DEPARTMENT OF INTERIOR

U.S. GEOLOGICAL SURVEY

Data on the Geochemistry of Pelagic Clay of the Subarctic North Pacific Ocean

by

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Open-File Report 89-371

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

Gravity cores collected by the U.S. Geological Survey (USGS) south of the Aleutian Islands on the floor of the Aleutian Trench (Figure 1; Table 1) recovered multiple oxidized reddish-brown layers within predominantly green diatom-bearing silty clay. The oxidized layers occur in hemipelagic mud at the tops of turbidites, most of which have coarse-silt bases and grade upward into greenish-gray silty clay and clay (Fig. 2). The upper sediment section (1.0 to 1.5 m) that contains the turbidites overlies bioturbated greenish-gray, diatom-bearing silty clay that extends to the total depth recovered by the gravity cores (ca. 2.4 m). The uppermost oxidized layer is at or within several centimeters of the top of the recovered section.

A survey of the sediment descriptions of all cores collected by Lamont-Doherty Geological Observatory (LDGO) between the Aleutian Islands and 40°N shows that south of about 50°N the sediments down to at least several meters consist entirely of red or brown clay (the Red Clay province of Horn and others, 1979; Figure 1). North of 50°N, however, the sediments are predominantly green diatom-bearing clays or silty clay (the Biogenic Ooze province of Horn and others, 1979) and commonly were described as containing one or more red or brown layers at some depth below the sediment-water interface. We examined the latter cores and sampled 11 of them for geochemical analyses (Table 1). This report presents the results of geochemical analyses of samples from USGS and LDGO cores, particularly with regard to differences between oxidized (brown) and reduced (green) sediments.

ANALYTICAL METHODS

Fifty-one samples of oxidized and reduced sediment were collected from six USGS Aleutian Trench cores (Table 1) as soon as possible after the cores arrived at the refrigerated core repository in Palo Alto, California. The samples were homogenized and dried at 90°C. Sixty samples were collected from 11 LDGO cores (Table 1) that had been air dried since the time they were collected. Duplicate splits of seven samples (same cruise-core-depth designation in Table 3; e.g. V20-118-80cm) were submitted for analysis. All samples were submitted for analysis in a random sequence. Concentrations of 30 major, minor, and trace elements (Al, Fe, Mg, Ca, Na, K, Ti, P, Mn, Ba, Cd, Ce, Co, Cr, Cu, Ga, La, Li, Mo, Nb, Nd, Ni, Pb, Sc, Sr, Th, V, Y, Yb, and Zn) were determined by inductively coupled, argon-plasma emission spectrometry (ICP; Lichte and others, 1987). The two sample sets (USGS and LDGO) were submitted in different years so that there are some differences in which elements were determined in each of the two sample sets. In particular, Nb, Nd, and Yb were not determined in the earlier (USGS) sample set. Organic carbon was calculated by difference between inorganic carbon and total carbon. Inorganic and total carbon were determined using a coulometric carbon analyzer with a precision of better than 1% relative deviation (Huffman, 1977).

ANALYTICAL RESULTS

Results of geochemical analyses of samples from the six USGS cores are given in Table 2 and of samples from the 11 LDGO cores in Table 3. The geochemical results show that the red or brown oxidized layers in the North Pacific and Aleutian Trench sediments, like those in sediments from the Aleutian Basin of the Bering Sea (Gardner and others, 1982), have distinctly higher concentrations of manganese and several trace transition elements, especially Mo, Co, and Ni. The high concentrations of Zn in several of the Lamont-Doherty cores probably is due to drying of the wet sediment in galvanized trays. Correlation coefficients between manganese and several other elements commonly associated with manganese are given in Table 4. The correlations between Mn, Mo, and Co are further illustrated by the scatter plots of percent Mn versus ppm Mo and ppm Co in Figure 3. Stratigraphic relationships between the concentration of manganese, total organic carbon (TOC) and oxidized layers are shown for four USGS Aleutian Trench cores (G1 through G4) in Figure 4, and for one LDGO North Pacific cores (RC12-177) in Figure 5.

The geochemical profiles of the Aleutian trench cores (Fig. 4) show that the maximum concentrations of manganese decrease in each successively deeper brown layer. This decrease in "geochemical intensity" with depth also is manifested as a decrease in color intensity of each oxidized layer with depth. That is, the upper oxidized layer always is the darkest brown and has the highest manganese concentration, and the intensity of the brown coloration and concentration of manganese decreases with each successively deeper layer until the lowest brown layer is barely discernable from the overlying and underlying green clay. The decrease in geochemical intensity with depth suggests that the iron and manganese in the oxidized layers are being chemically reduced with burial. There probably were other oxidized layers at greater depth that have been completely reduced so that they are no longer recognizable by geochemistry or color. The color difference itself is a geochemical signature (Lyle, 1983) that usually reflects the difference between oxidized and reduced iron. Although there is a change in oxidation state of the iron between reduced and oxidized layers, there is no difference in total iron concentration, and there is no correlation between concentrations of iron and manganese (Table 4).

The oxidized layers in cores from the Aleutian Trench occur at the tops of turbidites (Fig. 2) that were deposited at estimated intervals of about one thousand years during the transition between Pleistocene to Holocene conditions. The oxidized layers in the trench cores apparently formed by oxidation of the tops of turbidites utilizing dissolved oxygen from oxygenated surface waters transported with the turbidites into the poorly-oxygenated bottom-waters of the trench.

ACKNOWLEDGMENTS

We are grateful to Dave Scholl, Tracy Vallier, and Andrew Stevinson for first recognizing the oxidized layers in sediment in the Aleutian Trench and then collecting the series of cores used for this investigation. We are also grateful to Lamont-Doherty Geological Observatory for providing samples from their collection of cores from the North Pacific. Helpful comments, suggestions, and discussions were provided by Philip Froelich, Jim Herring, Margaret Leinen, Mitch Lyle, and John Thomson.

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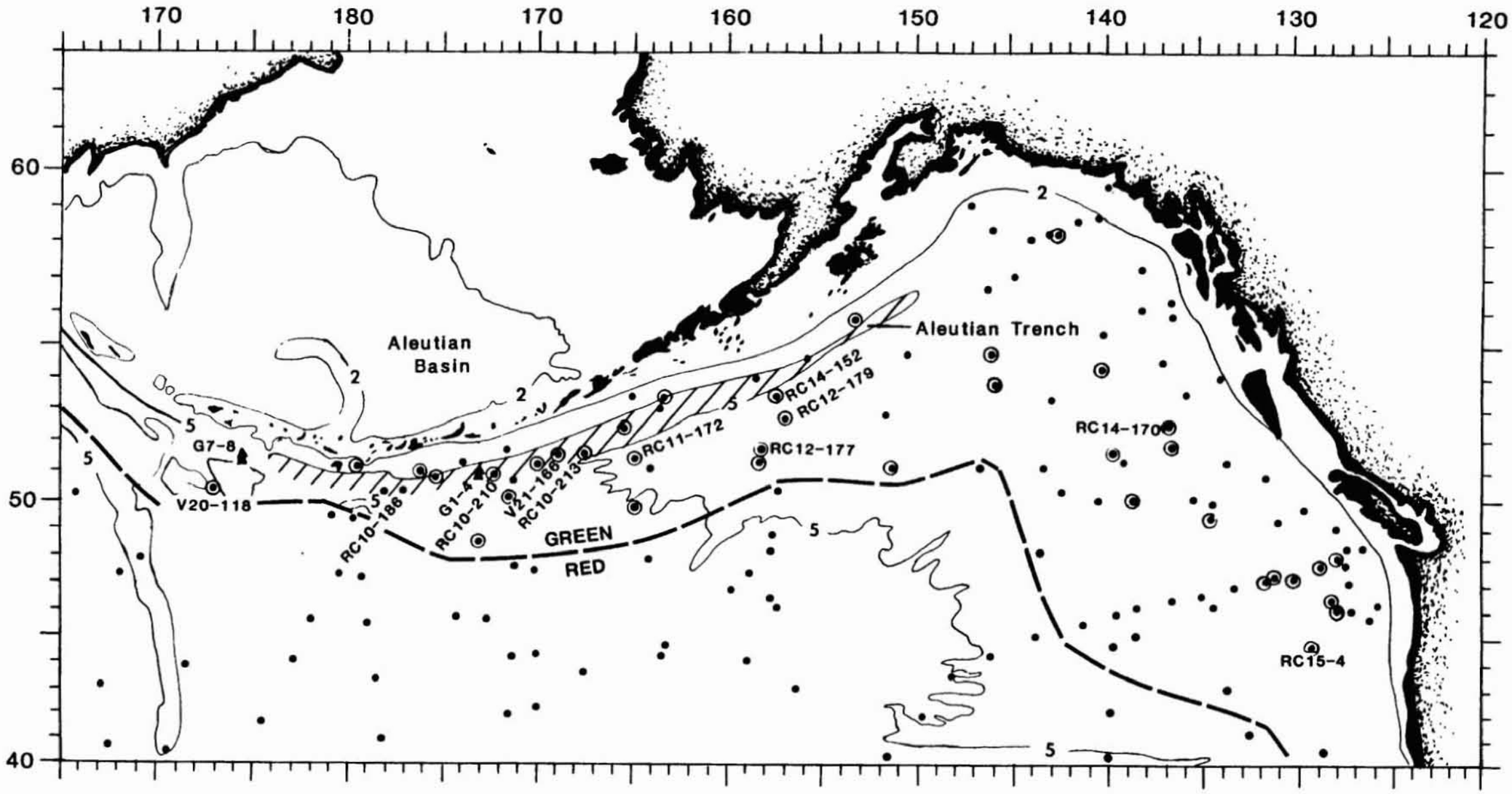

Figure 1. Map of the north-central Pacific Ocean showing the locations of U.S. Geological Survey (USGS; triangles) and Lamont-Doherty Geological Observatory (LDGO; dots). Isobaths are in km. Boundary between red and green surface sediment is indicated by dashed line. LDGO cores north and east of this line with one or more oxidized red layers at depth are circled.

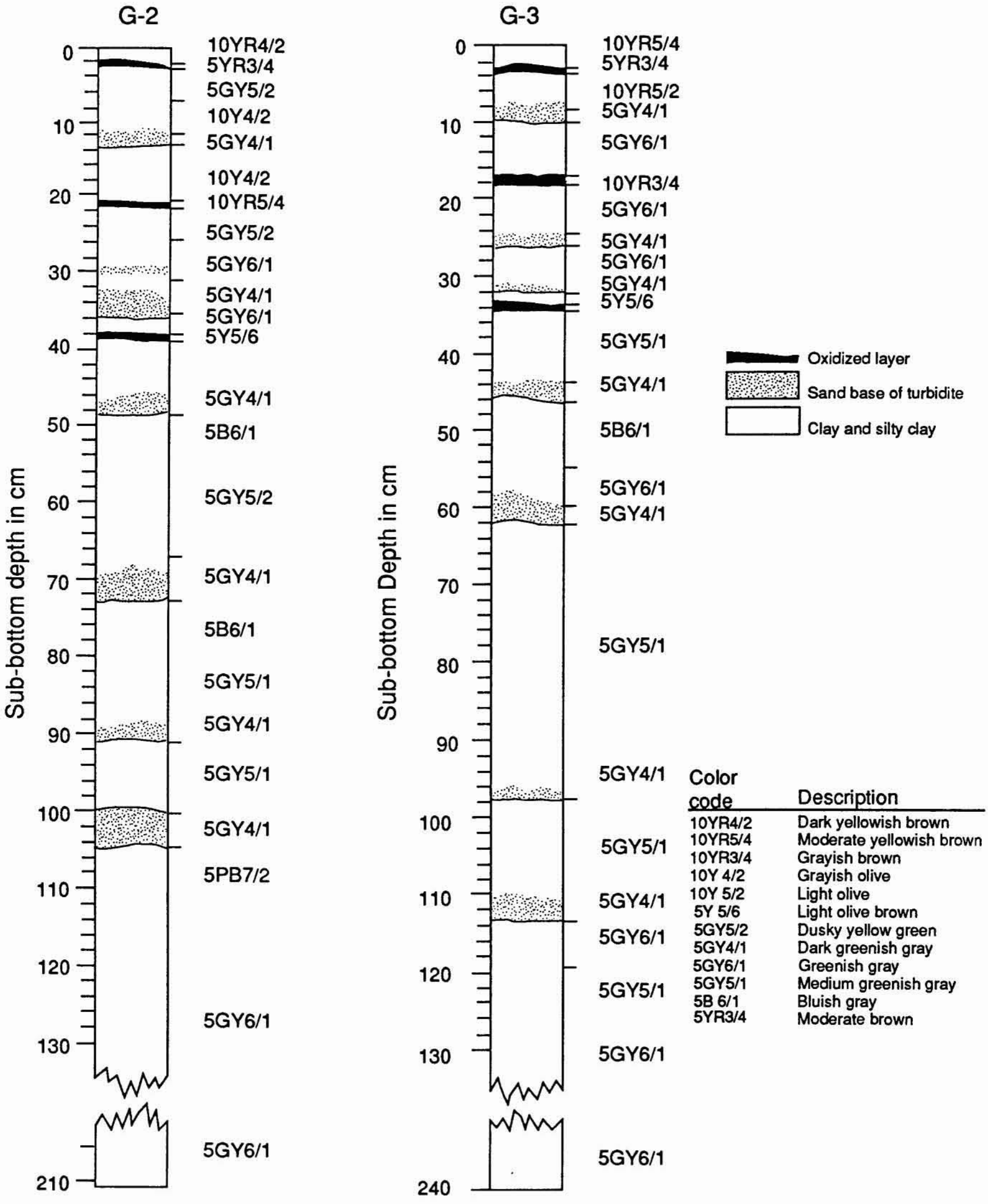

Figure 2. Stratigraphic relationships of turbidites, oxidized layers, and sediment color in USGS cores G2 and G3 from the Aleutian Trench.

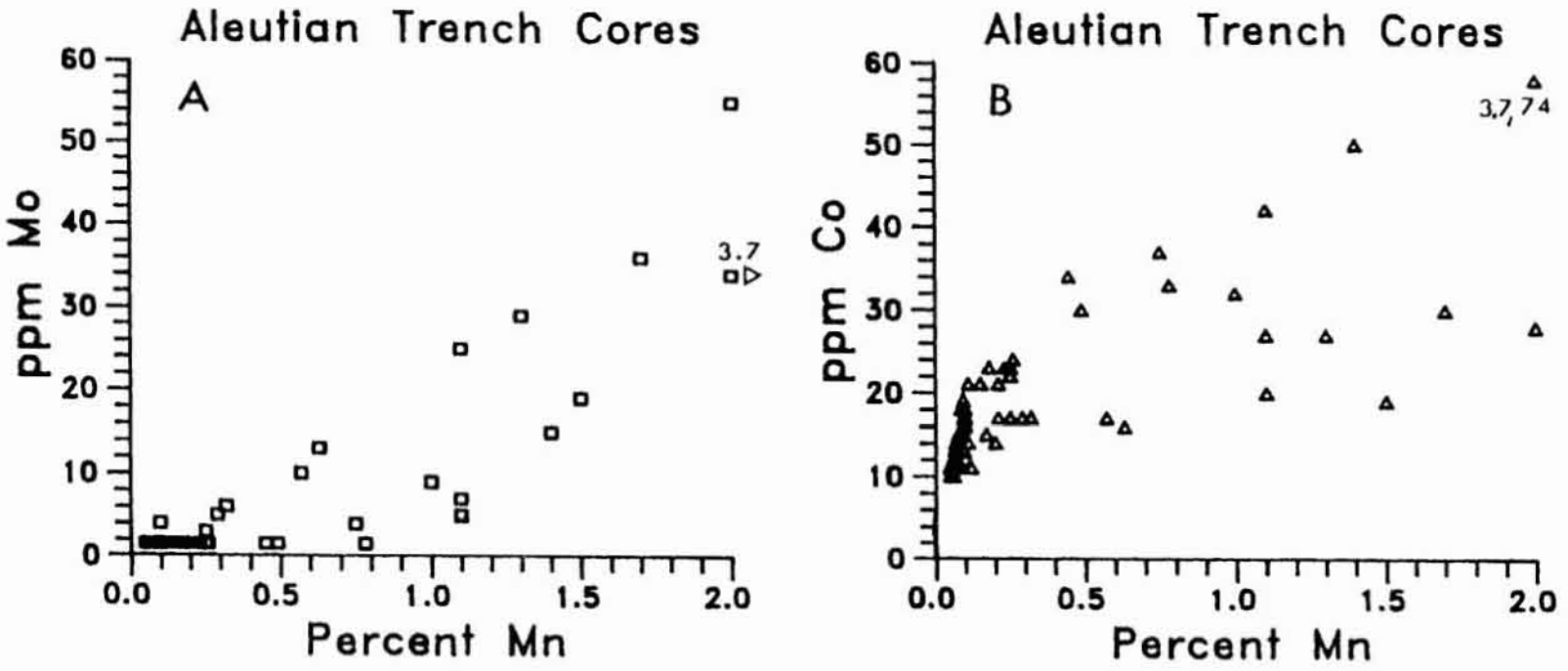

Figure 3. Scatter plots of weight percent Mn versus parts per million (ppm) Mo and ppm Co for samples from USGS Aleutian Trench cores and LDGO North Pacific cores.

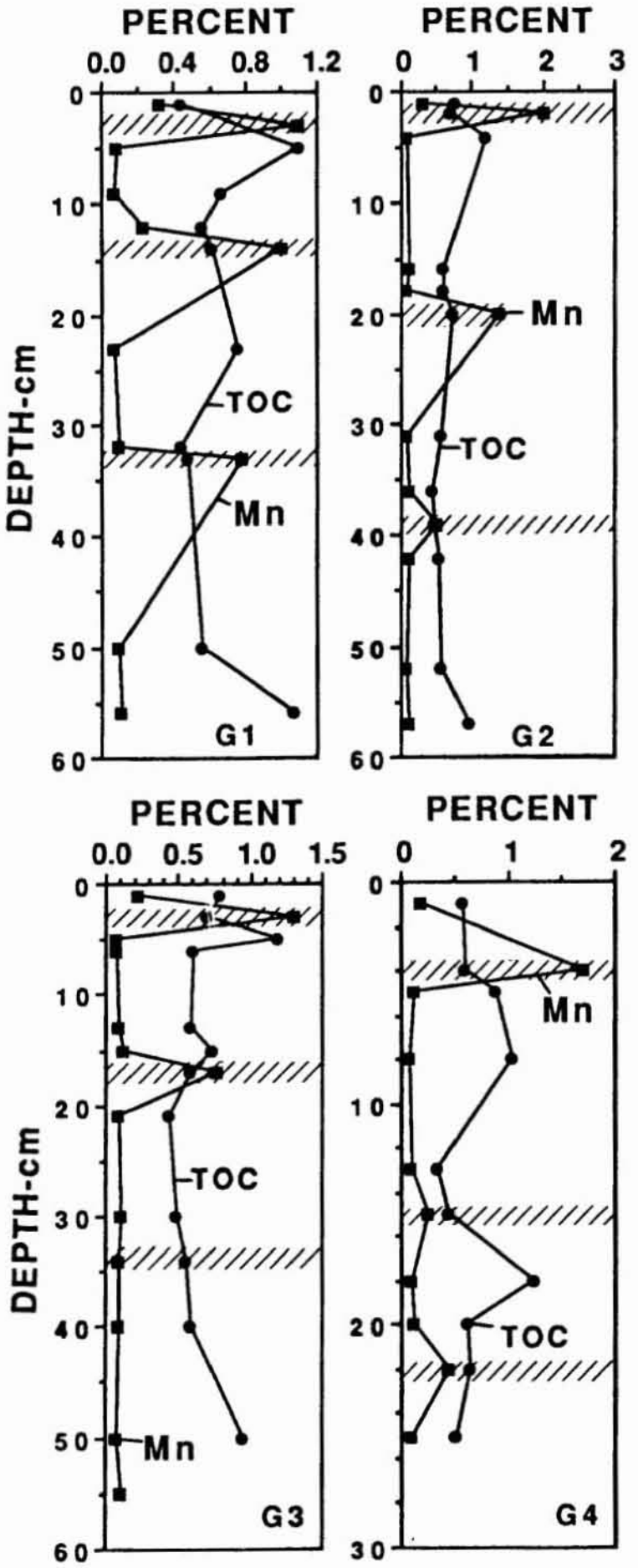

Figure 4. Plots of weight percent Mn and TOC versus depth within USGS cores G1 through G4 from the Aleutian Trench. Hachured intervals represent the locations of oxidized zones.

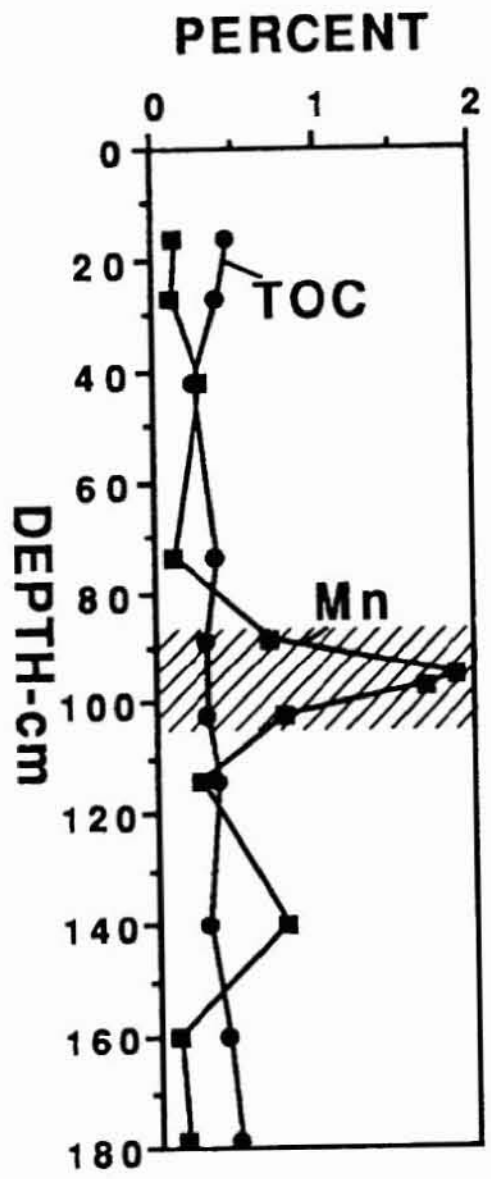

Figure 5. Plots of weight percent Mn and TOC versus depth within LDGO core RC12-177 from the North Pacific. Hachured interval represents the location of oxidized zone.

Table 1. Locations of cores used in this study

Core	Latitude	Longitude	Water depth (m)	No. of samples
U.S. Geological Survey, Cruise L9-81				
G1	50°47.02'	173°14.64'W	7292	11
G2	50°48.36'	173°15.0'W	7200	12
G3	50°30.34'	173°15.13'W	7214	13
G4	50°52.49'	173°15.18'W	7223	10
G7	51°10.61'	174°33.48'E	9585	13
G8	51°15.25'	174°33.43'E	7210	9
Lamont-Doherty Geological Observatory				
RC10-186	50°12'N	177°11'W	6591	4
RC10-210	50°48'N	172°38'W	7284	4
RC10-213	51°49'N	167°45'W	7196	3
RC11-172	52°15'N	164°53'W	4808	3
RC12-177	51°25'N	158°14'W	4826	13
RC12-179	52°29'N	157°03'W	4601	5
RC14-170TW	52°34'N	137°17'W	3530	7
RC14-152	53°13'N	157°28'W	4601	5
RC15-4	44°30'N	129°21'W	2811	3
V20-118	50°22'N	172°43'E	5360	10
V21-166	51°25'N	169°12'W	7103	3

Table 2. Geochemical data for USGS Aleutian Trench cores.

Sample	Core	Depth (cm)	% Al	% Fe	% Mg	% Ca	% Na	% K	% Ti
L981108	G1	1	8.0	4.8	2.0	1.6	3.6	1.6	.44
L981110	G1	3	5.3	3.3	1.3	1.1	2.5	1.2	.28
L981112	G1	5	8.0	5.1	2.0	1.6	3.6	1.8	.44
L981116	G1	9	7.0	4.1	1.7	1.8	2.7	1.4	.38
L981119	G1	12	7.3	4.9	2.1	1.6	2.5	1.5	.42
L981121	G1	14	8.9	5.9	2.4	1.8	3.3	1.9	.52
L981130	G1	23	7.0	4.1	1.6	1.5	2.6	1.5	.41
L981139	G1	32	8.5	5.8	2.1	1.9	3.4	1.7	.51
L981140	G1	33	8.0	6.6	1.9	2.0	3.3	1.7	.48
L981157	G1	50	8.2	4.8	2.0	1.9	3.5	1.6	.46
L981163	G1	56	8.3	5.2	2.1	2.3	3.4	1.6	.56
L981208	G2	1	7.7	4.7	2.0	1.6	3.8	1.6	.43
L981209	G2	2	8.0	5.0	2.0	1.9	3.6	1.7	.47
L981211	G2	4	6.3	4.2	1.6	1.3	2.8	1.4	.35
L981223	G2	16	8.9	5.5	2.3	2.3	3.3	1.7	.50
L981225	G2	18	7.0	4.9	2.0	1.7	2.7	1.5	.40
L981227	G2	20	9.3	6.6	2.9	2.0	3.1	1.9	.56
L981238	G2	31	6.8	3.9	1.5	1.7	2.7	1.4	.40
L981243	G2	36	8.8	5.2	2.0	2.2	3.4	1.7	.52
L981246	G2	39	7.9	6.9	2.0	1.9	3.3	1.6	.47
L981249	G2	42	9.0	5.1	1.9	2.3	3.2	1.8	.54
L981259	G2	52	6.3	3.6	1.5	1.4	2.6	1.4	.34
L981264	G2	57	8.3	5.1	2.0	2.4	3.6	1.5	.54
L981312	G3	1	6.1	3.6	1.5	1.2	2.7	1.3	.32
L981314	G3	3	8.0	5.0	2.0	1.8	3.3	1.7	.46
L981315	G3	5	6.4	4.0	1.4	1.5	2.6	1.3	.36
L981316	G3	6	6.5	3.5	1.2	2.1	2.5	1.1	.36
L981324	G3	13	9.0	5.6	2.2	2.2	3.2	1.8	.51
L981326	G3	15	9.2	6.2	2.6	2.1	3.1	1.8	.54
L981328	G3	17	7.3	5.1	2.2	1.6	2.4	1.5	.43
L981332	G3	21	8.6	5.2	2.0	1.9	3.3	1.9	.51
L981341	G3	30	8.9	5.1	1.9	2.6	3.2	1.5	.53
L981345	G3	34	6.4	4.7	1.5	1.4	2.6	1.4	.36
L981351	G3	40	8.8	5.2	1.9	2.1	3.3	1.8	.53
L981361	G3	50	6.5	3.5	1.3	1.7	2.4	1.3	.34
L981366	G3	55	7.8	5.7	2.0	2.1	3.6	1.6	.49
L981412	G4	1	8.3	4.7	1.8	1.9	3.1	1.6	.46
L981415	G4	4	8.0	4.6	1.9	1.8	3.4	1.6	.45
L981416	G4	5	6.4	3.8	1.5	1.5	2.5	1.3	.36
L981419	G4	8	6.7	3.7	1.5	1.5	2.6	1.4	.38
L981424	G4	13	8.4	4.3	1.6	2.5	2.9	1.4	.46
L981426	G4	15	6.7	3.6	1.4	1.7	2.3	1.3	.34
L981429	G4	18	8.7	5.6	2.3	2.0	3.1	1.8	.51
L981431	G4	20	9.2	6.2	2.7	2.0	3.0	1.8	.54
L981433	G4	22	7.1	5.1	2.1	1.6	2.4	1.5	.41
L981436	G4	25	8.8	4.9	2.0	2.2	3.1	1.7	.52

Table 2. Geochemical data for USGS Aleutian Trench cores.

Sample	% P	% Mn	% TOC	ppm Ba	ppm Cd	ppm Ce	ppm Co	ppm Cr
L981108	.08	.32	.44	850	6	21	17	72
L981110	.05	1.10	--	630	<4	19	20	50
L981112	.09	.08	1.09	930	6	19	14	78
L981116	.05	.07	.66	610	<4	21	13	62
L981119	.06	.23	.56	670	<4	22	23	89
L981121	.08	1.00	.61	840	5	22	32	95
L981130	.06	.07	.75	690	<4	23	14	61
L981139	.07	.09	.44	840	7	27	17	73
L981140	.21	.78	.48	810	6	60	33	68
L981157	.06	.09	.55	820	5	27	15	69
L981163	.08	.10	1.07	930	9	40	17	74
L981208	.07	.29	.77	810	6	11	17	72
L981209	.08	2.00	.70	890	6	36	28	73
L981211	.09	.06	1.18	750	<4	23	12	62
L981223	.07	.09	.60	760	5	29	18	85
L981225	.06	.08	.58	1,100	<2	24	18	81
L981227	.09	1.40	.72	880	8	21	50	130
L981238	.06	.08	.57	970	<2	27	15	54
L981243	.07	.10	.43	790	6	37	16	70
L981246	.22	.49	.47	810	6	33	30	64
L981249	.07	.10	.54	820	7	35	17	65
L981259	.04	.07	.57	650	<4	24	12	54
L981264	.09	.10	.94	910	6	20	16	64
L981312	.06	.21	.71	640	<4	22	17	56
L981314	.07	1.30	.72	880	6	24	27	77
L981315	.08	.07	.91	670	<4	23	13	55
L981316	.09	.06	.53	550	<4	22	10	40
L981324	.08	.09	.55	750	7	61	16	87
L981326	.08	.11	.56	820	7	36	21	100
L981328	.07	.75	.61	690	<4	25	37	93
L981332	.07	.08	.56	820	<4	30	11	76
L981341	.08	.10	.39	680	9	40	18	66
L981345	.08	.09	.45	630	<4	19	15	52
L981351	.08	.09	.56	820	6	36	18	68
L981361	.06	.06	.35	550	<4	26	11	51
L981366	.07	.10	.82	890	6	32	16	65
L981412	.07	.17	.57	730	7	31	15	75
L981415	.07	1.70	.59	860	9	25	30	72
L981416	.06	.11	.87	650	<4	19	14	59
L981419	.06	.06	1.03	730	<4	21	13	60
L981424	.07	.08	.33	630	6	37	11	65
L981426	.07	.25	.43	560	<4	26	22	55
L981429	.07	.09	1.23	740	6	42	19	98
L981431	.07	.10	.61	820	6	31	17	110
L981433	.09	.45	.63	680	<4	19	34	89
L981436	.08	.08	.51	720	5	28	15	84

Table 2. Geochemical data for USGS Aleutian Trench cores.

Sample	ppm Cu	ppm Ga	ppm La	ppm Li	ppm Mo	ppm Ni
L981108	73	14	15	42	6	44
L981110	47	13	11	36	25	40
L981112	72	12	15	43	<2	35
L981116	82	13	12	34	<2	32
L981119	64	19	13	38	<2	43
L981121	87	25	16	46	9	41
L981130	57	15	14	38	<2	28
L981139	54	16	16	45	<2	28
L981140	54	27	20	40	<2	26
L981157	91	19	15	41	<2	29
L981163	110	21	19	42	<2	32
L981208	78	15	13	44	5	38
L981209	83	22	18	57	55	62
L981211	52	13	12	36	<2	30
L981223	74	13	17	43	<2	42
L981225	45	15	13	38	<2	38
L981227	110	23	18	50	15	72
L981238	54	16	15	34	<2	28
L981243	87	19	17	44	<2	31
L981246	46	15	19	42	<2	31
L981249	110	17	16	44	<2	28
L981259	84	14	12	35	<2	26
L981264	96	11	16	38	<2	25
L981312	59	13	12	35	<2	32
L981314	67	20	16	50	6	60
L981315	49	14	13	32	<2	29
L981316	43	11	13	24	<2	17
L981324	71	16	21	42	<2	43
L981326	58	12	18	45	<2	63
L981328	81	17	15	38	4	52
L981332	57	19	15	41	<2	35
L981341	97	22	19	42	<2	23
L981345	33	14	13	33	<2	25
L981351	81	17	16	43	<2	33
L981361	35	12	14	31	<2	22
L981366	90	11	16	40	<2	31
L981412	69	17	17	37	<2	37
L981415	67	31	17	39	36	46
L981416	50	12	12	32	<2	25
L981419	52	15	13	36	<2	33
L981424	42	15	18	28	<2	29
L981426	55	13	15	29	<2	27
L981429	62	19	22	41	<2	43
L981431	57	15	17	47	<2	50
L981433	77	19	15	37	<2	47
L981436	53	17	19	41	<2	33

Table 2. Geochemical data for USGS Aleutian Trench cores.

Sample	ppm Pb	ppm Sc	ppm Sr	ppm V	ppm Y	ppm Zn
L981108	15	20	230	150	17	160
L981110	<8	14	160	100	12	83
L981112	12	18	220	150	18	120
L981116	10	18	190	140	15	84
L981119	8	21	190	150	15	130
L981121	14	23	240	190	19	110
L981130	11	20	200	140	17	100
L981139	<8	24	240	170	20	100
L981140	9	24	290	160	24	92
L981157	24	21	240	160	17	110
L981163	30	26	260	190	23	140
L981208	14	19	230	150	17	100
L981209	19	21	260	190	20	120
L981211	<8	17	180	120	14	90
L981223	8	23	250	180	19	110
L981225	10	19	190	150	15	86
L981227	14	26	250	200	21	110
L981238	12	19	210	130	17	82
L981243	17	26	240	190	20	110
L981246	28	22	280	160	23	92
L981249	20	26	240	190	23	110
L981259	10	17	180	120	14	81
L981264	15	23	270	190	21	120
L981312	11	16	180	110	13	76
L981314	<8	19	250	160	19	110
L981315	<8	16	200	120	15	80
L981316	9	16	250	110	17	64
L981324	17	25	240	180	21	100
L981326	14	23	260	190	19	120
L981328	<8	21	200	150	16	86
L981332	<8	26	250	170	19	110
L981341	22	25	280	190	21	99
L981345	8	17	190	120	15	76
L981351	12	24	270	180	24	110
L981361	<8	16	220	110	16	65
L981366	15	22	260	170	19	110
L981412	18	20	270	150	20	87
L981415	21	21	260	150	19	110
L981416	8	16	200	120	14	97
L981419	<8	17	200	130	16	99
L981424	<8	18	330	140	19	70
L981426	<8	16	240	120	14	63
L981429	8	24	260	180	20	100
L981431	16	25	220	190	19	110
L981433	<8	19	200	150	15	81
L981436	12	20	280	170	20	96

Table 2. Geochemical data for USGS Aleutian Trench cores.

Sample	Core	Depth (cm)	% Al	% Fe	% Mg	% Ca	% Na	% K	% Ti
L981714	G7	1	5.3	3.1	1.3	1.2	3.1	1.2	.25
L981716	G7	3	5.4	3.2	1.4	1.2	3.0	1.2	.26
L981719	G7	6	6.3	4.0	1.7	1.6	4.0	1.5	.35
L981723	G7	10	5.4	3.2	1.4	1.2	2.9	1.2	.27
L981724	G7	11	6.4	4.1	1.8	1.6	3.9	1.4	.36
L981725	G7	12	6.5	3.9	1.7	1.6	3.8	1.4	.36
L981729	G7	16	7.2	4.3	1.8	1.5	3.7	1.5	.38
L981731	G7	18	7.0	4.3	1.8	1.5	3.6	1.6	.36
L981732	G7	19	5.2	3.1	1.3	1.1	3.0	1.2	.26
L981734	G7	21	5.8	4.1	1.7	1.3	3.9	1.3	.31
L981735	G7	22	6.7	3.4	1.7	1.5	3.8	1.4	.35
L981737	G7	24	5.2	4.7	1.4	1.1	2.8	1.2	.27
L981740	G7	27	7.3	4.2	1.8	1.6	3.8	1.6	.38
L981808	G8	1	7.2	4.4	1.8	2.0	3.4	1.3	.38
L981810	G8	3	7.4	4.5	1.8	2.0	3.4	1.5	.40
L981812	G8	5	5.9	3.5	1.4	1.5	2.6	1.2	.31
L981814	G8	7	5.6	3.4	1.4	1.6	2.6	1.2	.30
L981816	G8	9	6.9	5.0	1.8	1.9	3.3	1.4	.38
L981818	G8	11	5.2	4.2	1.4	1.5	2.7	1.2	.27
L981820	G8	13	5.3	3.3	1.3	1.5	2.7	1.1	.28
L981822	G8	15	6.1	5.8	1.8	1.7	3.6	1.3	.33
L981824	G8	17	5.5	2.9	1.3	1.6	2.6	1.1	.28

Table 2. Geochemical data for USGS Aleutian Trench cores.

Sample	% P	% Mn	% TOC	ppm Ba	ppm Cd	ppm Ce	ppm Co	ppm Cr
L981714	.05	.63	1.06	730	2	17	16	41
L981716	.05	.57	--	710	<4	19	17	41
L981719	.06	1.50	.73	910	5	19	19	54
L981723	.05	.20	.85	750	<4	24	14	43
L981724	.06	1.10	.71	980	5	32	27	56
L981725	.05	.12	.82	920	6	23	11	56
L981729	.06	.10	.65	920	6	33	12	61
L981731	.06	1.10	.77	990	5	29	42	58
L981732	.04	.25	.68	750	<4	16	17	43
L981734	.06	3.70	.90	1,000	6	33	74	50
L981735	.05	.08	.92	930	6	32	15	55
L981737	.11	.25	.79	690	<4	29	23	43
L981740	.05	.09	.61	980	6	12	13	58
L981808	.06	.21	.68	930	7	33	21	58
L981810	.07	.26	.63	890	7	28	24	60
L981812	.05	.18	.56	770	<4	19	23	46
L981814	.05	.15	.58	750	<4	21	21	43
L981816	.07	.10	.56	930	7	32	16	58
L981818	.04	.05	.59	950	<4	16	10	42
L981820	.04	.05	.64	740	<4	17	11	43
L981822	.05	.07	.59	880	8	34	14	52
L981824	.04	.05	.57	700	<4	17	11	41

Table 2. Geochemical data for USGS Aleutian Trench cores.

Sample	ppm Cu	ppm Ga	ppm La	ppm Li	ppm Mo	ppm Ni
L981714	87	14	10	26	13	41
L981716	89	14	11	26	10	37
L981719	130	24	10	29	19	36
L981723	80	13	11	26	<2	26
L981724	130	22	13	32	7	39
L981725	110	22	14	30	<2	32
L981729	72	21	16	35	<2	40
L981731	180	14	12	34	5	52
L981732	74	12	11	26	3	28
L981734	270	25	14	28	34	76
L981735	280	14	12	32	<2	31
L981737	120	11	13	27	<2	30
L981740	88	8	12	37	4	28
L981808	110	22	17	29	<2	33
L981810	97	18	16	32	<2	25
L981812	68	12	10	26	<2	24
L981814	65	12	10	23	<2	21
L981816	71	15	14	27	<2	30
L981818	49	11	9	24	<2	19
L981820	57	12	9	25	<2	24
L981822	110	24	17	29	<2	28
L981824	78	11	9	25	<2	21

Table 2. Geochemical data for USGS Aleutian Trench cores.

Sample	ppm Pb	ppm Sc	ppm Sr	ppm V	ppm Y	ppm Zn
L981714	10	13	180	99	12	68
L981716	16	14	180	100	12	70
L981719	16	17	230	130	14	130
L981723	12	15	180	100	12	67
L981724	17	18	240	130	15	85
L981725	25	19	210	160	14	100
L981729	24	19	220	140	16	94
L981731	49	18	240	130	16	83
L981732	14	14	160	96	12	65
L981734	24	14	180	120	15	73
L981735	15	19	180	150	15	100
L981737	12	14	170	97	15	62
L981740	19	19	240	140	16	95
L981808	19	22	290	140	16	87
L981810	19	20	260	150	18	88
L981812	<8	17	200	110	13	68
L981814	<8	16	200	110	12	65
L981816	18	20	240	140	17	81
L981818	9	15	180	110	11	68
L981820	<8	15	190	110	11	68
L981822	24	18	230	150	15	89
L981824	10	15	190	110	11	79

Table 3. Geochemical data for Lamont-Doherty Geological Observatory cores from the North Pacific.

Sample	Cruise	Core	Depth (cm)	% Al	% Fe	% Mg	% Ca	% Na	% K	% Ti
D259682	RC10	186	24	7.5	4.7	2.1	2.7	3.4	1.7	.38
D259654	RC10	186	55	7.3	4.8	1.7	2.0	3.3	1.9	.40
D259650	RC10	186	65	5.7	5.2	1.6	1.6	2.6	1.6	.31
D259671	RC10	186	70	7.5	4.2	1.8	2.4	2.7	1.8	.41
D259676	RC10	186	70	7.4	4.1	1.8	2.3	2.6	1.7	.41
D259653	RC10	210	10	7.3	4.7	1.8	1.7	2.7	1.8	.42
D259656	RC10	210	13	7.3	4.6	1.7	2.0	3.0	1.9	.42
D259670	RC10	210	17	7.8	4.8	1.7	2.2	2.7	1.8	.46
D259666	RC10	210	25	7.2	4.6	1.8	1.8	2.7	1.9	.41
D259711	RC10	213	62	8.5	5.8	2.4	2.0	2.6	2.1	.50
D259675	RC10	213	68	8.2	5.9	2.5	2.0	2.4	1.9	.49
D259700	RC10	213	73	8.0	4.9	1.9	1.9	2.7	2.2	.46
D259667	RC11	172	18	7.2	5.3	1.9	3.1	3.0	1.5	.44
D259707	RC11	172	38	7.2	4.5	1.6	2.3	3.0	1.8	.41
D259687	RC11	172	55	8.3	4.9	1.9	2.0	2.6	2.0	.46
D259698	RC12	179	15	6.2	4.0	1.7	9.6	2.3	1.8	.31
D259652	RC12	179	21	7.2	4.6	2.0	4.8	2.6	2.0	.39
D259669	RC12	179	21	7.2	4.6	1.9	4.8	2.6	2.0	.39
D259690	RC12	179	25	7.4	4.7	2.1	2.1	2.3	2.0	.41
D259701	RC12	179	28	7.5	4.7	2.0	3.9	2.7	2.2	.41
D259693	RC12	179	31	7.2	4.5	2.0	4.7	2.6	2.1	.38
D259677	RC12	177	16	8.0	4.6	1.6	2.0	2.6	1.9	.45
D259663	RC12	177	27	7.5	4.3	1.6	1.9	2.7	1.9	.41
D259710	RC12	177	42	7.4	4.7	1.5	2.7	3.1	1.8	.47
D259692	RC12	177	74	7.7	4.6	1.7	2.1	2.3	1.9	.44
D259699	RC12	177	75	7.8	4.6	1.7	2.1	2.4	2.1	.44
D259696	RC12	177	88	7.0	4.1	1.6	2.0	2.6	1.8	.37
D259702	RC12	177	88	7.0	4.1	1.6	2.1	2.9	2.0	.37
D259681	RC12	177	95	6.7	4.0	1.5	3.1	2.7	1.5	.39
D259713	RC12	177	97	7.2	4.5	1.7	2.6	3.0	1.8	.44
D259684	RC12	177	102	7.5	4.3	1.7	2.1	2.6	2.0	.41
D259715	RC12	177	114	6.8	4.3	1.6	3.7	3.0	1.7	.42
D259664	RC12	177	140	7.7	4.5	1.7	1.8	2.5	2.0	.42
D259668	RC12	177	160	7.7	4.5	1.7	1.9	2.4	1.9	.43
D259679	RC12	177	179	7.0	4.0	1.5	1.7	2.2	1.8	.37
D259683	RC12	177	179	7.5	4.3	1.7	1.8	2.4	2.0	.40
D259686	RC14	152	5	6.9	4.2	1.6	1.8	3.0	1.9	.34
D259705	RC14	152	15	8.3	4.9	2.0	1.5	2.6	2.4	.45
D259709	RC14	152	15	9.5	5.5	2.2	1.8	2.9	2.6	.52
D259712	RC14	152	34	7.3	4.2	1.7	1.6	2.5	2.1	.40
D259680	RC14	152	40	8.2	4.7	1.8	1.9	2.6	2.1	.43
D259662	RC14	152	50	8.2	4.5	1.8	1.9	2.6	2.2	.43

Table 3. Geochemical data for Lamont-Doherty Geological Observatory cores from the North Pacific.

Sample	% P	% Mn	ppm Ba	ppm Cd	ppm Co	ppm Cr	ppm Cu	ppm La	ppm Mo
D259682	.07	.40	910	<2	27	64	120	14	6
D259654	.08	.32	970	<2	47	75	86	16	<2
D259650	.05	.10	860	<2	25	66	80	12	6
D259671	.07	.10	870	<2	23	83	170	15	3
D259676	.07	.10	850	<2	23	82	170	15	<2
D259653	.08	.23	780	<2	20	85	68	15	5
D259656	.09	2.10	780	<2	46	72	73	16	25
D259670	.08	.08	750	<2	16	80	52	15	<2
D259666	.07	.07	850	<2	15	80	58	13	<2
D259711	.09	.13	820	<2	24	140	41	17	<2
D259675	.13	1.40	830	<2	66	140	70	17	12
D259700	.10	.09	720	<2	16	100	60	19	<2
D259667	.05	.17	1,500	<2	25	52	110	12	<2
D259707	.06	.89	1,600	<2	29	52	120	17	11
D259687	.09	.13	1,100	<2	24	99	86	20	2
D259698	.05	.92	2,700	<2	45	62	130	19	7
D259652	.08	1.20	2,300	<2	83	84	140	20	11
D259669	.07	1.20	2,300	<2	83	85	140	20	13
D259690	.08	2.20	1,700	<2	170	110	210	22	25
D259701	.08	.87	1,900	<2	120	92	130	20	8
D259693	.07	.49	1,600	<2	81	93	110	19	6
D259677	.08	.13	1,000	<2	17	82	57	19	<2
D259663	.07	.10	980	<2	15	73	55	18	<2
D259710	.08	.28	860	<2	37	45	67	17	<2
D259692	.08	.12	1,100	<2	17	84	66	18	<2
D259699	.08	.12	1,100	<2	16	82	67	18	<2
D259696	.06	.91	1,200	<2	41	73	96	17	3
D259702	.06	.47	1,200	<2	28	71	72	16	<2
D259681	.06	1.90	1,100	<2	70	51	140	16	<2
D259713	.08	1.70	1,300	<2	65	52	140	16	3
D259684	.08	.80	1,200	<2	32	78	81	18	<2
D259715	.08	.26	1,300	<2	22	53	69	17	<2
D259664	.08	.79	1,100	<2	42	89	86	20	4
D259668	.08	.12	920	<2	19	89	62	18	<2
D259679	.07	.16	900	<2	20	75	80	17	<2
D259683	.07	.17	980	<2	22	83	88	18	<2
D259686	.06	.81	1,800	<2	34	65	96	19	<2
D259705	.09	.30	1,100	<2	25	110	45	20	<2
D259709	.10	.34	1,200	<2	28	130	50	28	<2
D259712	.07	.08	1,200	<2	19	85	63	19	<2
D259680	.08	.09	910	<2	27	99	58	19	<2
D259662	.08	.10	860	<2	28	100	53	19	3

Table 3. Geochemical data for Lamont-Doherty Geological Observatory cores from the North Pacific.

Sample	ppm Nb	ppm Ni	ppm Pb	ppm Sc	ppm Sr	ppm V	ppm Y
D259682	6	52	34	18	310	170	16
D259654	6	42	31	20	250	160	18
D259650	4	56	31	15	190	150	13
D259671	7	50	29	20	250	220	16
D259676	7	49	31	20	250	220	16
D259653	9	36	31	19	200	160	17
D259656	9	47	34	18	240	160	20
D259670	7	29	30	20	220	160	20
D259666	7	33	29	18	210	150	17
D259711	11	55	26	20	230	180	17
D259675	9	73	38	21	230	190	17
D259700	9	38	29	18	250	160	19
D259667	<4	28	35	24	260	200	21
D259707	4	110	30	22	240	140	26
D259687	10	49	35	20	260	160	18
D259698	4	150	46	16	560	120	23
D259652	8	130	55	19	380	150	21
D259669	8	130	53	18	380	150	21
D259690	14	190	71	20	270	160	20
D259701	9	90	55	19	340	150	19
D259693	9	68	56	19	350	140	18
D259677	8	36	32	19	250	150	21
D259663	8	33	28	18	240	140	20
D259710	5	28	28	20	270	150	26
D259692	7	41	31	19	240	140	19
D259699	8	41	30	19	240	140	19
D259696	6	79	31	18	250	140	18
D259702	5	51	31	18	240	130	18
D259681	6	120	35	19	280	170	21
D259713	5	120	28	19	280	150	22
D259684	7	71	32	18	260	150	19
D259715	5	35	26	18	290	120	21
D259664	8	72	47	19	250	160	18
D259668	10	39	29	19	240	150	18
D259679	7	41	33	17	220	130	16
D259683	8	44	32	18	230	140	18
D259686	<4	94	31	18	240	130	23
D259705	11	67	25	18	230	160	18
D259709	11	77	28	21	270	180	21
D259712	7	42	29	17	220	140	17
D259680	9	48	28	18	250	160	17
D259662	13	45	28	18	260	160	17

Table 3. Geochemical data for Lamont-Doherty Geological Observatory cores from the North Pacific.

Sample	ppm Zn	ppm Ce	ppm Ga	ppm Li	ppm Th	ppm Yb	ppm Nd
D259682	6,000	31	24	34	6	2	18
D259654	1,500	34	23	36	5	2	17
D259650	16,000	25	16	34	4	2	14
D259671	5,600	34	20	40	4	2	18
D259676	5,500	34	20	39	5	2	19
D259653	2,000	32	21	43	5	2	18
D259656	4,500	32	34	41	12	2	19
D259670	1,700	35	20	40	6	2	21
D259666	3,400	30	19	43	4	2	17
D259711	2,300	36	23	49	6	2	21
D259675	4,500	36	32	45	9	2	18
D259700	2,200	38	20	45	5	2	21
D259667	150	29	21	26	<4	3	17
D259707	190	33	29	34	6	3	21
D259687	140	43	22	40	7	2	22
D259698	170	32	29	44	6	3	23
D259652	160	43	30	66	9	2	22
D259669	160	42	33	64	9	2	23
D259690	180	47	36	73	13	2	23
D259701	160	45	30	69	8	2	22
D259693	140	41	24	51	5	2	19
D259677	120	42	21	36	5	2	22
D259663	130	40	20	34	6	2	21
D259710	100	34	22	28	<4	3	21
D259692	110	38	20	36	6	2	22
D259699	110	37	21	38	5	2	21
D259696	110	35	28	32	8	2	20
D259702	110	33	23	34	6	2	18
D259681	120	31	32	27	9	2	18
D259713	120	33	34	29	9	2	19
D259684	120	37	27	36	7	2	19
D259715	120	35	21	29	5	2	20
D259664	740	43	28	38	8	2	22
D259668	180	38	20	37	6	2	19
D259679	100	37	19	34	5	2	19
D259683	110	40	20	37	5	2	19
D259686	170	36	28	34	7	3	23
D259705	130	43	24	53	5	2	22
D259709	140	55	27	58	9	2	28
D259712	130	38	20	45	6	2	21
D259680	120	40	20	47	5	2	22
D259662	190	40	21	49	5	2	21

Table 3. Geochemical data for Lamont-Doherty Geological Observatory cores from the North Pacific.

Sample	Cruise	Core	Depth (cm)	% Al	% Fe	% Mg	% Ca	% Na	% K	% Ti
D259695	RC14	170TW	6	7.7	5.0	2.1	2.2	2.7	2.2	.45
D259655	RC14	170TW	12	7.8	5.7	2.2	1.9	2.5	2.0	.43
D259673	RC14	170TW	19	7.5	4.8	2.0	2.3	2.9	2.0	.44
D259694	RC14	170TW	30	8.3	5.1	2.2	2.3	2.9	2.1	.47
D259658	RC14	170TW	40	7.2	4.6	1.9	2.2	3.2	1.9	.43
D259674	RC14	170TW	45	8.2	6.0	2.3	1.7	3.0	2.1	.47
D259706	RC14	170TW	56	7.7	5.0	2.1	2.4	2.8	2.1	.45
D259649	RC15	4	11	5.7	4.4	2.0	3.5	3.1	1.7	.29
D259651	RC15	4	24	6.5	5.1	2.3	3.5	3.4	2.0	.34
D259672	RC15	4	51	7.7	4.8	2.2	4.1	2.6	2.6	.37
D259689	V20	118	9	6.9	4.4	1.7	1.9	2.4	1.6	.36
D259691	V20	118	18	7.4	5.2	1.8	1.8	2.6	2.0	.41
D259659	V20	118	46	6.9	4.4	2.3	2.0	3.1	1.8	.38
D259678	V20	118	60	7.7	5.7	1.9	2.1	3.3	2.7	.42
D259697	V20	118	80	7.6	4.8	2.0	2.1	2.6	2.0	.43
D259703	V20	118	80	7.7	4.9	2.0	2.1	2.6	2.0	.43
D259657	V20	118	98	7.3	4.8	1.6	2.0	2.8	2.0	.40
D259688	V20	118	98	7.4	4.7	1.6	2.0	2.8	2.0	.39
D259708	V20	118	114	6.9	4.4	1.6	2.0	2.8	1.9	.36
D259661	V20	118	122	7.5	4.6	1.6	1.7	2.9	2.2	.39
D259704	V20	118	142	7.6	4.8	1.6	1.4	2.8	2.3	.39
D259660	V20	118	162	7.6	4.6	1.6	1.6	2.5	2.2	.41
D259685	V21	166	12	8.6	4.5	1.7	3.1	3.0	2.0	.40
D259714	V21	166	20	8.4	6.1	2.5	2.0	2.9	2.2	.50
D259665	V21	166	23	8.6	6.6	2.5	2.1	2.7	2.1	.51

Table 3. Geochemical data for Lamont-Doherty Geological Observatory cores from the North Pacific.

Sample	% P	% Mn	ppm Ba	ppm Cd	ppm Co	ppm Cr	ppm Cu	ppm La	ppm Mo
D259695	.09	.49	3,700	<2	44	82	100	22	2
D259655	.09	.25	1,100	<2	30	97	57	18	2
D259673	.09	.56	2,400	<2	48	80	100	22	2
D259694	.10	.08	910	<2	18	98	48	19	2
D259658	.09	.41	980	<2	41	78	89	21	<2
D259674	.10	.07	800	<2	20	100	43	19	<2
D259706	.09	.60	3,800	<2	53	84	110	23	5
D259649	.09	1.80	550	<2	61	100	190	30	<2
D259651	.08	.22	1,500	<2	29	120	140	33	2
D259672	.08	.12	1,700	<2	23	110	130	33	<2
D259689	.06	.34	1,200	<2	37	70	110	15	3
D259691	.07	.14	770	<2	31	82	92	15	4
D259659	.06	.06	600	<2	19	70	82	14	2
D259678	.07	.07	760	2	21	77	66	15	<2
D259697	.07	.07	790	2	19	79	94	16	3
D259703	.07	.07	800	2	19	79	95	16	5
D259657	.07	.07	810	<2	17	72	60	16	<2
D259688	.07	.07	810	<2	17	72	59	16	<2
D259708	.06	.07	920	<2	15	73	63	16	3
D259661	.06	.08	1,100	<2	14	75	180	19	<2
D259704	.06	.19	1,200	<2	37	75	160	18	<2
D259660	.06	.28	900	<2	46	79	170	20	2
D259685	.08	.11	690	<2	16	52	88	14	<2
D259714	.11	1.60	890	4	51	140	68	17	15
D259665	.14	.10	840	3	23	150	64	18	2

Table 3. Geochemical data for Lamont-Doherty Geological Observatory cores from the North Pacific.

Sample	ppm Nb	ppm Ni	ppm Pb	ppm Sc	ppm Sr	ppm V	ppm Y
D259695	9	120	35	19	350	140	23
D259655	9	64	29	18	270	160	18
D259673	10	120	38	19	360	150	24
D259694	10	46	27	17	330	160	18
D259658	7	97	33	18	360	140	22
D259674	11	51	29	18	280	180	18
D259706	8	130	38	19	360	140	24
D259649	9	310	49	14	420	140	28
D259651	11	240	44	15	370	180	29
D259672	15	130	38	15	390	180	22
D259689	<4	58	36	18	240	140	17
D259691	7	50	36	20	230	150	17
D259659	7	34	35	18	260	150	17
D259678	<4	40	32	20	240	170	17
D259697	8	48	34	20	240	160	18
D259703	9	49	32	19	240	160	18
D259657	7	44	32	18	230	150	18
D259688	7	44	32	18	230	150	18
D259708	6	58	35	18	230	130	17
D259661	7	48	38	19	210	140	17
D259704	7	59	39	19	210	130	17
D259660	8	80	41	19	220	140	18
D259685	7	24	33	16	290	150	22
D259714	11	72	27	21	230	180	17
D259665	12	59	32	21	230	200	19

Table 3. Geochemical data for Lamont-Doherty Geological Observatory cores from the North Pacific.

Sample	ppm Zn	ppm Ce	ppm Ga	ppm Li	ppm Th	ppm Yb	ppm Nd
D259695	160	43	26	41	6	3	26
D259655	150	37	22	44	6	2	21
D259673	160	42	26	37	7	3	24
D259694	130	41	21	43	4	2	21
D259658	160	42	25	35	7	2	25
D259674	140	39	20	45	6	2	21
D259706	170	43	27	40	6	3	25
D259649	370	43	25	38	11	3	29
D259651	390	48	20	49	7	3	33
D259672	200	60	23	54	12	2	32
D259689	4,700	31	22	30	7	2	19
D259691	2,800	32	20	37	6	2	18
D259659	4,400	31	18	33	5	2	17
D259678	3,600	32	22	39	7	2	20
D259697	11,000	34	20	36	5	2	18
D259703	11,000	34	20	37	6	2	21
D259657	4,000	36	19	33	5	2	20
D259688	3,800	35	19	34	5	2	19
D259708	3,600	35	18	31	5	2	18
D259661	3,200	42	21	38	6	2	20
D259704	2,200	43	22	42	7	2	21
D259660	2,700	45	23	43	7	2	21
D259685	340	33	21	33	5	3	20
D259714	12,000	34	37	51	9	2	17
D259665	6,500	39	22	49	6	2	21

Table 4. Correlation coefficients between concentrations of Mn andd selected elements in samples from Aleutian Trench and North Pacific.

Element	Aleutian Trench	North Pacific
Fe	0.05	-0.10
Ba	0.29	0.24
Co	0.83	0.75
Cu	0.49	0.44
Mo	0.84	0.83
Ni	0.70	0.59