12. INTERSTITIAL WATER STUDIES ON SMALL CORE SAMPLES DEEP SEA DRILLING PROJECT, LEG 7[1]

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INTRODUCTION

The sediments cored on Leg 7 are predominantly deep sea biogenic oozes and chalks; only rarely were significant quantities of pelagic clays and volcanic detritus encountered. The biogenic sections include both siliceous and calcareous deposits. At three sites the drilling terminated in basalt, one of which (Site 62) is interpreted as being intrusive on the basis of intense alteration of the overlying sediment. With the exception of Ca^{++} and Sr^{++}, compositional changes in the pore waters are characteristically small relative to those reported previously for rapidly deposited, non-biogenic sediments. Ca^{++} and Sr^{++}, however, exhibit concentrations of up to three times and ten times, respectively, those found in sea water. In several instances, constant concentration gradients as a function of depth have been found.

The sampling, storage and analytical procedures employed have been briefly described in an earlier report (Sayles *et al.*, 1970) and are detailed in a manuscript in preparation (Manheim and Chan). Sodium has been calculated as the difference between the summation of the anions and the summation of the major cations exclusive of sodium; to date, this method has proven more accurate than direct analytical methods. Agreement between the two types of silica determination used (emission spectrometric and colorimetric) is poor; the values obtained by emission spectrometry are characteristically higher. The colorimetric technique measures only "reactive" silica (monomeric and possibly dimeric) while the emission spectrometric technique will determine all of the silica in solution and in suspension. The silica content of most of the solutions is high (60 ppm) and polymerization is likely. We are currently investigating this discrepancy. The *p*H and water content data reported were obtained aboard the *Glomar Challenger* immediately after sampling.

The authors gratefully acknowledge the assistance of Charlotte Lawson and Heidi Richards in conducting the laboratory determinations. Atomic absorption equipment was kindly made available by Derek Spencer and Peter Brewer.

RESULTS

Major and minor dissolved constituents of the interstitial waters sampled during Leg 7 are presented in Tables 1 and 2. The compositional changes in most constituents are relatively small but significant. Potassium characteristically is enriched in shallow samples (to 0.45 gm/kg) and is depleted to seawater concentrations or less at greater depths. Magnesium is commonly depleted to concentrations of 1.00 to 1.10 gm/kg. Sulphate is depleted to a variable degree at Sites 62, 63 and 64 (2.00 to 2.50 gm/kg) and to a lesser extent at other sites.

The "non-reactive" constituents sodium and chloride show little change, as has been reported for this type of sediment in Legs 1 through 6. No evidence is found for significant reaction, and it is felt that the departures of these two elements from seawater concentrations are due primarily to sample manipulation. The concentration of silica is as observed on Legs 5 and 6, normally ranging between 25 and 35 ppm silica. Lithium is usually enriched with respect to seawater (0.17 ppm), and concentrations are similar to those reported previously. The barium determinations showed considerable scatter below 1 ppm and are not reliable below this concentraiton.[3] With the exception of Samples 62-0-2-2 (1 ppm) and 63-13-3 (1.2 ppm), all values were less than 1 ppm.

The variation of calcium and strontium is markedly different from that of the other constituents at Sites 62, 63 and 64. Relative to seawater, calcium may be enriched almost 3-fold (1.00 gm/kg) while strontium exhibits an increase as great as 10-fold (70 to 80 ppm).

DISCUSSION

Some of the observed departures in concentration from seawater may be attributable to the temperature of squeezing effects described by Mangelsdorf *et al.* (1969) and demonstrated by Bischoff *et al.* (1970). Unfortunately, data on the behavior of specific

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[3]This limitation in Ba determination applies only to the results reported for this leg.

minerals as a function of temperature are largely lacking, as are *in situ* temperature data for the samples. The latter deficiencies prevent any quantitative evaluation of the temperature artifacts introduced by the tendency of clays to adsorb or desorb ions as the ambient temperature changes. However, it can be demonstrated qualitatively that most of the observed deviations from seawater cannot be due to the above temperature effect. Ca^{++} is enriched in the samples whereas warming of clays has been found to deplete the interstitial fluids of Ca^{++}. The depletion of Mg^{++} is as much as an order of magnitude greater than can be expected on the basis of the data of Bischoff *et al.* (1970). Further, the depletion of Mg^{++} continues to increase with depth as the *in situ* temperature approaches the squeezing temperature, rather than diminishing as should be the case if the depletions were temperature artifacts. Data are lacking for sulphate but conclusions regarding depletion should be simil to those reached for Ca^{++} and Mg^{++}. The validity of the K^+ changes is somewhat less certain. Bischoff *et al.* (1970) have documented an enrichment of 13 per cent for potassium through warming a sample 17°C. In most of the Leg 7 sites a similar increase in K^+ has been observed for near-surface samples. This excess is gradually diminished with depth to seawater values or less at 200 to 400 meters below the ocean bottom. If a normal oceanic geothermal gradient of 6°C/100m is assumed, the *in situ* temperature will approximate the squeezing temperature at 350 to 400 meters and the effluent should closely approximate the *in situ* pore fluid at these depths (assuming pressure effects to be small). If seawater is assumed to be a close approximation of the *in situ* pore fluid, then the samples from Site 64 exhibit this behavior. In other cores, however, depletions well below seawater concentration (as much as 24 per cent) are observed at depths ranging from 230 to 500 meters. Unless it is assumed that an unrealistically high geothermal gradient exists in these areas, the potassium deficiencies cannot be explained as artifacts introduced by discrepancies between *in situ* and squeezing temperatures.

The work of Mangelsdorf *et al.* (1969) was conducted with montmorillonite and that of Bischoff *et al.* (1970) with clay-rich sediments. It is presumed that ion exchange sites on the clays are the predominant sites of reaction. Temperature effects in sediments where clays are only a minor constituent, as in the bulk of the Leg 7 samples, can be expected to be much smaller than those found in the two reports mentioned above. The authors would conclude that most of the observed depletion of K^+ is real, and probably, in part, the enrichments as well. Just how much of this enrichment is a temperature artifact is open to question as are minor changes (a few per cent) in Ca^{++} and Mg^{++}.

In a number of cases the chemical gradients observed in the sediments are constant within analytical uncertainty. The concentrations of Ca^{++}, Mg^{++}, Sr^{++} and $SO_4^=$ at Site 63 are a good example (see Figure 1). Constant (non-zero) gradients also exists for Mg^{++} and Ca^{++} at Site 64, and for Ca^{++} at Site 66. A very weak case can be made for a constant K^+ gradient at Site 63 and 64, but the scatter is large and constancy questionable. In some instances constant gradients appear to hold over a portion of the hole, for example, Sr^{++} and $SO_4^=$ at Site 64. In both the latter cases, gradients approaching zero are found in the lower portions of the hole. Occasionally, the constant gradients appear to break down in the upper ten to twenty meters as in the case of sulphate in Figure 1.

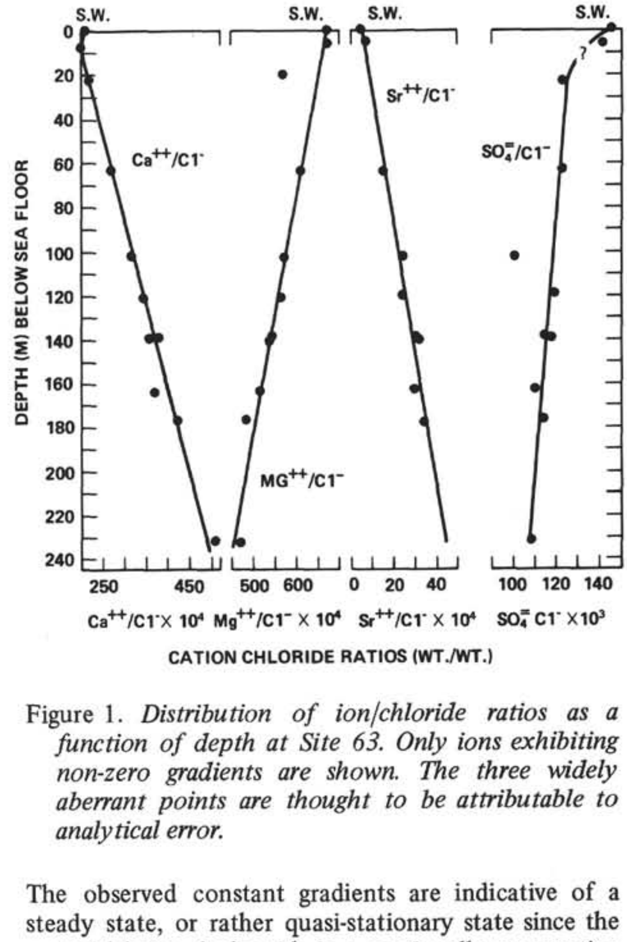

Figure 1. *Distribution of ion/chloride ratios as a function of depth at Site 63. Only ions exhibiting non-zero gradients are shown. The three widely aberrant points are thought to be attributable to analytical error.*

The observed constant gradients are indicative of a steady state, or rather quasi-stationary state since the material being dealt with is a continually compacting and accreting column. For changes in concentration of the order dealt with in these samples, diffusion is sufficiently rapid to counter reactions tending to produce fluctuations in concentration. In some instances, steeper gradients are found in the upper ten or twenty meters; this is most common with $SO_4^=$. While the authors' data for this depth range are few, they are substantiated by results from extensive piston core studies in the Pacific (Shishkina, 1966). These steeper gradients in the upper 10 meters indicate that, initially, reaction is rapid relative to diffusion. However, in most cases where the gradients to 6 to 10 meters are constant, they extrapolate well to seawater. In these instances, reactions do not appear to influence the gradients strongly.

The constancy of the chemical gradients suggests that the diffusion coefficients remain constant over the ranges of depth investigated at least to a first approximation. If the diffusion coefficients were not constant, a constant gradient (non-zero) could be maintained only if the effects of changing diffusion coefficients were countered precisely by changes in reaction rates that produce an equal and opposite effect upon concentration. Such a coincidence is highly unlikely. The data are sparse for the shallow samples, but where available, it appears that constancy often holds to within ten meters of the sediment surface. If this is so, then diffusion coefficients in these sediments appear to remain independent of porosity over the range of values reported for these holes.[4]

At Site 64, strontium and sulphate exhibit a definite break in concentration gradient 100 to 200 meters below the sea floor. The constant gradients of calcium and magnesium confirm that diffusional communication throughout the sediments (vertically) is good. The change in Sr^{++} and $SO_4^{=}$ concentration gradients may be the result of reaction that is rapid relative to diffusion in the lower portions of the hole. These reactions must not occur above the gradient change. Alternatively, a change in diffusion coefficient or possibly bulk flow of solutions of different composition could explain the gradient change, but these appear very unlikely as the constant gradients of Ca^{++} and Mg^{++} indicate that these diffusion coefficients are essentially constant. There is little reason to expect sufficiently different behavior in the diffusion coefficients of these four ions to be able to attribute the different gradients to changes in the diffusion coefficients of Sr^{++} and $SO_4^{=}$. Consequently, the authors strongly favor chemical reaction as the cause of the gradient changes. Although both Sr^{++} and $SO_4^{=}$ exhibit the break in slope, the changes do not appear to be coincident in depth, and the gradient shifts probably represent independent reactions.

The preliminary description of the biogenic oozes from Sites 47, 55 and 56 (Leg 6) and those from Sites 62, 63 and 64 (Leg 7) indicate that the oozes are very similar lithologically. Pore waters from the former group (Manheim and Sayles, 1970) are characterized by virtually no changes (from seawater) in Ca^{++} and Mg^{++} and by relatively small Sr^{++} changes, as contrasted with the very significant changes found in the Leg 7 group. With the data available, it is impossible to resolve the origin of these differences in pore fluid behavior. It is possible that reactions at, or below the bottom of the holes drilled on Leg 7 are important in producing the observed concentration gradients. Reaction between basalt and overlying sediment, particularly intrusive basalt, should produce concentration differences. There is, however, no consistent relationship between extrusive or intrusive basalt, and the compositional changes or lack thereof observed at Sites 55, 56, 62, 63 and 64. It is not possible to resolve the question of the origin of the chemical gradients observed on the basis of the data available. Mineralogic determinations are at present being conducted and should provide the data necessary to differentiate these sites on a mineralogic basis.

[4]Porosity values reported in the initial report for Leg 7 for Site 63 range from 85 per cent at 6 meters to 61 per cent at 177 meters; at Site 64, the range is 70 to 52 per cent.

REFERENCES

Bischoff, J. L., Green, R. E. and Luistro, A. O., 1970. Composition of interstitial waters of marine sediments: temperature of squeezing effect. *Science.* **167**, 1245.

Mangelsdorf, P. C., Jr., Wilson, T. R. S. and Daniell, E., 1969. Potassium enrichments in interstitial waters of recent marine sediments. *Science.* **165**, 171.

Manheim, F. T. and Sayles, F. L., 1970. Interstitial water studies on small core samples, Deep Sea Drilling Project, Leg 6. In Heezen, B. C. *et al.*, 1970, *Initial Reports of the Deep Sea Drilling Project, Volume VI.* Washington (U.S. Government Printing Office), in press.

Sayles, F. L., Manheim, F. T. and Chan, K. M., 1970. Interstitial water studies on small core samples, Deep Sea Drilling Project, Leg 4. In Bader, R. G. *et al.*, 1970, *Initial Reports of the Deep Sea Drilling Project, Volume IV.* Washington (U.S. Government Printing Office), in press.

Shiskina, O. V., 1966. Osnovnoi sostav (general chemical composition). In Ch. 2, Khimiya gruntovykh rastvorov Tikhoyo okeana (Chapter 2, Chemistry of pore waters in the Pacific Ocean) of *Khimiya Tikhogo Okeana (Chemistry of the Pacific Ocean).* S. W. Bruevich (Ed.), (Nauk, USSR) Izd Akademiia, 289,

TABLE 1
Major Constituents of Samples from Leg 7
(All values are in g/kg (°/₀₀) unless indicated otherwise.)[a]

Sample Designation	Depth Below Sea Bed (m)	Age	Description	Na[b]	K	Ca	Mg	Total Cations (meq/kg)	Cl	SO_4	Alk. (meq/kg)	HCO_3[c]	Total Anions (meq/kg)	Sum[b]	H_2O (°/₀₀)[d]	pH
Hole 61 (12°05.8′N, 147°03.9′E, water depth 5562 meters; Mariana Basin)																
1-1-2	93	Upper (?) Cretaceous	Zeolitic clay	11.2	0.36	0.39	1.17		19.7	2.75	–	–	(614)	–	39	7.5
Hole 62-0, Hole 62-1 (1°52.2′N, 141°56.3′E, water depth 2591 meters; Eauripik – New Guinea Rise)																
0-1-2	92	Lower Pleistocene	Chalk ooze (Nannofossils, foraminifera)	–	–	0.89	1.07		19.3	1.66	1.8	0.11	580	–	38	7.7
0-2-2	207	Upper Miocene	Slightly indurated chalk ooze	10.8	0.30	0.91	1.03		19.5	2.78	1.0	0.06	609	35.4	32	7.5
0-3-2	301	Middle Miocene	Chalk	10.8	0.28	0.83	1.05		19.6	2.50	1.7	0.10	607	35.2	34	6.9
0-4-4	400	Middle-Lower Miocene*	Chalk	10.9	0.29	0.85	1.03	Na calculated by difference	19.6	2.51	1.2	0.07	606	35.2	46	7.5
0-5-3	493	Lower Miocene	Chalk	10.8	0.32	0.85	1.05		19.6	2.37	1.7	0.10	604	35.1	–	7.5
1-1-3	9	Pleistocene	Mainly chalk ooze (nannofossils, foraminifera)	10.9	0.45	0.44	1.15		19.4	2.60	1.6	0.09	603	35.0	–	7.4
1-2-4	20	Pleistocene	Mainly chalk ooze (nannofossils, foraminifera)	10.9	0.44	0.62	1.05		19.5	2.48	2.1	0.13	604	35.2	–	7.4
1-4-6	42	Upper Pliocene	Chalk ooze (nannofossils, foraminifera)	11.1	0.43	0.67	0.99		19.6	2.55	1.1	0.07	607	35.4	43	7.6
1-6-5	60	Upper Pliocene	Chalk ooze (nannofossils, foraminifera)	10.9	0.40	0.69	1.12		19.5	2.74	2.4	0.15	609	35.5	34	7.3
1-8-5	78	Lower Pliocene	Chalk ooze (nannofossils, foraminifera)	10.8	0.38	0.84	1.04		19.6	2.51	2.4	0.15	608	35.3	42	7.2
1-14-5	136	Upper Miocene	Chalk ooze (nannofossils, foraminifera)	10.8	0.34	0.75	1.07		19.5	2.58	1.6	0.10	605	35.1	39	7.5

*Note: Middle-Lower Miocene: Middle to Lower Miocene, more exact date impossible.

TABLE 1 – *Continued*

Sample Designation	Depth Below Sea Bed (m)	Age	Description	Na^b	K	Ca	Mg	Total Cations (meq/kg)	Cl	SO_4	Alk. (meq/kg)	$HCO_3{}^c$	Total Anions (meq/kg)	Sum^b	H_2O (°/∞)^d	*p*H
1-16-5	154	Upper Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	10.7	0.32	0.80	1.05	Na calculated by difference	19.5	2.36	1.6	0.10	600	34.8	36	7.3
1-18-2	167	Upper Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	11.1	0.32	0.81	0.95		19.6	2.54	2.0	0.12	608	35.4	34	7.6
1-20-5	192	Upper Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	10.5	0.32	0.85	1.03		19.6	2.03	2.1	0.13	598	34.6	37	7.4
1-24-5	231	Upper Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	11.3	0.29	0.83	0.97		19.5	(2.5)^e	2.6	0.16	607	35.3	34	7.5
1-26-2	248	Upper Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	11.0	0.30	0.87	1.03		19.8	2.57	2.4	0.15	614	35.7	34	7.5
1-28-5	269	Upper Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	10.9	0.30	0.90	1.03		19.5	2.76	2.5	0.15	611	35.6	28	7.4
1-30-2	283	Upper Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	10.7	0.31	0.87	1.03		19.6	2.24	2.8	0.17	602	34.9	32	7.5
1-34-5	326	Middle Miocene	Chalk	11.1	0.34	0.82	0.96		19.6	2.64	0.7	0.04	610	35.6	–	8.0
1-36-2	343	Middle Miocene	Chalk	11.1	0.34	0.81	1.03		19.6	(2.7)^e	1.2	0.07	610	35.6	–	8.1
Hole 63-0, Hole 63-1, Hole 63-2 (0°50.16′N, 147°53.25′E, water depth 4472 meters; East Caroline Basin)																
0-1-5	6	Quarternary	Brown pelagic clay (minor Fe-Mn micronodules)	10.7	0.44	0.38	1.26		19.2	2.70	2.7	0.16	601	35.0	64	7.6
0-2-3	64	Upper Miocene	Chalk ooze (nannofossils, foraminifera), minor pyrite	10.8	0.44	0.53	1.19		19.6	2.37	2.4	0.14	606	35.1	36	7.4

TABLE 1 – *Continued*

Sample Designation	Depth Below Sea Bed (m)	Age	Description	Na[b]	K	Ca	Mg	Total Cations (meq/kg)	Cl	SO_4	Alk. (meq/kg)	HCO_3[c]	Total Anions (meq/kg)	Sum[b]	H_2O (‰)[d]	*pH*
0-3-2	139	Middle-Lower Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	10.8	0.39	0.74	1.06	Na calculated by difference	19.6	2.23	3.6	0.22	603	35.1	34	7.3
0-4-2	232	Lower Miocene	Chalk, slightly pyritic	10.8	0.33	1.00	0.92		19.7	2.13	2.9	0.18	602	35.0	28	7.4
1-5-2	103	Upper Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	10.7	0.39	0.62	1.11		19.6	1.96	2.7	0.17	596	34.5	44	7.3
1-7-2	121	Middle Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	10.8	0.39	0.68	1.10		19.5	2.30	3.4	0.21	602	35.0	43	7.2
1-9-2	140	Middle-Lower Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	10.8	0.37	0.71	1.05		19.6	2.28	2.2	0.13	602	34.9	39	7.3
1-11-5	163	Lower Miocene	Chalk	10.9	0.37	0.73	1.01		19.7	2.15	3.2	0.19	603	35.0	–	7.5
1-13-3	177	Lower Miocene	Chalk	10.9	0.37	0.83	0.95		19.7	2.22	3.0	0.19	604	35.2	33	7.4
2-2-3	23	Lower Pliocene	Green foraminiferal-nannofossil marl ooze	11.0	0.52	0.42	1.12		19.6	2.36	1.6	0.10	603	35.1	65	7.6
Hole 64-0 (1°44.56′N, 158°36.51′E, water depth 2052 meters; Ontong Java Plateau)																
0-1-3	6	Quarternary	Chalk ooze (nannofossil); accessory Radiolaria and volcanic glass	11.0	0.44	(0.40)[f]	1.23		19.3	2.56	3.1	0.19	599	–	48	7.8
0-2-2	103	Lower Pliocene	Chalk ooze (nannofossil); accessory Radiolaria and volcanic glass	10.9	0.44	0.41	1.20		19.5	2.29	3.9	0.24	603	35.0	–	7.7

TABLE 1 – *Continued*

Sample Designation	Depth Below Sea Bed (m)	Age	Description	Na[b]	K	Ca	Mg	Total Cations (meq/kg)	Cl	SO_4	Alk. (meq/kg)	HCO_3[c]	Total Anions (meq/kg)	Sum[b]	H_2O (°/oo)[d]	pH
0-3-4	207	Upper Miocene	Chalk ooze (nannofossil); accessory Radiolaria and volcanic glass	10.9	0.40	0.50	1.13	Na calculated by difference	19.7	2.07	4.6	0.28	603	35.0	36	7.5
0-4-5	311	Middle Miocene	Chalk ooze (nannofossil); accessory Radiolaria and volcanic glass	11.1	0.40	0.56	1.04		19.8	2.05	4.2	0.26	606	35.2	39	7.5
Hole 64-1 (1°44.44′N, 158°36.54′E, water depth 2052 meters; Ontong Java Plateau)																
1-1-6	441	Middle (?) Miocene	Slightly indurated chalk ooze (nannofossils; accessory Radiolaria and volcanic glass	11.3	0.37	0.61	1.00	Na calculated by difference	20.1	2.05	4.0	0.24	614	34.7	31	7.4
1-3-5	458	Lower Miocene	Slightly indurated chalk ooze (nannofossils); accessory Radiolaria and volcanic glass	11.1	0.39	0.68	1.00		20.1	1.85	4.3	0.26	610	35.5	–	7.2
Hole 65-0, Hole 65-1 (4°21.21′N, 176°59.16′E, water depth 6130 meters; Central Basin East of Gilbert Islands																
0-3-4	26	Upper Miocene	Brown Radiolarian ooze	10.9	(0.41)[f]	0.42	1.29	Na calculated by difference	19.6	2.72	3.2	0.20	612	–	76	7.5
0-7-5	61	Middle (?) Miocene	Brown Radiolarian ooze	10.9	0.42	0.42	1.25		19.5	2.70	3.2	0.20	610	35.4	74	7.6
0-11-5	96	Lower Miocene	Dark brown Radiolarian ooze	10.9	0.40	0.44	1.22		19.6	2.56	2.5	0.16	607	35.2	–	7.7
0-13-6	117	Oligocene	Dark brown Radiolarian ooze	10.8	0.41	0.45	1.33		19.5	2.77	3.3	0.20	612	35.5	74	7.6
0-16-5	144	Upper Eocene	From section of interbedded volcanic sand and Radiolarian ooze predominately the latter	10.8	0.39	0.46	1.28		19.6	2.59	3.4	0.21	609	35.3	–	7.7
11-4-5	160	Middle Eocene	Some layers calcareous	10.8	0.39	0.45	1.33		19.5	2.70	3.0	0.19	610	35.4	–	7.7

TABLE 1 – *Continued*

Sample Designation	Depth Below Sea Bed (m)	Age	Description	Na[b]	K	Ca	Mg	Total Cations (meq/kg)	Cl	SO_4	Alk. (meq/kg)	HCO_3[c]	Total Anions (meq/kg)	Sum[b]	H_2O (°/oo)[d]	*p*H
Hole 66-0, Hole 66-1 (2°23.63′N, 166°07.28′W, water depth 5293 meters; East side of Central Basin)																
0-2-2	82	Middle Miocene	Brown siliceous ooze (Radiolaria and diatoms) minor carbonates	10.9	0.40	0.41	1.28	Na calculated by difference	19.6	2.70	2.0	0.12	610	35.4	76	7.7
0-3-5	124	Lower Miocene or Upper Oligocene	Brown siliceous ooze (Radiolaria and diatoms) minor carbonates	10.8	0.36	0.45	1.28		19.6	2.56	2.8	0.17	608	35.2	75	7.5
0-6-3	169	Unknown	Light brown pelagic clay (zeolitic?) minor Fe-Mn micronodules	10.8	0.34	0.56	1.29		19.6	2.57	3.0	0.18	610	35.4	46	7.8
0-9-3	191	Cretaceous	Sample from complex sequence of volcanoclastic sands and Fe-Mn chemical sediments in interval 190.6-192 meters	10.6	0.31	0.55	1.33		19.5	2.61	1.5	0.09	605	35.0	57	7.7
1-2-4	18	Quarternary	Brown siliceous ooze (Radiolaria and diatoms)	10.7	0.46	0.39	1.31		19.3	2.74	2.8	0.17	605	35.1	80	7.6
1-6-5	62	Middle Miocene	Brown siliceous ooze (Radiolaria and diatoms)	10.6	0.44	0.44	1.31		19.4	2.58	2.9	0.18	603	34.9	77	7.6

[a]Sum refers to sum of the cations, excluding minor constituents, plus Cl, SO_4 and HCO_3. NH_4 has not been determined here, but should normally not contribute more than about 0.5 meg except where unusually high alkalinities are encountered.
[b]Determined by difference, utilizing cation-anion balance.
[c]Total CO_2 is taken to be present as HCO_3.
[d]The H_2O contents are shipboard data. Determinations are made on separate samples taken from the same core sections.
[e]Estimated from total salinity values.
[f]Determined by interpolation from neighboring samples and seawater.

TABLE 2
Minor Constituents of Samples from Leg 7

Sample Designation	Depth Below Sea Bed (m)	Age	Description	Sr	Li	Si (col.)[a]	Si (spec.)[b]
Hole 61 (12°05.8′N, 147°03.9′E, water depth 5562 meters; Mariana Basin)							
1-1-2	93	Upper (?) Cretaceous	Zeolitic clay	9.0	0.26	–	19
Hole 62-0, Hole 62-1 (1°52.2′N, 141°56.3′E, water depth 2591 meters, Eauripik-New Guinea Rise)							
0-1-2	92	Lower Pleistocene	Chalk ooze (nannofossils, foraminifera)	31.0	0.51	–	32
0-2-2	207	Upper Miocene	Slightly indurated chalk ooze	21.0	0.47	–	33
0-3-2	301	Middle Miocene	Chalk	25.0	0.34	–	24
0-4-4	400	Middle-Lower Miocene*	Chalk	20.0	0.44	28	29
0-5-3	493	Lower Miocene	Chalk	15.0	0.46	34	52
1-1-3	9	Pleistocene	Mainly chalk ooze (nannofossils, foraminifera)	15.0	0.40	11	18
1-2-4	20	Pleistocene	Mainly chalk ooze (nannofossils, foraminifera)	23.0	0.30	–	20
1-4-6	42	Upper Pliocene	Chalk ooze (nannofossils, foraminifera)	30.0	0.25	12	18
1-6-5	60	Upper Pliocene	Chalk ooze (nannofossils, foraminifera)	49.0	0.20	18	21
1-8-5	78	Lower Pliocene	Chalk ooze (nannofossils, foraminifera)	32.0	0.23	21	23
1-14-5	136	Upper Miocene	Chalk ooze (nannofossils, foraminifera)	25.0	0.29	23	28
1-16-5	154	Upper Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	26.0	0.27	–	30
1-18-2	167	Upper Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	26.0	0.32	–	40
1-20-5	192	Upper Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	23.0	0.32	18	36
1-24-5	231	Upper Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	26.0	0.32	–	34
1-26-2	348	Upper Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	23.0	0.36	31	35
1-28-5	269	Upper Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	24.0	0.56	–	39
1-30-2	283	Upper Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	27.0	0.50	26	41
1-34-2	326	Middle Miocene	Chalk	22.0	0.53	27	22
1-36-2	343	Middle Miocene	Chalk	22.0	0.38	20	24

TABLE 2 – *Continued*

Sample Designation	Depth Below Sea Bed (m)	Age	Description	Sr	Li	Si (col.)[a]	Si (spec.)[b]
Hole 63-0, Hole 63-1, Hole 63-2 (0°50.16′N, 147°53.25′E, water depth 4472 meters; East Caroline Basin)							
0-1-5	6	Quarternary	Brown pelagic clay (minor Fe-Mn micro-nodules)	12.0	0.24	25	27
0-2-3	64	Upper Miocene	Chalk ooze (nannofossils, foraminifera, minor pyrite	28.0	0.17	–	26
0-3-2	139	Middle-Lower Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	58.0	0.21	30	28
0-4-2	232	Lower Miocene	Chalk, slightly pyritic	87.0	0.33	–	38
1-5-2	103	Upper Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	46.0	0.22	20	29
1-7-2	121	Middle Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	44.0	0.26	23	32
1-9-2	140	Middle-Lower Miocene	Slightly indurated chalk ooze (nannofossils, foraminifera)	60.0	0.30	42	32
1-11-5	163	Lower Miocene	Chalk	57.0	0.43	31	34
1-13-3	177	Lower Miocene	Chalk	65.0	0.45	33	47
2-2-3	23	Lower Pliocene	Green foraminiferal-nannofossil marl ooze	17.0	0.28	17	26
Hole 64-0 (1°44.56′N, 158°36.51′E, water depth 2052 meters; Ontong Java Plateau)							
0-1-3	6	Quarternary	Chalk ooze (nannofossil); accessory Radiolaria and volcanic glass	12.0	0.23	9	41
0-2-2	103	Lower Pliocene	Chalk ooze (nannofossil); accessory Radiolaria and volcanic glass	65.0	0.21	19	22
0-3-4	207	Upper Miocene	Chalk ooze (nannofossil); accessory Radiolaria and volcanic glass	79.0	1.40	23	27
0-4-5	311	Middle Miocene	Chalk ooze (nannofossil); accessory Radiolaria and volcanic glass	74.0	–	–	27
Hole 64-1 (1°44.44′N, 158°36.54′E, water depth 2052 meters; Ontong Java Plateau)							
1-1-6	441	Middle (?) Miocene	Slightly indurated chalk ooze (nannofossil); accessory Radiolaria and volcanic glass	73.0	–	30	28
1-3-5	458	Lower Miocene	Slightly indurated chalk ooze (nannofossil); accessory Radiolaria and volcanic glass	70.0	0.19	–	35
Hole 65-0, Hole 65-1 (4°21.21′N, 176°59.16′E, water depth 6130 meters; Central Basin east of Gilbert Islands							
0-3-4	26	Upper Miocene	Brown radiolarian ooze	8.0	0.26	19	38
0-7-5	61	Middle (?) Miocene	Brown radiolarian ooze	8.0	0.24	22	20

TABLE 2 – *Continued*

Sample Designation	Depth Below Sea Bed (m)	Age	Description	Sr	Li	Si (col.)[a]	Si (spec.)[b]
0-11-5	96	Lower Miocene	Dark brown Radiolarian ooze	9.4	0.28	20	25
0-13-6	117	Oligocene	Dark brown Radiolarian ooze	8.0	0.29	24	31
0-16-5	144	Upper Eocene	From section of interbedded volcanic sand and Radiolarian ooze, predominately the latter. Some layers calcareous	8.0	0.26	–	28
1-4-5	160	Middle Eocene		7.0	0.28	25	36
Hole 66-0, Hole 66-1 (2°23.63'N, 166°07.28'W, water depth 5293 meters; East side of Central Basin)							
0-2-2	82	Middle Miocene	Brown siliceous ooze (Radiolaria and diatoms) minor carbonates	7.0	0.22	23	30
0-3-5	124	Lower Miocene or Upper Oligocene	Brown siliceous ooze (Radiolaria and diatoms) minor carbonates	6.0	0.24	–	29
0-6-3	169	Unknown	Light brown pelagic clay (zeolitic?) minor Fe-Mn micronodules	9.0	0.25	17	26
0-9-3	191	Cretaceous	Sample from complex sequence of volcanoclastic sands and Fe-Mn chemical sediments in interval 190.6-192 meters	7.0	0.33	–	4
1-2-4	18	Quarternary	Brown siliceous ooze (Radiolaria and diatoms)	12.0	0.27	19	6
1-6-5	62	Middle Miocene	Brown siliceous ooze (Radiolaria and diatoms)	10.0	0.30	17	7