.18	145	33	56	15	64	<6
8-2, 140-141	0.00	0.48	3.54	0.37	0.46	0.06	2.13	1.84	106	32	72	25	61	<6
9-2, 50-52	0.00	0.39	3.62	0.02	0.52	0.03	1.61	1.76	104	232	52	21	60	<6
11-2, 91-92	0.00	0.21	4.52	0.04	0.50	0.04	1.44	1.67	125	24	66	23	87	<6
12-4, 60-62	0.00	0.42	4.65	0.02	0.48	0.03	1.40	1.52	138	26	86	25	79	<6
13-3, 52-54	0.00	0.33	4.73	0.04	0.52	0.03	1.44	1.81	134	85	82	23	82	<6
14-3, 93-94	0.00	0.27	5.37	0.04	0.59	0.05	1.36	2.24	157	50	100	37	88	<6

TABLE 2 – *Continued*

Sample (Interval in cm)	$CaCO_3$ (%)	C_{org}	Fe	Mn	Ti	P	Na_2O	K_2O	Zn (10^{-4}%)	Cu	Ni	Co	Cr	Cd
14-5, 87-89	0.00	0.30	6.77	0.07	0.61	0.06	1.33	2.35	156	30	96	32	93	<6
15-1, 84	1.50	0.63	4.53	0.70	0.63	0.05	1.30	2.86	171	113	86	33	93	<6
15-1, 127	0.00	0.51	7.32	0.13	0.65	0.06	1.19	2.64	160	27	112	37	93	<6
17-3, 140-142	69.80	0.30	1.21	0.06	0.14	0.03	0.60	1.08	45	6	19	11	23	<6
17-4, 15-17	75.05	0.36	1.76	0.12	0.12	0.03	0.58	0.96	26	9	31	10	21	<6
17-6, 61-63	81.30	0.39	1.18	0.10	0.03	0.02	0.52	0.73	18	8	21	10	18	<6
18-1, 115-117	75.78	0.51	1.23	0.15	0.08	0.02	0.62	0.65	22	21	26	10	18	<6
18-3, 36-38	64.79	0.15	2.05	0.18	0.16	0.03	0.58	1.30	52	30	24	16	24	<6
19-2, 127-129	60.79	0.66	3.08	0.76	0.23	0.06	0.82	1.53	66	44	69	36	30	<6
20-2, 115-117	89.12	0.48	1.40	0.26	0.08	0.04	0.49	0.68	24	23	28	10	13	<6
Hole 356														
2-1, 28-31	85.80	1.08	0.70	0.03	0.05	0.03	1.02	0.34	18	20	12	10	15	<6
3-2, 71-73	57.54	0.51	2.05	0.05	0.23	0.05	2.08	1.15	56	20	9	<10	29	<6
4-3, 43-45	48.78	1.08	2.29	0.05	0.23	0.04	2.22	1.33	70	20	11	<10	33	<6
5-4, 120-123	60.04	1.02	1.52	0.06	0.18	0.04	2.10	1.01	59	44	11	<10	18	<6
6-4, 80-83	25.52	0.51	2.95	0.06	0.27	0.03	2.18	1.57	71	25	16	<10	44	<6
7-4, 30-33	21.76	0.66	3.18	0.04	0.31	0.05	2.08	1.60	74	27	19	<10	47	<6
8-2, 70-73	30.02	0.75	3.24	0.04	0.42	0.03	1.95	1.71	85	28	19	<10	37	<6
9-2, 130-132	37.77	0.54	3.00	0.08	0.27	0.04	1.70	1.40	52	23	6	<10	35	<6
10-3, 59-61	29.52	1.14	2.46	0.12	0.37	0.03	2.36	2.04	98	34	22	<10	57	<6
11-3, 113-115	41.78	0.81	3.00	0.13	0.27	0.05	1.62	1.37	56	13	11	<10	45	<6
12-1, 9-11	19.01	0.48	2.57	0.08	0.31	0.03	1.62	1.33	56	23	24	13	47	<6
14-1, 20-23	31.52	0.54	1.81	0.13	0.20	0.03	1.41	0.98	62	50	13	<10	35	<6
16-1, 127-129	22.26	0.72	2.64	0.12	0.27	0.03	1.36	1.14	96	33	26	<10	55	<6
17-4, 60-63	14.76	0.60	3.86	0.04	0.52	0.03	1.95	2.22	116	73	58	13	70	<-"-
19-4, 42-44	41.78	0.78	2.00	0.09	0.25	0.03	1.27	1.68	38	34	75	20	29	<-"-
23-2, 60-62	42.53	0.90	2.78	0.10	0.37	0.03	1.55	1.71	64	31	13	<10	45	<6
24-5, 121-123	45.54	0.60	3.25	0.12	0.29	0.06	1.31	1.73	82	20	22	<10	42	<6
25-2, 40-42	57.54	1.20	2.52	0.13	0.27	0.03	1.24	1.50	71	18	19	<10	33	<6
26-2, 26-28	52.31	1.20	3.01	0.14	0.30	0.03	1.21	1.74	75	45	22	<10	32	<6
29-2, 120-122	18.51	0.60	3.88	0.04	0.50	0.03	1.80	2.68	93	32	45	25	63	<6
29-6, 40-42	55.03	0.69	2.12	0.16	0.23	0.03	1.15	1.57	57	23	9	<10	29	<6
31-5, 54-56	42.03	0.66	2.60	0.07	0.31	0.04	1.17	2.00	56	23	16	<10	31	<6
33-2, 88-90	39.02	0.60	3.50	0.07	0.35	0.03	1.20	2.20	70	22	13	<10	50	<-"-
35-3, 70-72	42.03	1.05	2.57	0.10	0.34	0.05	1.35	1.79	77	23	16	<10	46	<6
38-3, 107-109	45.28	0.75	3.27	0.09	0.48	0.05	0.90	2.01	65	29	24	<10	55	<6
39-5, 95-97	6.25	0.72	5.66	0.032	0.79	0.05	1.30	3.66	86	78	42	12	92	<6
40-6, 44-46	1.75	1.35	4.34	0.021	0.65	0.05	1.39	2.62	130	85	25	13	111	<6
41-4, 56-58	32.02	9.81	3.41	0.03	1.01	0.02	1.01	1.57	109	95	208	<10	60	15
44-3, 109-111	37-77	0.87	3.32	0.10	0.40	0.05	1.21	2.06	52	33	14	<10	37	<6
Hole 356A														
1-4, 74-76	33.02	0.36	2.86	0.03	0.34	0.05	2.48	1.60	61	27	9	<10	41	<6
2-5, 73-75	40.02	1.35	2.14	0.04	0.29	0.05	2.16	1.44	49	34	13	<10	26	<6
Site 357														
1-3, 93-96	92.56	0.45	0.40	0.03	0.006	0.02	0.94	0.19	4	17	<8	<10	10	<6
3-2, 97-99	89.56	0.42	0.34	0.03	0.01	0.01	1.16	0.22	4	14	<8	<10	11	<6
5-3, 90-92	84.10	0.84	0.95	0.03	0.08	0.02	1.50	0.53	14	14	9	<10	13	<6
6-4, 70-73	85.30	0.75	0.78	0.04	0.05	0.03	0.95	0.54	15	16	9	<10	17	<6
8-2, 80-83	87-81	0.36	0.47	0.02	0.01	0.03	1.10	0.33	7	11	<8	<10	12	<6
9-2, 60-63	92.56	0.30	0.35	0.003	0.01	0.03	0.85	0.21	25	17	<8	5	14	<6
10-1, 70-72	84.30	0.24	0.49	0.02	0.03	0.03	0.86	0.77	24	14	<8	6	14	<6
10-2, 70-72	81.06	0.69	0.30	0.02	0.01	0.03	1.04	0.27	6	13	<8	9	12	<6
11-2, 108-111	89-06	0.60	0.37	0.03	0.01	0.03	0.99	0.36	8	14	<8	12	16	<6
13-5, 65-68	80.30	0.54	0.74	0.03	0.04	0.05	1.29	0.66	16	15	8	<4	17	<6
15-2, 100-103	81.55	0.60	0.81	0.03	0.08	0.06	0.96	0.66	14	15	8	8	19	<6
17-2, 70-72	76.30	0.54	0.88	0.02	0.10	0.05	1.14	0.83	25	18	<8	<4	19	<6
20-3, 91-94	86.05	0.27	0.98	0.02	0.08	0.05	0.38	0.57	8	5	<8	<4	17	<6
22-3, 84-87	81.30	0.54	0.98	0.04	0.10	0.04	0.87	0.59	35	16	8	4	35	<6
23-3, 42-45	73-87	0.30	1.36	0.05	0.31	0.07	0.85	0.49	23	17	9	<10	90	<6
24-1, 96-99	85.56	0.33	0.60	0.05	0.08	0.04	0.86	0.62	80	14	9	<10	24	<6
24-5, 75-78	64.29	0.39	1.50	0.05	0.61	0.12	1.36	0.64	66	60	58	13	154	<6

TABLE 2 – *Continued*

Sample (Interval in cm)	(%)								(10^{-4} %)					
	$CaCO_3$	C_{org}	Fe	Mn	Ti	P	Na_2O	K_2O	Zn	Cu	Ni	Co	Cr	Cd
24-5, 84-87	35.52	0.60	2.08	0.02	1.05	0.20	1.96	0.85	29	20	37	<10	513	<6
24-5, 91-94	59.04	0.72	2.68	0.07	0.80		1.48	0.86	33	45	354	65	224	<6
24-6, 101-104	89.56	0.54	2.23	0.05	0.10	0.03	0.37	0.32	14	11	31	<10	16	<6
24-6, 131-134	90.31	0.51	2.77	0.07	0.16	0.03	0.62	0.45	27	8	29	<10	32	<6
26-3, 148-151	70.80	0.30	1.19	0.04	0.22	0.06	0.65	0.52	14	15	9	<10	35	<6
27-3, 107-110	70.04	0.60	1.45	0.06	0.35	0.65	1.54	0.97	16	16	18	8	19	<6
28-1, 92-95	24.27	0.39	3.48	0.04	0.79	0.19	1.92	1.15	72	20	33	12	20	<6
29-1, 6-9	87.05	0.24	0.59	0.06	0.05	0.03	1.23	0.83	26	14	15	5	22	<6
30-1, 13-16	83.30	0.33	0.92	0.04	0.08	0.03	0.74	0.72	14	17	21	4	16	<6
31-2, 122-125	80.80	0.63	0.62	0.05	0.08	0.01	0.70	0.90	9	16	12	7	19	<6
33-3, 140-143	63.04	0.36	2.00	0.64	0.23	0.03	1.05	1.79	35	18	23	6	28	<6
34-4, 34-37	51.28	0.48	1.79	0.06	0.23	0.03	1.14	2.10	50	23	23	5	28	<6
36-1, 65-68	44.03	0.24	3.12	0.06	0.30	0.03	–	–	68	20	24	6	39	<6
40-1, 76-79	55.79	0.36	2.38	0.06	0.31	0.03	–	1.91	76	28	20	<4	32	<6
40-4, 44-45	1.00	0.39	3.41	0.02	0.34	0.01	2.06	0.67	160	18	34	50	9	<6
41-2, 76-79	15.01	0.24	3.59	0.02	0.34	0.02	1.81	1.11	111	16	85	18	19	<6
41-2, 81-82	3.00	0.39	4.67	0.003	0.31	0.03	1.92	0.47	231	19	520	75	7	<6
42-3, 37-40	40.78	0.42	3.02	0.05	0.40	0.03	1.12	2.48	101	37	38	11	47	<6
43-3, 82-85	56.04	0.36	1.82	0.05	0.27	0.03	0.74	1.57	51	27	26	6	32	<6
44-3, 30-33	47.28	0.57	3.82	0.05	0.41	0.03	1.02	2.30	127	32	61	<4	51	<6
46-3, 72-75	55.54	0.51	3.05	0.05	0.34	0.04	0.85	2.04	80	32	33	<4	34	<6
47-2, 60-63	59.54	0.36	2.33	0.06	0.29	0.05	0.90	1.94	65	33	31	8	32	<6
48-1, 42-43	67.29	0.39	1.30	0.06	0.16	0.03	–	–	25	20	15	<4	26	<6
50-2, 126-128	48.53	0.72	1.45	0.06	0.14	0.03	0.65	0.88	34	18	7	5	22	<6
51-3. 34-36	40.27	0.45	1.34	0.05	0.16	–	0.76	0.88	10	19	13	<4	20	<6
Site 358														
1-6, 82-84	0.00	0.48	4.86	0.06	0.52	0.03	2.76	2.74	122	107	38	22	43	<6
2-4, 94-96	0.00	0.45	4.43	0.09	0.50	0.02	3.10	2.48	108	82	46	24	45	<6
3-2, 68-70	0.00	0.24	5.48	0.06	0.53	0.02	2.41	3.00	108	119	68	30	38	<6
3-5, 68-70	0.00	0.54	5.28	0.18	0.52	0.11	2.35	2.78	102	74	46	22	38	<6
4-1, 98-100	0.00	0.18	4.26	0.06	0.42	0.07	2.99	2.46	88	32	50	22	31	<6
5-1, 56-58	0.00	0.18	4.04	0.04	0.45	0.03	3.13	2.74	94	65	38	13	36	<6
6-3, 71-73	0.00	0.24	4.06	0.06	0.47	0.03	2.90	2.43	140	83	48	10	33	<6
7-1, 69-71	0.00	0.18	4.43	0.04	0.48	0.03	2.75	2.56	97	54	33	11	33	<6
8-1, 112-114	0.00	0.33	4.04	0.04	0.50	0.03	2.07	2.76	196	78	33	13	50	<6
9-3, 28-30	0.00	0.24	4.09	0.08	0.50	0.03	1.85	3.23	111	70	27	5	44	<6
10-4, 68-70	0.00	0.39	4.00	0.03	0.47	0.05	1.82	3.22	118	49	44	4	47	<6
11-3, 9-11	0.00	0.30	4.58	0.07	0.50	0.08	2.04	1.94	113	39	52	13	31	<6
11-4, 82-84	61.29	0.24	1.60	0.03	0.16	0.03	0.96	1.08	56	23	35	11	20	<6
12-3, 77-79	71.04	0.30	1.10	0.30	0.12	0.03	0.85	0.83	37	15	28	6	25	<6
12-4, 61-63	40.02	0.24	2.45	0.19	0.22	0.05	1.14	1.38	69	76	30	11	44	<6
13-4, 105-107	22.01	0.45	4.44	0.12	0.38	0.07	1.40	3.10	123	64	46	18	45	<6
14-2, 138-140	40.02	0.30	3.62	0.18	0.38	0.08	1.36	2.45	108	42	44	<6	45	<6
15-1, 65-67	1.75	0.36	5.40	0.10	0.56	0.05	1.67	3.77	128	82	57	22	38	<6
16-2, 101-103	10.26	0.33	4.63	0.12	0.46	0.05	1.51	3.09	95	40	32	18	42	<6
Hole 359														
1-3, 72-74	89.31	0.15	0.12	0.01	0.006	0.01	1.11	0.07	<2	12	<8	<6	10	<6
2-6, 132-134	71.80	0.18	2.52	0.12	0.23	0.18	1.45	0.72	30	17	20	<6	27	<6
3-4, 66-68	3.25	0.24	3.98	0.06	0.25	0.02	4.73	4.38	223	6	10	<6	6	<6
3-5, 49-51	56.29	0.24	2.64	0.11	0.52	0.08	2.19	1.53	52	18	10	<6	28	<6
4-2, 17-19	7.90	0.39	6.07	0.15	1.58	0.26	1.95	1.01	133	7	26	26	4	<6
Hole 359A														
1-4, 110-112	87.81	0.45	0.14	0.02	0.09	0.02	0.86	0.12	2	<8	<8	<6	11	<6
2-2, 80-82	90.06	0.66	0.19	0.02	0.09	0.01	1.30	0.12	<2	<8	<6	<6	7	<6

authigenic calcite, the quantity of which increases downward; (2) lesser quantity of foraminifer shells; and (3) the absence of pteropods. The oozes are locally cemented, grading into limestones. Nannofossil oozes with a decreased content of $CaCO_3$ from 35.52 to 64.29% (Core 24, Section 5) are typical of the second unit. These sediments are enriched by silica (spicules, diatoms, radiolaria) and volcanic material (weathered ash). An interlayer at the very bottom of the unit (Core 28, Section 1) contains 24.27% of $CaCO_3$. These are silico-terrigenous sediments.

Unit III was not studied, but is similar to Unit II.

TABLE 3
Total Chemical Composition of the Sediments in the Central Atlantic, Leg 39 (in %)

Sample (Interval in cm)	SiO_2	TiO_2	Al_2O_3	FeO	Fe_2O_3	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	CO_2	L. o. i.	S	F	H_2O^+
353-2-2, 30-32	52.72	0.92	19.36	1.73	5.35	0.06	3.11	2.84	2.69	1.69	0.217	2.98	9.45	0.15	0.09	6.64
353-3-2, 120-122	78.76	0.48	7.35	4.03	1.51	0.04	1.41	1.02	1.50	1.36	0.068	0.61	1.90	0.17	0.02	1.74
354-8-2, 30	26.19	0.50	11.42	0.29	3.77	0.03	27.44	1.22	0.98	1.27	0.142	21.47	26.50	0.17	0.06	5.02
354-14-1, 106	14.94	0.30	4.48	0.43	1.79	0.03	41.16	1.22	0.31	1.02	0.093	31.64	34.03	0.14	0.04	1.80
354-18-4, 127	40.75	0.58	12.19	1.73	1.96	0.05	18.93	1.22	1.00	0.41	0.235	16.50	20.49	0.22	0.05	4.22
355-1-2, 72-74	49.90	1.07	19.24	0.43	8.26	0.06	1.13	3.45	2.82	2.82	0.223	0.45	9.24	1.28	0.06	8.34
355-3-5, 60-62	52.86	1.11	19.24	0.43	8.82	0.06	1.13	3.65	2.58	2.42	0.247	2.32	8.10	0.20	0.09	7.20
355-5-1, 38-40	55.07	1.07	17.87	0.29	7.64	0.06	0.58	2.94	2.46	2.32	0.223	0.00	9.05	0.16	0.09	9.10
355-5-4, 100-102	56.09	1.08	17.69	0.43	7.10	0.06	0.58	3.45	2.50	2.14	0.167	0.00	8.25	0.23	0.08	8.20
355-12-5, 86-88	60.69	1.02	15.92	1.15	6.63	0.06	0.58	2.84	2.12	1.32	0.161	0.91	6.93	0.29	0.06	6.09
355-13-3, 75-77	55.01	1.04	17.97	0.43	9.46	0.06	0.58	3.25	2.32	1.33	0.124	0.00	8.02	0.08	0.08	8.00
355-17-4, 20-22	12.36	0.34	4.30	0.14	3.24	0.03	41.27	1.42	1.13	1.02	0.093	32.77	34.52	0.06	0.05	1.98
356-5-4, 101-103	23.63	0.45	6.28	0.21	2.19	0.03	32.23	1.63	1.13	2.72	0.198	26.89	29.17	0.14	0.06	2.74
356-6-4, 50-53	43.82	0.72	9.34	0.43	4.15	0.05	15.46	2.84	1.77	2.40	0.173	12.88	18.47	0.27	0.08	5.49
356-14-1, 25-27	49.64	0.44	6.91	0.36	2.64	0.05	17.16	2.03	1.13	1.62	0.198	13.41	17.40	0.11	0.08	4.00
356-24-5, 120-122	31.56	0.62	9.24	0.43	4.64	0.04	24.12	2.44	1.88	1.69	0.266	18.76	23.00	0.12	0.07	4.12
356-39-5, 75-77	51.46	1.43	13.55	2.01	6.77	0.07	0.85	4.27	3.42	1.52	0.266	2.71	10.34	1.69	0.09	7.74
357-40-1, 76-79	26.24	0.65	7.17	1.15	2.77	0.04	28.64	3.25	2.00	1.27	0.148	23.73	26.35	0.19	0.08	2.76
357-51-3, 34-36	48.85	0.39	4.12	0.54	1.50	0.05	21.20	2.24	0.88	0.88	0.148	16.16	18.91	0.35	0.07	2.80
357-9-2, 60-63	2.23	0.16	1.08	0.43	0.18	0.02	52.01	0.81	0.26	1.44	0.179	41.81	41.09	0.07	0.04	0.49
358-1-6, 70-72	54.69	1.02	17.76	1.13	6.42	0.06	0.85	3.64	2.95	2.35	0.137	tr	8.24	0.31	0.05	8.30
358-3-2, 71-73	55.51	1.08	17.76	0.94	6.69	0.06	0.85	3.75	3.20	2.60	0.105	tr	7.00	0.17	0.09	6.98
358-3-5, 71-73	55.91	1.09	17.44	0.58	7.25	0.06	0.85	3.75	2.90	2.70	0.334	tr	6.50	0.07	0.08	6.58
358-5-2, 62-64	56.92	0.99	15.92	0.58	6.12	0.06	1.13	4.06	2.66	2.90	0.155	2.26	8.00	0.30	0.09	5.70
358-10-3, 73-75	61.00	1.04	14.90	0.86	6.52	0.05	1.13	3.25	3.06	1.90	0.192	1.63	5.74	0.12	0.07	4.24
358-15-1, 66-68	56.70	1.01	17.44	0.29	7.64	0.06	0.85	3.55	4.05	1.60	0.210	0.00	6.40	0.05	0.09	6.44
359-3-5, 49-51	23.01	0.97	6.63	0.86	3.09	0.04	31.73	1.22	1.37	2.90	0.384	25.28	26.70	0.10	0.10	1.66
359-2-6, 139-141	10.05	0.41	2.33	0.36	2.67	0.03	42.24	1.22	0.71	2.01	0.711	35.26	36.82	0.23	0.09	1.41

TABLE 4
Contents of Carbonate Minerals in Bottom Sediments From Leg 39 (in %)

Depth (m)	Sample (Interval in cm)	Calcite	Aragonite	Dolomite	Siderite	Magnesite	Manganocalcite
Hole 353							
126.5	2-3, 50-52	<1.0	0.0	0.0	0.0	0.0	–
263.7	3-2, 120-122	<1.0	0.0	0.0	0.0	0.0	–
263.9	3-2, 142-144	<2.0	0.0	0.0	0.0	0.0	–
Hole 353A							
	1-2, 91-94	tr	0.0	tr	tr	0.0	–
181.0	1, CC	<1.0	0.0	0.0	0.0	0.0	–
Site 354							
4.8	1-1, 75	13.0	0.0	0.0	0.0	0.0	–
5.4	1-1, 140	23.0	0.0	0.0	0.0	0.0	–
54.5	2, CC	18.0	0.0	0.0	2.0	0.0	–
59.6	3-1, 110	31.0	0.0	0.0	<2.0	0.0	–
140.6	4-1, 60-62	38.0	0.0	<2.0	0.0	0.0	–
142.1	4-2, 60-62	53.0	0.0	<2.0	0.0	0.0	–
145.3	4-4, 75	33.0	0.0	<1.0	0.0	0.0	–
147.6	4-6, 10	30.0	0.0	<2.0	1.0	0.0	–
148.5	4-6, 102	55.0	0.0	0.0	0.0	0.0	–
195.5	5-2, 91-93	35.0	0.0	0.0	0.0	0.0	–
243.0	6-3, 84	30.0	0.0	0.0	0.0	0.0	–
243.4	6-3, 94	54.0	0.0	<1.0	0.0	0.0	–
243.9	6-3, 138	26.0	0.0	<1.0	1.0	0.0	–
285.9	7-3, 43	47.0	0.0	<1.0	0.0	0.0	–
345.5	8-2, 5	17.0	0.0	0.0	0.0	0.0	–
397.7	9-1, 117	41.0	0.0	<1.0	0.0	0.0	–
455.8	10-2, 126	41.0	0.0	0.0	0.0	0.0	–
522.3	11-2, 79	35.0	0.0	<1.0	0.0	0.0	–
611.9	12-5, 40	48.0	0.0	<1.0	0.0	0.0	–
612.4	12-5, 91	42.0	0.0	<1.0	0.0	0.0	–
699.7	13-6, 124	47.0	0.0	0.0	0.0	0.0	–

TABLE 4 – *Continued*

Depth (m)	Sample (Interval in cm)	Calcite	Aragonite	Dolomite	Siderite	Magnesite	Manganocalcite
705.4	14-4, 35-40	51.0	0.0	0.0	0.0	0.0	–
820.9	15-2, 35	47.0	0.0	0.0	0.0	0.0	–
823.4	15-3, 138	31.0	0.0	0.0	0.0	0.0	–
835.5	16-2, 47	36.0	0.0	0.0	0.0	0.0	–
842.2	16-6, 124	37.0	0.0	0.0	0.0	0.0	–
858.3	17-1, 127	34.0	0.0	6.0	4.0	0.0	–
872.8	18-1, 130	42.0	0.0	<1.0	0.0	0.0	–
877.3	18-4, 127	27.0	0.0	0.0	0.0	0.0	–
Site 355							
55.2	1-2, 72-74	0.0	0.0	0.0	0.0	–	0.0
113.5	2-3, 50-52	0.0	0.0	0.0	0.0	–	0.0
117.3	2-5, 130-132	0.0	0.0	0.0	tr	–	tr
169.4	3-2, 90-92	33.0	0.0	0.0	0.0	–	0.0
173.6	3-5, 60-62	0.0	0.0	0.0	0.0	–	tr
223.1	4-3, 110-112	0.0	0.0	0.0	0.0	–	tr
243.4	5-1, 38-40	0.0	0.0	0.0	<2.0	–	3.0
248.5	5-4, 100-102	0.0	0.0	0.0	<1.0	–	2.0
264.2	6-2, 66-68	0.0	0.0	0.0	<1.0	–	1.0
287.9	7-2, 90-92	0.0	0.0	0.0	<2.0	–	3.0
289.5	7-3, 100-102	0.0	0.0	0.0	<1.0	–	2.0
308.7	8-2, 120-121	0.0	0.0	0.0	<2.0	–	4.0
321.1	9-2, 58-60	0.0	0.0	0.0	0.0	–	1.0
349.9	11-2, 86-88	0.0	0.0	0.0	tr	–	2.0
363.9	12-5, 86-88	0.0	0.0	0.0	0.0	–	tr
374.8	13-3, 75-77	0.0	0.0	0.0	0.0	–	tr
386.4	15-1, 86	0.0	0.0	3.0(?)	0.0	–	tr
386.5	15-1, 101	0.0	0.0	0.0	0.0	–	tr
408.9	17-3, 142-145	87.0	0.0	0.0	0.0	–	0.0
409.2	17-4, 20-22	79.0	0.0	0.0	0.0	–	0.0
412.7	17-6, 65-67	89.0	0.0	0.0	0.0	–	0.0
419.7	18-1, 120-122	82.0	0.0	0.0	0.0	–	0.0
421.9	18-3, 41-43	72.0	0.0	0.0	0.0	–	0.0
430.8	19-2, 131-133	61.0	0.0	0.0	0.0	–	0.0
442.0	20-2, 148-150	86.0	0.0	0.0	0.0	–	0.0
Hole 356							
10.3	2-1, 82-85	67.0	0.0	0.0	0.0	–	0.0
39.8	3-2, 28-30	52.0	0.0	0.0	0.0	–	0.0
60.6	4-3, 55-57	42.0	0.0	0.0	0.0	–	0.0
91.0	5-4, 101-103	52.0	0.0	0.0	0.0	–	0.0
119.0	6-4, 50-53	30.0	0.0	0.0	0.0	–	0.0
138.0	7-4, 50-53	24.0	0.0	0.0	0.0	–	0.0
169.6	8-2, 60-63	30.0	0.0	0.0	0.0	–	0.0
198.5	9-2, 98-100	36.0	0.0	0.0	tr	–	0.0
225.0	10-3, 48-50	29.0	0.0	0.0	tr	–	0.0
244.8	11-2, 129-131	16.0	0.0	0.0	0.0	–	0.0
253.1	12-1, 11-13	21.0	0.0	0.0	0.0	–	0.0
273.8	14-1, 25-27	31.0	0.0	0.0	tr	–	0.0
292.0	16-1, 100-102	17.0	0.0	0.0	0.0	–	0.0
299.5	17-4, 50-53	44.0	0.0	0.0	0.0	–	0.0
318.4	19-4, 40-42	16.0	0.0	0.0	0.0	–	0.0
353.7	23-2, 70-72	38.0	0.0	0.0	0.0	–	0.0
365.0	24-3, 101-103	21.0	0.0	0.0	0.0	–	0.0
365.9	24-4, 35-37	70.0	0.0	0.0	0.0	–	0.0
368.2	24-5, 120-122	42.0	0.0	0.0	0.0	–	0.0
372.8	25-2, 30-33	50.0	0.0	0.0	tr	–	0.0
381.7	26-2, 23-25	46.0	0.0	0.0	tr	–	0.0
408.8	29-1, 30-32	8.0	0.0	0.0	0.0	–	0.0
411.1	29-2, 110-112	24.0	0.0	0.0	0.0	–	0.0
416.7	29-6, 30-32	50.0	0.0	0.0	0.0	–	0.0
443.7	31-5, 68-70	63.0	0.0	0.0	0.0	–	0.0
487.0	33-2, 94-97	45.0	0.0	0.0	0.0	–	0.0
545.0	35-3, 50-52	46.0	0.0	0.0	0.0	–	0.0
654.3	38-3, 82-84	45.0	0.0	tr	tr	–	0.0
681.3	39-5, 75-77	0.0	0.0	0.0	0.0	–	0.0
701.4	40-6, 42-44	2.0	0.0	0.0	0.0	–	0.0
705.0	41-2, 48-50	0.0	0.0	0.0	0.0	–	0.0
734.1	44-2, 110-112	26.0	0.0	0.0	0.0	–	0.0

TABLE 4 – *Continued*

Depth (m)	Sample (Interval in cm)	Calcite	Aragonite	Dolomite	Siderite	Magnesite	Manganocalcite
Hole 356A							
24.2	1-4, 72-74	34.0	0.0	0.0	0.0	–	0.0
35.1	2-5, 55-57	43.0	0.0	0.0	0.0	–	0.0
Hole 359							
6.4	1-3, 91-141	74.0	0.0	0.0	0.0	–	0.0
36.9	2-6, 139-141	58.0	0.0	0.0	0.0	–	0.0
58.2	3-1, 15-17	47.0	0.0	0.0	0.0	–	0.0
62.0	3-3, 96-98	40.0	0.0	0.0	0.0	–	0.0
62.8	3-4, 26-28	0.0	0.0	0.0	<1.0	–	0.0
91.2	4-2, 19-21	3.0	0.0	0.0	0.0	–	0.0
Hole 359A							
17.6	1-6, 108-110	73.0	0.0	0.0	0.0	–	0.0
17.6	1-6, 112-114	72.0	0.0	0.0	0.0	–	0.0
21.5	2-2, 104-106	72.0	0.0	0.0	0.0	–	0.0

Unit IV is represented by slightly cemented nannofossil oozes (chalk) and limestones containing $CaCO_3$ in the range of 44.03 to 87.05%, with carbonate decreasing from top to bottom. In addition to coccoliths and foraminifers, dolomite is found locally (up to 10-15% of the sediment).

Unit V consists of marly muds and siliceous limestones; the content of $CaCO_3$ is 40.27 to 67.29%. The basic components are authigenic calcite, coccoliths, and planktonic foraminifers. At the very bottom of the unit a calcareous concretion of 10 cm was found. In the upper part of Unit V (Core 40, Section 4 and Core 41, Section 2) are found interlayers of terrigenous (siliceous) sediments, containing 1 to 15.01% of $CaCO_3$, enriched by Zn, Ni, Co, and very low in potassium.

Thus, the quantity of $CaCO_3$ decreases from top to bottom. The role of foraminifers decreases in the same direction, and authigenic calcite and biogenic siliceous remains increase.

Site 357 presents a classical example of transition from loose foraminiferal-coccolith ooze of Plio-Pleistocene age into chalk and limestones of Cretaceous age.

Site 358

The content of $CaCO_3$ varies in the range from 0.00 to 61.29%. In Unit I $CaCO_3$ is completely absent. It is possibly related to: (1) unfavorable (cold) conditions for organisms with calcareous skeletons; (2) with position of the site below the present compensation depth (4600-5000 m for the Argentine Basin); or (3) with intrusion of cold Antarctic bottom waters into the basin.

The lower unit of sediments is represented by marly chalks and terrigenous muds (mudstones). The calcareous material consists mostly of coccoliths, with foraminifers occurring more rarely. This material consists exclusively of low-magnesian calcite (Table 5). The content of $CaCO_3$ decreases to 1.75% in mudstones.

The high $CaCO_3$ content indicates that the depth had been either close to the compensation depth or above it during the period of accumulation of the sediments of the lower unit. Large amounts of barite are in the chalk and Paleogene sediments of Site 358 (Figure 2).

After the deposition of Unit II sediments (late Eocene?), the conditions of sedimentation abruptly changed. This change represents not only a possible variation (rise) of the compensation depth (or subsidence of the bottom below it), but also a time of general drop of temperature in the southern hemisphere, beginning in the Eocene when local glaciers

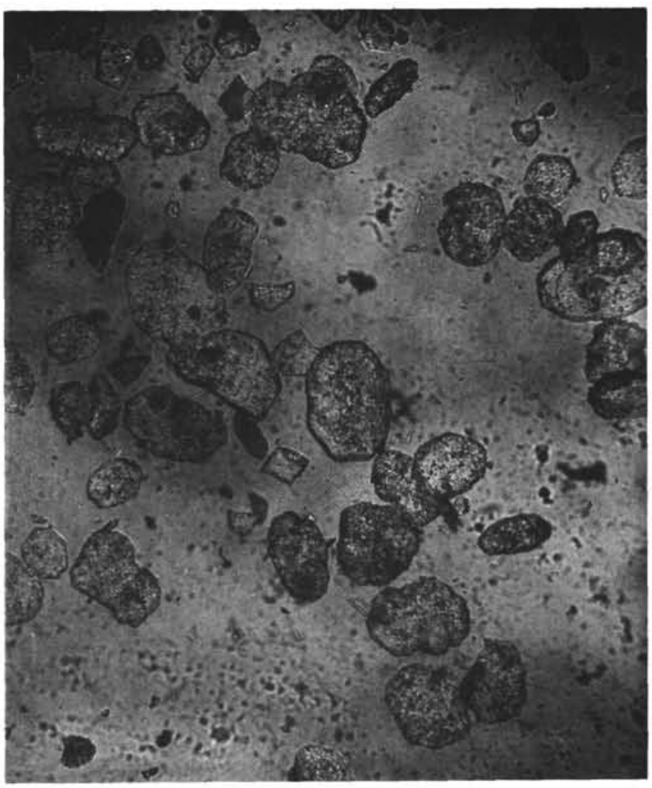

Figure 2. *Microphotograph of barite at the Site 358 (Sample 11-4, 91-93 cm). Heavy coarse aleurite fraction (0.1-0.05 mm).*

TABLE 5
X-ray Diffraction Analysis of Bulk Samples From Sites 357, 358, Leg 39
(in % from total crystalline componnets)

Depth (m)	Sample (Interval in cm)	Calcite	Dolomite	Siderite	Total	Pyrite
4.0	1-3, 100-103	95.2	0.0	0.0	95.2	0.0
20.4	3-2, 90-92	93.5	3.9	0.0	97.4	0.0
41.0	5-3, 100-102	90.5	0.0	0.0	90.5	0.0
51.8	6-4, 80-83	91.3	0.0	0.0	91.3	0.0
67.7	8-2, 70-73	81.0	0.0	0.0	81.0	0.0
77.2	9-2, 70-73	96.2	0.0	0.0	96.2	0.0
88.3	10-1, 80-82	94.3	0.0	0.0	94.3	0.0
89.8	10-2, 80-82	92.8	0.0	0.0	92.8	0.0
112.1	11-2, 103-106	96.6	0.0	0.0	96.6	0.0
137.1	13-4, 62-65	81.8	0.0	0.0	81.8	0.0
178.3	15-2, 78-81	90.6	0.0	0.0	90.6	0.0
193.0	17-3, 100-102	89.2	0.0	0.0	89.2	0.0
196.0	17-5, 100-102	80.8	0.0	0.0	80.8	0.0
262.7	20-2, 117-120	88.4	0.0	0.0	88.4	0.0
309.2	22-4, 13-16	88.1	0.0	0.0	88.1	0.0
333.6	23-2, 61-64	91.2	0.0	0.0	91.2	0.0
351.0	24-1, 45-48	86.1	3.4	0.0	89.5	0.0
357.4	24-5, 84-87	82.3	10.2	0.0	92.5	0.0
359.0	24-6, 101-104	0.0	100.0	0.0	100.0	0.0
359.3	24-6, 132-135	0.0	100.0	0.0	100.0	0.0
383.5	26-3, 148-151	100.0	0.0	0.0	100.0	0.0
411.6	27-3, 108-111	87.9	0.0	0.0	87.9	0.0
436.9	28-1, 91	57.6	0.0	0.0	57.6	0.0
471.5	29-1, 98-101	88.5	0.0	0.0	88.5	0.0
474.3	30-1, 31-34	94.8	0.0	0.0	94.8	0.0
498.7	31-2, 123-126	91.6	0.0	0.0	91.6	0.0
525.9	33-3, 142-145	68.0	9.5	0.0	77.5	0.0
554.8	84-4, 32-35	71.9	tr	0.0	71.9	0.0
607.7	36-1, 68-71	52.8	7.0	0.0	59.8	0.0
693.3	40-1, 74-77	61.0	15.4	0.0	76.4	0.0
697.4	40-4, 44-45	17.4	0.0	0.0	17.4	0.0
697.5	40-4, 45-46	tr	0.0	0.0	tr	tr
705.3	41-2, 76-79	51.4	tr	0.0	51.4	0.0
705.3	41-2, 79-80	17.9	0.0	0.0	17.9	6.3
705.3	41-2, 81-82	19.5	0.0	0.0	19.5	8.6
718.0	42-3, 96-99	49.7	11.1	2.0	62.8	0.0
726.4	43-3, 140-143	50.3	1.8	1.4	53.6	0.0
733.2	44-2, 18-21	67.2	10.3	0.0	77.5	0.0
746.3	46-3, 31-34	77.8	0.0	tr	77.8	0.0
753.1	47-3, 56-59	59.6	18.0	0.0	77.6	0.0
759.5	48-1, 47-48	82.2	0.0	0.0	82.0	0.0
781.4	50-3, 42-44	80.7	6.8	0.0	87.5	0.0
790.9	51-3, 34-36	62.1	0.0	0.0	62.1	0.0
796.2	51-6, 125-126	64.5	0.0	0.0	64.5	0.0
Site 358						
55.7	1-6, 70-72	0.0	tr	4.4	4.4	0.0
128.9	2-4, 94-96	0.0	tr	4.3	4.3	0.0
201.7	3-2, 71-73	0.0	0.0	0.0	0.0	0.0
206.2	3-5, 71-73	0.0	0.0	0.0	0.0	0.0
282.5	4-1, 96-98	0.0	0.0	3.6	3.6	0.0
359.6	5-2, 62-64	0.0	0.0	3.1	3.1	0.0
426.9	6-3, 139-141	0.0	0.0	2.9	2.9	0.0
493.0	7-2, 99-101	0.0	0.0	0.0	0.0	0.0
552.2	8-1, 117-119	0.0	0.0	0.0	0.0	0.0
595.6	9-2, 63-65	0.0	0.0	4.0	4.0	0.0
640.2	10-3, 73-75	0.0	0.0	0.0	0.0	0.0
706.1	11-3, 7-9	0.0	0.0	0.0	0.0	0.0
708.4	11-4, 86-88	86.7	0.0	0.0	86.7	0.0
752.6	12-2, 59-61	64.3	0.0	0.0	64.3	0.0
754.3	12-3, 75-77	89.1	0.0	0.0	89.1	0.0
781.8	13-2, 130-132	86.6	0.0	0.0	86.6	0.0
791.4	14-2, 137-139	70.8	0.0	0.0	70.8	0.0
804.7	15-1, 66-68	8.9	0.0	0.0	3.9	0.0
825.5	16-2, 103-105	22.6	0.0	0.0	22.6	0.0

TABLE 6
Comparative Data on the Chemical Composition of the Recent and Upper Quaternary Sediments in Areas Near Leg 39 Sites (see Figure 1 for locations)

Horizon, (in cm)	Type of Sediment	Content (%) $CaCO_3$	SiO_2-Amorph	C_{org}	Fe	Mn	Ti	P
	Guiana Basin, Site 53. Depth 5080m, 12°59′N, 53°01′W.							
0-10	Pelitic terrigenous low-calcareous brown mud	26.22	1.31 (1.85)	0.36 (0.50)	4.01 (5.56)	0.14 (0.19)	0.33 (0.46)	0.03 (0.04)
30-40	Pelitic terrigenous low-ferrugenous, low-manganese brown mud	0.64	1.28 (1.29)	0.26 (0.27)	6.12 (6.26)	1.01 (1.03)	0.49 (0.50)	0.04 (0.04)
80-90	Pelitic terrigenous low-ferrugenous, low-manganese brown mud	3.75	1.35 (1.41)	0.38 (0.40)	5.37 (5.68)	0.25 (0.26)	0.46 (0.47)	0.04 (0.04)
110-120	Pelitic terrigenous, low-ferrugenous brown mud	1.64	1.00 (1.02)	0.23 (0.24)	6.31 (6.50)	0.10 (0.13)	0.46 (0.47)	0.04 (0.04)
140-149	Pelitic terrigenous dark-gray mud	0.00	0.74 (0.74)	0.50 (0.50)	4.19 (4.24)	0.08 (0.08)	0.51 (0.52)	0.02 (0.02)
170-180	Pelitic terrigenous low-calcareous, low-manganese brownish gray mud	0.50	0.94 (1.12)	0.35 (0.42)	4.42 (5.34)	0.21 (0.23)	0.33 (0.40)	0.02 (0.02)
210-220	Pelitic terrigenous low-ferrugenous grayish brown mud	0.50	2.20 (2.24)	0.23 (0.24)	5.37 (5.53)	0.05 (0.05)	0.46 (0.47)	0.03 (0.03)
240-250	Aleuritic-pelitic, low-ferrugenous, bluish gray mud	0.00	8.44 (8.44)	0.27 (0.30)	5.45 (6.11)	0.05 (0.06)	0.42 (0.47)	0.02 (0.02)
260-270	Aleuritic-pelitic, ethmodiseus, low-siliceous, bluish gray mud	0.00	12.84 (12.84)	0.33 (0.39)	3.44 (4.09)	0.02 (0.02)	0.39 (0.46)	0.03 (0.04)
290-302	Pelitic terrigenous, low ferrugenous, bluish gray mud	0.50	1.38 (1.39)	0.25 (0.25)	5.65 (5.77)	0.12 (0.12)	0.46 (0.47)	0.03 (0.03)
313-320	The same	0.00	1.27 (1.27)	0.25 (0.25)	5.98 (6.07)	0.05 (0.05)	0.48 (0.49)	0.05 (0.05)
Guiana Basin, Site 375. Depth 4330m, 03°00′N, 39°58′W								
0-3	Aleuritic-pelitic coccolith-foraminiferal ooze	56.06	0.84 (1.93)	0.33 (0.77)	2.54 (5.93)	0.08 (0.19)	0.24 (0.56)	0.04 (0.09)
Brasilian Basin, Site 400-2. Depth 4670m, 17°50′S, 31°35′W.								
0-7	Pelitic terrigenous, low-ferrugenous-low-manganese, grayish brown mud (red clay)	0.75	0.98 (1.00)	0.38 (0.39)	5.84 (5.96)	0.25 (0.26)	0.51 (0.52)	0.05 (0.05)
20-25	Pelitic terrigenous, low-ferrugenous-low-manganese, brown mud (red clay)	1.57	1.51 (1.56)	0.31 (0.32)	5.65 (5.84)	0.32 (0.33)	0.43 (0.44)	0.04 (0.04)
41-46	Pelitic terrigenous, low-ferrugenous-low-manganese, brown mud (red clay)	2.64	1.50 (1.57)	0.32 (0.33)	5.09 (5.32)	0.32 (0.33)	0.43 (0.45)	0.05 (0.05)
74-79	The same	0.50	1.65 (1.69)	0.50 (0.51)	5.37 (5.52)	0.24 (0.24)	0.45 (0.46)	0.04 (0.04)
103-108	Pelitic terrigenous low-manganese, brown mud (red clay)	0.75	1.72 (1.77)	0.29 (0.29)	4.80 (4.94)	0.26 (0.26)	0.46 (0.47)	0.04 (0.04)
131-136	Pelitic terrigenous, low-ferrugenous low-manganese, brown mud (red clay)	0.50	1.66 (1.70)	0.26 (0.26)	5.37 (5.50)	0.32 (0.32)	0.45 (0.46)	0.05 (0.05)
155-160	The same	0.00	1.53 (1.53)	0.24 (0.24)	5.47 (5.47)	0.33 (0.33)	0.45 (0.45)	0.05 (0.05)
178-183	Pelitic terrigenous, low-ferrugenous low-manganese, grayish brown mud (red clay)	0.26	1.61 (1.64)	0.26 (0.26)	5.56 (5.68)	0.38 (0.38)	0.46 (0.47)	0.05 (0.05)
217-222	The same	0.25	1.81 (1.95)	0.18 (0.18)	5.56 (5.69)	0.35 (0.36)	0.46 (0.46)	0.06 (0.06)
233-238	The same	0.00	1.75 (1.75)	0.16 (0.16)	5.18 (5.18)	0.30 (0.30)	0.51 (0.51)	0.06 (0.06)
Argentine Basin, Site 16. Depth 5100m, 40°39′S, 36°27′W.								
0-25	Pelitic terrigenous, low-calcareous, with diatoms, greenish gray mud	11.14	5.14 (6.31)	–	3.82 (4.81)	0.20 (0.24)	–	–
25-30	Pelitic terrigenous, with manganese nodulas, greenish gray mud	4.94	1.64 (1.69)	–	4.94 (5.21)	0.05 (0.05)	–	–
50-70	Pelitic terrigenous, low-ferrugenous, greenish gray mud	7.04	2.08 (2.24)	–	5.05 (5.61)	0.06 (0.06)	–	–
75-100	Pelitic terrigenous, greenish gray mud	4.88	1.55 (1.63)	–	4.91 (5.27)	0.05 (0.05)	–	–
100-125	Pelitic terrigenous, low-ferrugenous, greenish gray mud	7.27	1.15 (1.24)	–	6.75 (7.47)	0.04 (0.04)	–	–

TABLE 6 – *Continued*

Horizon (in cm)	Type of Sediment	Content (%) CaCO$_3$	SiO$_2$-Amorph	C$_{org}$	Fe	Mn	Ti	P
Argentine Basin – *Continued*								
125-150	Pelitic terrigenous, greenish gray mud	6.59	1.13 (1.21)	–	4.88 (5.36)	0.05 (0.05)	–	–
150-175	Pelitic terrigenous, low-ferrugenous, greenish gray mud	4.32	1.12 (1.17)	–	5.22 (6.43	0.05 (0.05)	–	–
175-200	Pelitic terrigenous, low- ferrugenous, greenish gray mud	9.66	1.32 (1.46)	–	5.64 (6.43)	0.07 (0.08)	–	–
200-225	Pelitic terrigenous, low-ferrugenous, low-calcareous, light-green mud	16.94	1.08 (1.30)	–	5.66 (6.98)	0.05 (0.06)	–	–
225-250	The same	14.34	1.21	–	5.71	0.04	–	–

Content of elements in dry sediment and on a carbonate-free basis (in brackets).

TABLE 7
Average Contents of Elements in Extended Genetic Types of Sediments in Sites 353 to 358 (see Table 2)

Type of Sediment	Sites	Total Samples	Content (in %) CaCO$_3$	C$_{org}$	Fe	Mn	Ti	P	Na$_2$O	K$_2$O	Content in 10^{-4}% Zn	Cu	Ni	Co	Cr	Cd
Terrigenous sediments (<30 % CaCO$_3$)	353[a], 354[a], 356[a], 357[a], 358[a]	13	9.43	0.46	4.55	0.11	0.50	0.06	2.09	2.30	120	45	84	26	49	<5
	353[b], 354[b], 356[b], 357[b], 358[b]	13	–	–	5.04	0.13	0.56	0.06	2.29	2.54	132	50	91	28	54	<6
Siliceous muds (<30% CaCO$_3$)	356[a]	9	28.79	0.68	2.76	0.09	0.30	–	1.81	1.46	72	28	18	10	47	<6
	356[b]	9	–	–	3.92	0.13	0.42	–	2.53	2.05	101	40	25	10	63	<9
	358[a, b]	9	0.00	0.28	4.46	0.06	0.49	0.04	2.68	2.57	118	74	47	18	38	<6
	356 + 358[a]	18	28.79	0.48	3.61	0.07	0.39	–	3.03	2.43	95	52	33	–	42	<6
	356 + 358[a, b]	18	–	–	4.19	0.09	0.45	–	–	–	110	57	36	–	50	<7
Calcareous sediments (>60% CaCO$_3$)	354[a] to 15-3[c]	9	68.98	0.11	1.71	0.08	0.11	0.03	0.81	0.71	37	61	22	–	31	<4
	354[a, b] to 15-3[c]	9	–	–	5.97	0.25	0.40	0.09	–	–	130	207	78	–	104	<14
	357[a] to 28-1[c]	21	82.68	0.48	0.98	0.03	0.12	–	0.98	0.58	18	16	15	–	28	<6
	357[b] to 28-1[c]	21	–	–	6.35	0.27	0.61	–	–	–	136	105	87	–	154	<46
	354, 355[a], 356[a], 357[a], 358[a]	45	76.94	0.41	1.27	0.09	0.12	0.03	0.91	0.73	27	27	19	–	26	<6
	354[b], 355[b], 356[b], 357[b], 358[b]	45	–	–	6.04	0.40	0.52	0.12	–	–	132	119	90	–	122	<33
Marly carbonaceous sediments (30-60% CaCO$_3$)	354[a], 356[a], 357[a]	35	49.32	0.77	2.66	0.07	0.34	0.04	1.14	1.58	66	42	46	–	60	<5
	354[a,b],356[a,b],357[a,b]	35	–	–	5.16	0.14	0.54	0.07	–	–	126	80	89	–	114	<11
Pelagic muds (ancient clays)	355[a]	21	1.27	0.39	5.28	0.18	0.57	0.05	1.84	2.30	132	62	76	25	67	<6
	355[b]	21	–	–	5.34	0.18	0.58	0.05	–	–	133	66	77	25	67	<6

[a]Natural (dry) sediment.

[b]Evaluated in carbonate free basis.

[c]From surface to noted depth.

began appearing in the Antarctic (Geitzenauer et al., 1968). More intensive glaciation occurred in the Oligocene and an ice surface, similar to that of the present, was formed in the Miocene. The fall of temperature in the Antarctic resulted in formation of cold water masses, which as near-bottom currents (Neumann and Pierson, 1966; Bulatov, 1971; Ewing et al., 1971) penetrated far to the north and probably crossed the Equator. This resulted in (1) the rise of the compensation depth level: (2) a sharp increase of cold Antarctic water productivity and mass development of phytoplankton with siliceous skeletons, leading to the accumulation of siliceous muds in the Argentine Basin.

Oligocene-Pleistocene sedimentation took place mainly in a reducing environment, evidenced by gray sediment color and the presence of pyrite and siderite (Table 5). In late Quaternary time, the climatic condition of the Argentine Basin had evidently become more moderate (warm), as a result of which the content of $CaCO_3$ increases locally to 16.94%, whereas $SiO_{2\ amorph}$ drops to 1.08% (Table 6).

Site 359

The upper sediment unit (Core 2, Section 6 and Core 1, Section 3) consists of foraminiferal-coccolithic ooze, the content of $CaCO_3$ being respectively 71.8% and 89.31%. Considerable authigenic magnesian calcite (5-6 mol. % of $MgCO_3$) occurs.

Unit II (from Core 4, Section 2 up to Core 3, Section 4) consists of foraminiferal (Core 3, Section 5), terrigenous (Core 3, Section 4), and volcanogenic (Core 4, Section 2) sediments with the content of $CaCO_3$ being low (up to 3.25%). Authigenic magnesian calcite and dolomite occur in negligible quantities there.

Organic Carbon

The content of C_{org} in the sediments of the western part of the central Atlantic varies from 0.03 up to 9.81%

TABLE 8
Average Contents of Elements in the Recent Sediments (0.5 cm layer) of the Atlantic Ocean
(Emelyanov, Shurko, 1973, Emelyanov, 1974a, b, 1975; Emelyanov et al., 1975)

Type of Sediments		C_{org} Quantity Samples	C_{org} Limits of Contents	C_{org} Average	Fe Quantity Samples	Fe Limits of Contents	Fe Average	Mn Quantity Samples	Mn Limits of Contents	Mn Average
Terrigenous sediments (<10% $CaCO_3$)	a	169	0.04-8.10	0.92	284	tr.-9.97	3.18	131	tr.-1.88	0.09
	b	168	0.04-8.90	0.98	270	tr.-7.35	3.22	128	tr.-2.00	0.10
(and terrigenous pelitic muds)	a	53	0.10-12.20	0.84	55	0.74-7.00	5.01	28	0.02-1.88	0.19
	b	52	0.15-20.62	1.42	54	0.80-7.35	5.34	28	0.03-2.00	0.20
Mixed biogenic-terrig. (30-50% $CaCO_3$)	a	18	0.37-8.10	1.84	123	0.75-6.71	2.96	64	tr.-0.39	0.10
	b	18	0.41-8.90	1.94	120	0.92-10.40	5.16	50	tr.-0.74	0.20
Foram-sands nanno-foram oozes (<50% $CaCO_3$)	a	71	0.17-6.57	0.93	265	0.06-4.94	1.46	135	tr.-1.12	0.08
	b	63	0.38-20.08	3.60	263	0.50-16.24	5.71	110	tr.-2.98	0.29
Diatom ooze (>30% SiO_2) amorph.	a	4	0.18-0.60	0.34	5	0.58-1.62	0.97	2	0.06-0.61	0.33
	b				5	1.58-4.14	2.85	2	0.14-1.67	0.90
Volcanogenic sediments Iceland area	a	31	0.12-1.90	0.92	66	5.04-11.85	7.07	36	0.05-0.24	0.15
	b	31	0.12-2.54	1.09	66	5.47-12.88	8.23	30	0.06-0.36	0.17
Red clays (<10% $CaCO_3$)	a	14	0.11-0.44	0.32	8	5.28-6.59	5.85	18	0.08-1.15	0.40
	b	14	0.11-0.45	0.33	14	4.92-13.52	6.43	14	0.23-3.62	0.71
All types of sediments	a	452	0.04-12.50	1.09	959	tr.-16.05	3.05	494	tr.-3.14	0.10
	b	435	0.04-20.62	1.67	947	tr.-19.94	4.88	428	tr.-3.62	0.19

or 0.4 to 0.5% on the average. It is lower than in the Recent sediments of the Atlantic Ocean, but approximately the same as reported from Cenozoic sediments at sites drilled on Legs 3 and 4 (Pimm, A.C., 1970; Pimm, A.C., 1970).

The lowest contents of C_{org} (from 0.03-0.27%) occur in biogenic calcareous sediments at Site 354. They are slightly lower than in pelagic terrigenous muds of late Quaternary age in the Guiana Basin (Table 2). This is a result of low biological productivity of this area in the Late Cretaceous and Cenozoic, and of low rates of sedimentation and rapid oxidation of organic material. In the Miocene the sedimentation rate was as low as 0.004 cm/1000 years (probably representing important hiatuses). In the Eocene-Oligocene-Miocene the rate was 1.7-2.2 cm/1000 years, compared to 10 cm/1000 years in the Pleistocene.

The content of C_{org} at Site 355 varies in the range of 0.15 to 0.66%; i.e., it is very close to the average content in Recent red clays (Table 8). Approximately the same quantities of C_{org} occur in the pelagic muds at Site 358. Thus, despite the high productivity of phytoplankton in Antarctic waters and waters of the Argentine Basin in the Oligocene-Pleistocene, the intensive accumulation of the remains of diatoms there, the rapid rates of sedimentation and, presumably, reducing environments of sedimentation, as little organic substance occurs there as in pelagic diatom muds from near Antarctica. Probably this is a result of rapid rates of decomposition of organic substances.

The C_{org} in the sediments of the Rio Grande Rise (Site 357) contain from 0.24 to 0.84%, with an average of 0.50%, which is approximately the same as in Recent coccolith-foraminiferal oozes of the west Atlantic (Emelyanov, 1975).

Abnormally high quantities of C_{org} (from 0.48-9.81%) occur in older sediments at Site 356, being 0.80 to 1.0% on the average. Interlayers of sediments with sapropels and pyrite accumulated there during Coniacian and Turonian time. Similar interlayers with sapropels were described in holes drilled during Leg 14 (Berger and von Rad, 1972), and also in the Caribbean Sea. The high quantities of organic substance are thought to have accumulated in situ under reducing conditions. High contents of C_{org} are independent of genetic type of sediment and depth of subbottom. The high contents of C_{org} are caused mainly by high constant biologic productivity, favorable conditions for burial and possible supply of organic material from outside the basin. The area of the ocean now occupied by the São Paulo Plateau was a semi-isolated (shallow) basin, supplied by terrigenous material from South America during the Late Cretaceous and Early Cenozoic. Rates of sedimentation were usually high (2-6 cm/1000 years), and reducing conditions (pyrite is frequently present in sediments) were prevalent. Redeposition of sediment occurred, with the formation of conglomerates and turbidites.

DISCUSSION AND CONCLUSIONS

Tables 1 to 5, 7, and 9 show the relative abundance of a series of selected elements determined to be in cores of sediments from DSDP Leg 39. Tables 6, 8, and 10 show their comparative abundance in a variety of ancient and modern marine lithofacies elsewhere in the Atlantic Ocean. Examination of this data shows that, in general, sediments of any one genetic type have a chemical composition that varies only slightly through space and time which suggests, in turn, that there has been essentially no geochemical "evolution" in the central Atlantic from Late Cretaceous to the present. In contrast, the geographic distribution of the lithofacies in that area has changed markedly during the same time

TABLE 8 – *Continued*

Ti			P			$Ba.10^{-4}$			$Zr.10^{-4}$		
Quantity Samples	Limits of Contents	Average	Quantity Samples	Limits of Contents	Average	Quantity Samples	Limits of Contents	Average	Quantity Samples	Limits of Contents	Average
188	tr.-0.82	0.34	177	tr.-0.46	0.07	100	130-3750	470	103	300-850	210
177	tr.-0.85	0.38	177	tr.-0.48	0.08	100	130-4260	500	103	300-860	220
53	0.04-0.66	0.40	47	tr.-0.46	0.08	22	130-3750	690	22	80-270	150
46	0.11-0.71	0.47	47	0.02-0.48	0.08	22	130-4260	740	22	90-290	160
94	0.05-0.81	0.27	81	0.01-0.70	0.09	42	100-1200	450	42	<50-500	150
93	0.08-1.49	0.47	81	0.02-1.16	0.14	42	160-2100	740	42	<70-1180	240
206	tr.-0.44	0.12	184	tr.-4.36	0.11	80	<200-1830	350	80	<20-670	90
204	tr.-1.30	0.48	183	0.01-9.13	0.42	80	<200-7870	460	80	<40-2220	340
6	0.07-0.10	0.08	6	0.02-0.03	0.02	8	210-1040	570	7	40-130	70
5	0.11-0.31	0.21	5	0.03-0.06	0.05	8	220-1090	590	–	–	–
36	0.52-1.96	1.13	31	0.06-0.18	0.11	29	<200-1300	410	27	<40-360	180
32	0.70-2.36	1.35	27	0.07-0.20	0.13	29	<200-1870	460	27	<40-370	190
15	0.11-0.66	0.44	14	0.05-0.11	0.08	–	–	–	–	–	–
10	0.41-0.57	0.50	14	0.05-0.12	0.08	–	–	–	–	–	–
700	tr.-1.96	0.31	623	tr.-4.36	0.10	352	90-7870	450	354	<20-850	160
682	tr.-2.36	0.50	615	tr.-9.13	0.21	352	110-7870	780	354	<40-1630	240

interval, influenced by paleoenvironmental conditions and diagenesis.

$CaCO_3$ data indicate that the conditions of carbonate accumulation changed sharply near the Paleocene-Eocene boundary. This is particularly true of areas that were deep or distant from the continent of South America (i.e., Sites 355, 357, and 358).

In the Argentine Basin terrigenous sediment had been primarily accumulating in the Late Cretaceous; carbonates were meager. The conditions of sedimentation in Cretaceous time suggest the site was shallower than at present. During Paleocene and the beginning of Eocene time, biogenic calcareous material accumulated in greater quantities, producing chalk. Conditions then changed sharply with the onset of glaciation in the Antarctic and the generation of cold, near-bottom current, which penetrated into the Argentine Basin. The compensation depth became shallower, leading to dissolution of carbonates and accumulation of siliceous and silico-terrigenous sediments. This sedimentation regime lasted into the Pleistocene. In late Pleistocene-Holocene time conditions appear to have moderated, favoring biogenic calcareous material as witnessed by an increase of $CaCO_3$, up to 16% in Holocene sediments.

At the Rio Grande Rise site, in the Cretaceous, conditions for accumulation of $CaCO_3$ were variable, perhaps because of the changing distance of the site from the continent and variations in rates of supply of terrigenous material. The depth of the Rio Grande Rise site itself may also have been changing. From late Maestrichtian to the present, the conditions of accumulation of $CaCO_3$ were rather stable and favorable, resulting in a thick section (about 550 m) of foraminiferal-nannofossil oozes. These oozes (beginning in the Miocene, at least) underwent diagenetic transformation (consolidation, cementation) and, down section, were converted into chalk and limestones. In addition, in the middle Eocene, dolomite occurs with limestones and marls.

Conditions for accumulation of biogenic carbonates in the Brazil Basin, during Late Cretaceous, were even more favorable than those in the Argentine Basin or on the Rio Grande Rise. The consistently high content of $CaCO_3$ in the form of pelagic nannofossil oozes and chalk give evidence to this. In the Eocene an abrupt change occurred and conditions became unfavorable for $CaCO_3$ accumulation. This was caused by either subsidence of the bottom, and/or intrusion of cold bottom waters from the Antarctic into the basin with consequent shoaling of the compensation depth. These conditions have remained essentially unchanged to the present and resulted in accumulation of noncarbonate pelagic muds and terrigenous sediments. The rates of sedimentation during this interval has been low, permitting extensive formation of zeolites.

In cases where sites were situated close to the continent (i.e., Sites 354, 350) and where depths were moderate (above compensation), terrigenous material diluted the biogenic carbonate. At certain times (Late Cretaceous especially) the accumulation of carbonates was affected not only by dilution by terrigenous matter, but also by partial dissolution of carbonate, resulting from either subsidence of the bottom below compensation level or a rise in the compensation level itself.

The paucity of volcanogenic (pyroclastic) material is noteworthy (except at Site 359). In the Cretaceous period volcanic activity is evidenced but became much less active in Tertiary time; in only a few cases are there pyroclastics in the post-Cretaceous sediments. An example is the middle Eocene at Site 357 (Core 24,

TABLE 8 – *Continued*

Type of Sediment		Cr.10^{-4} Quantity Samples	Cr.10^{-4} Limits of Contents	Cr.10^{-4} Average	Ni.10^{-4} Quantity Samples	Ni.10^{-4} Limits of Contents	Ni.10^{-4} Average	V.10^{-4} Quantity Samples	V.10^{-4} Limits of Contents	V.10^{-4} Average
Terrigenous sediments	a	103	<20-850	78	103	2->500	46	100	<10-400	97
(<10% $CaCO_3$)	b	103	<20-850	81	103	2->511	48	100	<10-494	102
(and terrigenous	a	22	43-166	101	22	2->500	78	22	100-400	180
pelitic muds)	b	22	47-173	106	22	2->511	81	22	100-494	191
Mixed biogenic-terrig.	a	43	9-250	53	42	10-110	28	41	<20-160	67
(30-50% $CaCO_3$)	b	43	18-403	88	42	16-177	50	41	32-260	111
Foram-sands nanno-foram oozes	a	81	<10-250	47	80	<5-101	26	82	5-180	43
(<50% $CaCO_3$)	b	81	41-793	193	80	21-381	109	81	16-866	182
Diatom ooze	a	8	55-110	73	8	8-107	82	8	113-570	323
(>30% SiO_2 amorph	b	8	56-117	76	8	9-111	85	8	118-590	337
Volcanogenic sediments	a	27	23->1000	145	26	<10-67	35	26	<20-400	212
Iceland area	b	27	29->1000	155	26	<15-74	38	26	23-420	228
Red Clays	a	–	–	–	–	–	–	–	–	–
(<10% $CaCO_3$	b	–	–	–	–	–	–	–	–	–
All types of	a	359	<9-1000	71	354	2->500	35	353	5-570	89
sediments	b	359	13->1000	114	354	2->511	39	353	10-590	133

Note: C - C_{org}, Fe, Mn, Ti, and P for deep water muds of the preantarctic zone of the ocean (Emelyanov and others., - Ba, Zr, Cr, Ni, V, and Cu for shallow water muds of the southwest coast of Africa (Emelyanov, 1973)

Section 5) where limestones and marls, enriched in pyroclastics accumulated. The carbonates are characterized by a peculiar chemical composition, with properties in common with volcanoclastic sediments of basaltic composition. Ti (1.63-2.00%)[1] and Cr (431-796 ppm) contents are high, as are Ni, Co, P, Mn, and Mo. Like volcanoclastic sediments, they are characterized by low concentrations of Fe (3.22-6.54%).

In some cases, the chemical composition of sediment was affected by endogenic (hydrothermal) processes. Chalk deposits at the bottom of Site 355 (Core 19, Section 2 and Core 20, Section 2) overlie basalt substrate (Core 21, Section 1). The sediments, influenced by the products of hydrothermal activity, contain high quantities of Fe, Zn, Cu, Ni, and Co and low quantities of Ti, Na_2O_3, K_2O, and Cr. Such ferruginous sediments, formed by means of endogenic sources, have been described from surface samples in the South Atlantic Ridge area (Boström et al., 1969; Boström et al., 1972), and in certain other recent sediments (Emelyanov, 1975).

Ferruginous sediments were found in the cores and dredge material recovered from the Iceland Plateau and Norwegian Sea during cruises on the R/V *Academic Kurchatov*. The age of these sediments ranges from early Miocene to Pleistocene. They are represented by tuffoargillites, tuffosandstones, sandstones, terrigenous (glacial) clays, and ferromanganese crusts. The following contents are characteristic of these ore-bearing sediments: Fe, up to 19%; Mn, up to 17.36%; Ti, up to 0.83%; P, up to 0.35%; Ni, up to 1000 ppm; Co, up to 500 ppm; Cu, up to 440 ppm; V, up to 240 ppm; Zn, up to 525 ppm; Ba, up to 720 ppm; Mo, up to 100 ppm; Cr, up to 74 ppm; Zr, up to 160 ppm; $CaCO_3$ is absent. As a rule, the ratio (Fe + Mn)/Ti (Strahov, 1974), a good indicator of endogenic processes for areas of the open ocean and the Mid-Atlantic Ridge, is over 25. Although the value is not over 25 in the sediments of Site 355 (Core 19, Section 2 and Core 20, Section 2), it is close to it (ranging from Core 17, Section 21). The upper chalk deposits at Site 355 (Core 18, Section 3 up to Core 17, Section 3) were also enriched in iron and manganese by hydrothermal activity (Fe, 4.01-7.05%; and Mn, 0.20-0.62%). This enrichment is less pronounced up the section. The influence of hydrothermal action on the chemical composition of sediments in the Cretaceous is further indicated by the presence of calcite veins associated with reddish-brown ferruginous nannofossil ooze. By early Eocene hydrothermal activity had completely ceased.

A second zone enriched in ore matter as a result of volcanic activity is the layer of dolomites, occurring in conjunction with a volcanic breccia at Site 357 (Core 24, Section 6). These dolomites are overlain and underlain by limestones, are associated with pyroclastics, and contain the highest quantities of Fe (21.36-28.58%) of all studied samples. They also contain high quantities of Mn, Zn, and Ni. However, Ti and Cr, which are characteristic of pyroclastics and volcanoclastic sediments of basaltic composition, occur very rarely in the dolomites. Therefore we may conclude that the dolomites were formed as the result of a combination of several factors: (1) supply of pyroclastics (found in quantity up to 5%; see description of the smear slide of Sample 357-24-6, 140 cm; (2) emanation of ore matter by means of hydrothermal action, associated with subjacent volcanic

[1]Here and hereafter evaluated on carbonate-free basis.

TABLE 8 – *Continued*

	Cu.10^{-4}	
Quantity Samples	Limits of Contents	Average
26	14-234	75
26	15-253	80
7	50-135	86
7	51-150	90
10	31-82	54
10	50-152	93
32	11-88	31
32	16-640	178
–	–	–
–	–	–
11	29-80	55
11	30-99	62
–	–	–
–	–	–
105	11-264	54
105	15-640	108

breccias; (3) possible chemical precipitation of dolomite and authigenic calcite from sea water. The range of the ratio (Fe + Mn)/Ti, being 17 to 23, is less than in ferruginous sediments of endogenic origin (where it usually exceeds 25), but greater than in pyroclastic sediments (where it usually equals 5-10, Emelyanov, 1975). This suggests that both fluid and solid volcanic source products supplied the Fe, Mn, and Zn and also Ti and Co.

Leg 39 shipboard scientists concluded that mudstones and marly chalk of Late Cretaceous age (Maestrichtian) are also enriched in ore matter. Laboratory study shows clearly that these sediments contain neither high contents of Fe, Mn, Zn, Ni, or Co nor low contents of Ti, Cr, or Al_2O_3. (Fe + Mn)/Ti ratio is very low in these sediments (10-11), and is more typical of normal terrigenous or biogenic calcareous sediments (Emelyanov, 1975). A hydrothermal influence is evidenced by relatively high contents of Fe (7.10%) and Mn (0.15%) in sediments of Cretaceous age at Site 354 (Core 17, Section 2).

Some of the chalk sediments are enriched in organic matter and contain sapropelic interlayers (Site 356, Core 41, Section 4). In addition to the high C_{org} content (up to 9.8%) they are also characterized by high values of Ni and Zn and low concentrations of Mn. Ni, and Zn, probably precipitated in the form of organometallic compounds. The low content of Mn is generally characteristic of shallow reduced muds (Emelyanov, 1973; Emelyanov et al, 1975).

The chemical composition of marly limestones of Santonian age at Site 357 (Core 48, Section 1 up to Core 51, Section 3) is rather unusual in that the sediments contain very low concentrations of Fe, Zn, Ni, and Co, and low concentrations of Ti, Cu, Cr, and other elements. Most likely this has been caused by admixture of considerable biogenic siliceous material, since the sediments are high in SiO_2 and low in Al_2O_3 (Site 357, Core 51, Section 3).

TABLE 9
Content of Some Elements in Bottom Sediments From Leg 39

Sample (Interval in cm)	Ba	Zr	V	Sn	Mo	Be	Ge
Site 354							
3-1, 120	<200	80	70		6.5	3.7	<5
4-1, 40-42	<200	60	80		<5.0	3.6	<5
4-2, 40-42	<200	34	51		11.0	2.5	<5
5-2, 71-73	<200	70	82		<5.0	4.0	<5
6-2, 107	<200	60	59		10.0	3.1	<5
6-3, 91	<200	<40	32		13.0	2.5	<5
7-1, 137	<200	<40	29		12.0	<1.0	<5
7-3, 16	<200	60	53		10.0	2.6	<5
8-2, 30	<200	<40	48		5.7	<1.0	<5
9-3, 112	840	<40	62		6.4	<1.0	<5
10-2, 98	830	<40	30		18	<1.0	<5
11-5, 25	970	50	35		10.0	2.6	<5
12-4, 11	960	<40	37		7.8	2.5	<5
13-6, 125	960	50	31		8.0	3.2	<5
14-1, 106	990	<40	13		7.8	2.1	<5
15-2, 45	1300	60	19		8.7	2.5	<5
15-3, 84	980	<40	27		7.9	2.2	<5
17-2, 117	980	<40	37		6.3	2.3	<5
18-1, 130	1000	<40	38		<5.0	1.2	<5
Site 355							
1-2, 69-71	350	110	180		<5.0	<1.0	<5
1-6, 80-82	350	130	150		<5.0	<1.0	<5
2-3, 130-132	320	90	180		<5.0	<1.0	<5
2-5, 135-137	220	70	140		<5.0	<1.0	<5
3-2, 88-90	300	60	110		<5.0	<1.0	<5
3-5, 58-60	300	100	130		<5.0	<1.0	<5
4-3, 110-112	250	90	140		<5.0	<1.0	<5
5-1, 40-42	<200	70	130		<5.0	<1.0	<5
5-4, 98-100	<200	90	150		<5.0	<1.0	<5
6-2, 100-102	300	70	110		<5.0	<1.0	<5
7-3, 100-102	<200	60	170		<5.0	<1.0	<5
8-2, 140-141	<200	130	120		<5.0	<1.0	<5
9-2, 50-52	<200	200	110		<5.0	<1.0	<5
11-2, 91-92	<200	130	100		<5.0	<1.0	<5
12-4, 60-62	320	120	110		<5.0	<1.0	<5
13-3, 52-54	<200	140	160		<5.0	<1.0	<5
14-3, 93-94	<200	170	280		<5.0	<1.0	<5
14-5, 87-89	<200	140	220		<5.0	<1.0	<5
15-1, 84	<200	250	870		<5.0	<1.0	<5
15-1, 127	<200	100	120		<5.0	<1.0	<5

The composition of pelagic zeolithic claystones and mudstones of Eocene age (Site 355), with low contents of Mn, Fe, P, and several other elements, is quite different from mid-Pleistocene muds and red clays of the Brazil Basin. It is proposed that they may not be paleo red clays, but pelagic terrigenous muds, accumulated at the depths below the compensation level.

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TABLE 10
Content of Rare Elements in the Recent Sediments of the Atlantic Ocean near Leg 39 Sites, (10^{-4}%)

Station	Horizon (in cm)	Ba	Cr	Zr	Ni	V	Mo	Ge	Be	Sn
375	0-3	200	66	180	46	820	<50	<50	<1.0	<6.0
		(460)	(150)	(410)	(105)	(1870)	(<114)	(<114)	(<2.3)	(<13.6)
400-2	0-7	<200	102	90	65	1910	<50	<50	<1.0	<6.0
		(<200)	(103)	(90)	(66)	(1920)	(<50)	(<50)	(<1.0)	(<6.0)

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