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4. Data Report: Major and Trace Element Geochemistry of Rise and Shelf Sediments from the Antarctic Peninsula, Leg 178[1]

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ABSTRACT

Geochemical analyses have been performed on sediment samples collected during Ocean Drilling Program Leg 178 from the continental rise and outer continental shelf of the Antarctic Peninsula. A suite of 21 trace elements was measured by neutron activation analysis in 39 sediment samples, and major element oxides were determined in 67 samples by electron microprobe analyses of fused glass beads. These geochemical data, combined with the X-ray diffraction and X-ray fluorescence data from shipboard analyses, provide a reasonable estimate of the mineral and chemical composition of sediments deposited along the western margin of the Antarctic Peninsula.

INTRODUCTION

During Leg 178 of the Ocean Drilling Program (ODP), sediments were drilled along the continental margin of the Antarctic Peninsula (Barker, Camerlenghi, Acton, et al., 1999). The sites drilled included three sites on hemipelagic drifts on the continental rise and a number of sites on the inner and outer continental shelf. During the cruise, 71 sediment samples were taken for X-ray diffraction (XRD) analyses to determine both bulk and clay mineralogy. Most of these samples (66) were silts and clays collected from the continental rise at Sites 1095, 1096, and 1101. Only five samples were from the outer continental shelf, and

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these represented glacial tills and glacial marine sediments from Site 1097. A subset of 52 of these sediment samples were analyzed by X-ray fluorescence (XRF) to determine a suite of 12 trace elements (V, Cr, Ni, Cu, Zn, Rb, Sr, Y, Zr, Nb, Ba, and Ce).

Splits of all 71 samples were retained for shore-based analyses. Major element chemistry was determined on 67 of these samples by electron microprobe analyses of fused beads. An additional suite of trace elements (Sc, Cr, Fe, Co, Zn, As, Rb, Sr, Sb, Cs, Ba, La, Ce, Sm, Eu, Tb, Yb, Lu, Hf, Ta, and Th) was determined by instrumental neutron activation analyses (INAA) on 39 samples.

ANALYTICAL PROCEDURES

Samples analyzed in this study were splits taken from XRD and XRF samples that were analyzed on board during Leg 178. The initial XRD and XRF samples, originally ~10 g, were crushed to a fine gravel, and ~1 g of this gravel was set aside for possible INAA analyses. The remainder was powdered in an agate mortar, washed in nanopure water to remove salts, sonicated for 30 to 40 min, and centrifuged. The centrifuged sediments were dried for at least 12 hr at 120°C and powdered in a tungsten carbide mixer mill. An ~1-g aliquot was ignited for 10 hr at 950°C to determine loss on ignition (LOI). This sample was retained for onshore major element analyses. Thus, the INAA samples are distinct from the major element samples and were only minimally processed on board to ensure that trace element chemistry was not affected.

Once ashore, the INAA samples were ground to a fine powder in a high-purity alumina mortar. In a series of three irradiations, 39 samples were analyzed along with U.S. Geological Survey (USGS) geochemical standards BHVO-1 and G-2 (Govindaraju, 1989). Powders weighing ~200 mg were irradiated in polyethylene vials with standard flux monitors at the University of California, Irvine, Research Reactor for 4 hr at a neutron flux of 1.8×10^{12} n/cm^2/s. Samples were counted on high-purity, intrinsic Ge detectors at ~1 week and 4 weeks following irradiation, and gamma-ray spectra were used to determine the concentrations of Sc, Cr, Fe, Co, Zn, As, Rb, Sr, Sb, Cs, Ba, La, Ce, Sm, Eu, Tb, Yb, Lu, Hf, Ta, and Th.

The powders taken from shipboard XRF and LOI were ground again in a high-purity alumina mortar. About 20 mg of sample was fused into a glass bead at temperatures of ~1700°C, using a Mo strip heater (Brown, 1977) under an Ar atmosphere. Glass beads were mounted in epoxy, polished, and analyzed by electron microprobe. Analyses were performed at 11-nA beam current and 15-keV accelerating voltage on a CAMEBAX electron microprobe. Standardization was obtained by using a set of Smithsonian Institution mineral standards (Jarosewich et al., 1980). In some samples, fusion was not complete and quartz crystals were observed in backscatter electron images. These samples were ground further and fused again until complete melting was achieved. Analyses were performed by scanning the electron beam across a box 20 µm in diameter. Typically, eight analyses were performed on each sample and these were spaced out over much of the exposed surface of the glass bead. The multiple analyses were averaged to obtain the bulk chemical composition.

RESULTS

Analytical results for the USGS standards measured in each of the three INAA experiments are shown in Table T1, along with recommended values for these samples (Govindaraju, 1989). INAA results for sediments from Sites 1095, 1096, and 1101 are presented in Tables T2, T3, and T4, respectively. Major element chemistry from the microprobe analyses for Sites 1095, 1096, 1097, and 1101 are presented in Tables T5, T6, T7, and T8, respectively. In addition to the oxides reported, Cr_2O_3 was also measured. Results for this oxide have been omitted, because they were all at or below detection limits (<0.05 wt%) and Cr was measured with much greater precision by INAA. Results from the LOI measurement conducted on board ship during Leg 178 are also included with the microprobe data.

DISCUSSION

Comparisons between the INAA results for the USGS standard rocks and the recommended values (Govindaraju, 1989) were all good and show that the expected precision and accuracy for the INAA element suite is of the order of 5% to 10% for most elements. Six elements—Cr, Zn, Rb, Sr, Ba, and Ce—that were determined by INAA were also measured by the shipboard XRF (Barker, Camerlenghi, Acton, et al., 1999). Differences between these two sets of analyses are small and can largely be attributed to analytical scatter and small interlaboratory biases. It is also important to note that the INAA sample is not from exactly the same powder as the XRF sample, and it was not washed to remove salts, so some variability might also reflect real differences between samples or differences in preparation.

LOI ranged from 3% to 5% in most samples to nearly 15% in two samples from Site 1101 (Table T8). This mass loss at high temperatures is most likely related to loss of water in hydrated phases, such as smectites, and CO_2 loss caused by decomposition of calcite. The highest LOIs in the samples from Site 1101 were known to contain about 22% calcite (Shipboard Scientific Party, 1999), which would produce about 10% CO_2. However, the CaO reported in the microprobe data is probably derived from both feldspars and calcite. The iron oxide reported in the microprobe analyses is given as FeO, but its oxidation state is unknown. The LOI was part of the normal XRF procedure and was designed to oxidize all Fe to Fe_2O_3. However, the glass beads were formed on a strip of metallic Mo under an Ar atmosphere, and some reduction back to FeO is possible.

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REFERENCES

Barker, P.F., Camerlenghi, A., Acton, G.D., et al., 1999. *Proc. ODP, Init. Repts.,*178 [CD-ROM]. Available from: Ocean Drilling Program, Texas A&M University, College Station, TX 77845-9547, U.S.A.

Brown, R.W., 1977. A sample fusion technique for whole rock analysis with the electron microprobe. *Geochim. Cosmochim. Acta,* 41:433–438.

Govindaraju, K., 1989. 1989 compilation of working values and sample description for 272 geostandards. *Geostand. Newsl.,* 13 (spec. iss.).

Jarosewich, E., Nelen, J.A., and Norberg, J.A., 1980. Reference samples for electron microprobe analysis. *Geostand. Newsl.,* 4:43–47.

Shipboard Scientific Party, 1999. Site 1101. *In* Barker, P.F., Camerlenghi, A., Acton, G.D., et al., *Proc. ODP, Init. Repts.,* 178, 1–83 [CD-ROM]. Available from: Ocean Drilling Program, Texas A&M University, College Station, TX 77845-9547, U.S.A.

Table T1. Trace element composition of USGS rock powders from INAA analyses.

USGS standard rock powder	Sc (µg/g)	Cr (µg/g)	Fe (mg/g)	Co (µg/g)	Zn (µg/g)	As (µg/g)	Rb (µg/g)	Sr (µg/g)	Sb (µg/g)	Cs (µg/g)	Ba (µg/g)	La (µg/g)	Ce (µg/g)	Sm (µg/g)	Eu (µg/g)	Tb (µg/g)	Yb (µg/g)	Lu (µg/g)	Hf (µg/g)	Ta (µg/g)	Th (µg/g)
BHVO-1 basalt	32.7	284	84.7	45.1	109	0.4	16	420	0.18	<0.6	128	16.5	36	6.02	2.36	0.86	1.95	0.27	—	—	1.2
BHVO-1 basalt	31.5	288	88.3	45.2	115	<1	10	446	0.16	<0.3	143	15.9	34	6.00	2.04	0.83	1.91	0.26	4.4	1.22	1.3
BHVO-1 basalt	31.5	306	87.4	46.1	103	0.6	15	474	0.15	<0.3	151	16.0	40	6.21	2.27	0.94	1.92	0.28	4.3	1.02	1.3
BHVO-1 recommended	31.8	289	85.5	45	105	0.4	11	403	0.16	0.13	139	15.8	39	6.2	2.06	0.96	2.02	0.291	4.38	1.23	1.1
G-2 granite	3.5	8	18.7	5.5	86	<0.9	173	465	0.14	1.31	1927	96.6	152	7.40	1.52	0.60	0.75	0.11	7.6	0.76	25.8
G-2 granite	3.3	8	18.2	5.2	78	<0.6	167	496	0.1	1.34	1856	87.4	142	7.11	1.28	0.48	0.69	0.09	7.8	0.76	25.0
G-2 granite	3.3	7	18.4	5.2	77	<0.6	169	488	0.096	1.34	1848	90.6	165	7.41	1.46	0.45	0.75	0.11	7.9	0.85	24.9
G-2 recommended	3.5	9	18.6	4.6	86	0.25	170	478	0.07	1.34	1882	89	160	7.2	1.4	0.48	0.8	0.11	7.9	0.88	24.7

Notes: recommended values for BHVO-1 basalt and G-2 granite are given by Govindaraju (1989). — = no data.

Table T2. Trace element composition from INAA analyses of bulk sediment samples, Site 1095.

Core, section, interval (cm)	Depth (mbsf)	Sc (μg/g)	Cr (μg/g)	Fe (mg/g)	Co (μg/g)	Zn (μg/g)	As (μg/g)	Rb (μg/g)	Sr (μg/g)	Sb (μg/g)	Cs (μg/g)	Ba (μg/g)	La (μg/g)	Ce (μg/g)	Sm (μg/g)	Eu (μg/g)	Tb (μg/g)	Yb (μg/g)	Lu (μg/g)	Hf (μg/g)	Ta (μg/g)	Th (μg/g)
178-1095A-																						
1H-3, 59-61	3.52	18.9	55	49.8	17.1	113	4.7	105	261	0.55	5.30	621	24.9	48	5.14	1.20	0.90	2.45	0.38	4.3	0.66	9.6
1H-4, 87-89	5.30	18.1	49	44.9	28.8	100	5.3	86	251	0.72	4.22	1357	21.2	45	4.44	1.09	0.69	2.15	0.33	3.6	0.66	7.8
3H-6, 99-101	17.77	17.9	49	44.4	15.1	103	5.0	85	268	0.40	4.42	930	24.2	48	5.06	1.19	0.78	2.27	0.37	5.2	0.67	8.6
3H-8, 13-15	19.12	19.5	59	53.2	19.5	119	9.9	114	259	0.58	5.76	606	26.3	50	5.57	1.25	0.86	2.56	0.41	4.4	0.69	10.0
4H-2, 83-85	23.13	19.1	55	50.1	17.7	117	4.0	101	261	0.68	5.24	521	26.1	50	5.55	1.27	0.84	2.52	0.40	4.1	0.64	9.8
4H-5, 85-88	27.65	19.2	56	50.1	18.4	118	4.9	88	225	0.46	4.97	977	23.8	47	5.06	1.21	0.79	2.31	0.35	3.9	0.67	8.9
7H-1, 58-61	49.88	17.7	44	44.9	13.7	97	5.5	93	297	0.45	4.46	411	21.8	41	4.77	1.12	0.73	2.28	0.36	3.6	0.48	7.7
7H-2, 51-54	51.31	18.2	53	47.1	15.2	107	3.3	96	230	0.67	4.98	515	24.4	46	5.26	1.19	0.80	2.46	0.36	4.1	0.57	9.0
178-1095B-																						
1H-5, 20-22	89.20	14.3	38	35.7	9.2	74	1.7	76	271	0.34	3.56	731	21.8	41	4.45	0.99	0.69	1.99	0.31	4.4	0.55	7.4
5H-5, 128-130	128.30	14.6	42	35.8	10.9	84	4.1	73	200	0.30	3.28	419	18.7	35	4.12	0.92	0.65	1.94	0.31	3.0	0.48	7.2
9H-3, 18-19	162.20	14.3	41	36.5	11.3	85	3.2	72	275	0.32	3.35	605	19.3	37	4.26	0.93	0.68	1.95	0.31	3.1	0.47	7.7
9H-5, 39-41	165.40	11.4	41	52.1	9.7	77	2.2	102	148	0.45	5.20	404	17.9	33	3.60	0.73	0.55	1.57	0.23	2.6	0.52	8.3
13H-3, 64-66	199.60	17.4	51	41.7	11.8	103	3.1	92	187	0.34	3.29	483	22.1	43	4.71	1.18	0.76	2.14	0.35	3.1	0.45	8.4
18X-3, 128-130	247.80	18.0	49	43.6	12.8	110	3.7	85	201	0.31	3.34	432	20.8	42	4.48	1.14	0.75	2.09	0.34	3.0	0.41	8.0
21X-2, 124-126	275.10	17.2	47	42.9	12.4	111	7.3	92	211	0.35	3.33	595	23.8	46	4.81	1.21	0.78	2.31	0.37	3.0	0.42	9.1
23X-3, 34-36	295.00	16.1	49	40.0	11.8	103	9.5	91	290	0.28	2.74	460	21.6	43	4.56	1.12	0.71	1.97	0.35	3.1	0.40	7.9
25X-2, 35-37	312.80	16.6	46	42.3	12.4	106	6.3	85	267	0.29	3.04	459	21.0	41	4.44	1.13	0.72	2.18	0.36	2.9	0.40	8.2
29X-4, 71-73	354.30	15.5	43	36.6	10.6	91	5.7	72	276	0.39	2.34	453	20.9	40	4.52	1.16	0.70	1.99	0.32	3.3	0.44	7.1
33X-3, 71-73	391.40	16.4	47	40.9	10.5	90	4.9	88	246	0.17	3.52	454	22.3	43	4.70	1.14	0.70	2.16	0.36	2.8	0.42	8.1
33X-3, 45-48	427.80	16.4	43	43.1	10.5	142	1.4	86	217	0.35	3.28	423	22.3	43	4.84	1.23	0.76	2.14	0.35	4.2	0.42	7.5
41X-3, 101-104	468.50	18.3	50	46.0	12.9	114	7.7	85	246	0.33	3.35	471	22.8	43	4.95	1.20	0.75	2.37	0.36	3.3	0.40	7.9
45X-1, 90-92	498.90	17.6	49	42.8	11.2	95	5.0	84	211	0.33	3.28	494	23.4	43	4.98	1.26	0.77	2.46	0.40	3.2	0.47	7.8

Table T3. Trace element composition from INAA analyses of bulk sediment samples, Site 1096.

Core, section, interval (cm)	Depth (mbsf)	Sc (µg/g)	Cr (µg/g)	Fe (mg/g)	Co (µg/g)	Zn (µg/g)	As (µg/g)	Rb (µg/g)	Sr (µg/g)	Sb (µg/g)	Cs (µg/g)	Ba (µg/g)	La (µg/g)	Ce (µg/g)	Sm (µg/g)	Eu (µg/g)	Tb (µg/g)	Yb (µg/g)	Lu (µg/g)	Hf (µg/g)	Ta (µg/g)	Th (µg/g)
178-1096A-																						
3H-3, 15-17	20.35	20.0	55	47.9	16.3	127	4.2	88	210	0.37	3.52	1420	23.8	48	4.92	1.24	0.73	2.46	0.37	3.6	0.58	7.9
3H-4, 110-112	22.80	20.1	56	49.3	15.9	129	3.6	101	237	0.60	4.03	540	26.6	51	5.58	1.37	0.82	2.56	0.41	3.8	0.52	9.3
5H-4, 85-87	41.55	19.5	59	48.8	15.0	122	8.8	106	226	0.59	4.10	553	27.0	52	5.55	1.32	0.83	2.30	0.39	3.7	0.53	9.6
7H-2, 49-52	57.19	19.8	67	49.7	16.3	130	6.0	131	263	0.76	5.24	715	32.9	61	6.36	1.47	0.86	2.80	0.42	4.1	0.66	11.6
9H-5, 46-47	79.44	20.2	61	49.6	17.1	139	5.3	125	222	0.95	5.23	680	31.2	58	6.24	1.45	0.97	2.85	0.45	4.0	0.66	11.3

Table T4. Trace element composition from INAA analyses of bulk sediment samples, Site 1101.

Core, section, interval (cm)	Depth (mbsf)	Sc (µg/g)	Cr (µg/g)	Fe (mg/g)	Co (µg/g)	Zn (µg/g)	As (µg/g)	Rb (µg/g)	Sr (µg/g)	Sb (µg/g)	Cs (µg/g)	Ba (µg/g)	La (µg/g)	Ce (µg/g)	Sm (µg/g)	Eu (µg/g)	Tb (µg/g)	Yb (µg/g)	Lu (µg/g)	Hf (µg/g)	Ta (µg/g)	Th (µg/g)
178-1101A-																						
10H-2, 14-16	77.84	19.4	46	46.1	14.0	108	2.8	79	241	0.33	3.54	362	18.8	41	4.73	1.22	0.87	2.62	0.41	3.4	0.46	6.5
10H-2, 86-88	78.56	20.3	64	47.0	17.5	99	3.6	70	319	0.34	3.33	448	18.3	40	4.65	1.24	0.84	2.41	0.37	3.2	0.47	6.1
10H-3, 40-42	79.60	18.7	56	43.4	16.3	88	2.9	61	273	0.34	2.91	467	18.1	39	4.46	1.19	0.81	2.23	0.37	3.2	0.43	5.7
10H-3, 86-88	80.06	16.7	54	38.3	14.8	83	3.6	58	353	0.36	2.98	558	17.6	38	4.18	1.10	0.73	2.01	0.31	3.0	0.44	5.7
10H-3, 118-120	80.38	15.0	48	35.6	12.2	80	1.7	46	454	0.25	2.63	689	15.1	32	3.76	1.03	0.62	1.95	0.32	3.1	0.34	4.5
10H-3, 141-143	80.61	13.9	44	33.8	10.9	76	1.9	51	475	0.21	2.74	686	15.3	33	3.60	0.97	0.64	1.79	0.27	2.7	0.40	4.7
10H-4, 15-17	80.85	16.0	50	39.4	12.8	90	2.1	68	331	0.22	3.16	644	18.6	40	4.12	1.07	0.73	2.15	0.33	3.2	0.42	5.9
10H-4, 40-42	81.10	18.8	55	49.2	18.9	96	9.5	72	264	0.33	3.56	462	19.6	42	4.69	1.21	0.81	2.34	0.37	3.6	0.45	6.5
10H-4, 64-66	81.34	18.7	53	47.6	14.6	90	2.4	74	255	0.44	3.54	457	19.6	43	4.66	1.20	0.83	2.27	0.36	3.6	0.54	6.6
10H-4, 77-79	81.47	19.7	61	50.9	17.8	102	4.0	57	382	0.23	2.96	344	17.4	37	4.41	1.21	0.72	2.33	0.38	3.1	0.45	5.1
10H-4, 101-103	81.71	18.0	45	46.8	14.7	99	2.5	74	270	0.27	3.30	339	17.7	39	4.48	1.15	0.81	2.46	0.37	3.3	0.41	6.1
10H-4, 129-131	81.99	20.2	60	46.0	17.0	98	2.2	69	273	0.71	3.49	359	18.9	40	4.77	1.27	0.80	2.62	0.39	3.3	0.45	5.9

Table T5. Major element composition obtained by electron microprobe analyses of fused beads, Site 1095.

Core, section, interval (cm)	Depth (mbsf)	LOI (wt%)	SiO_2 (wt%)	TiO_2 (wt%)	Al_2O_3 (wt%)	FeO (wt%)	MnO (wt%)	MgO (wt%)	CaO (wt%)	Na_2O (wt%)	K_2O (wt%)	P_2O_5 (wt%)	Total (wt%)
178-1095A-													
1H-3, 59-61	3.52	3.95	60.75	1.02	18.71	6.76	0.16	3.36	3.03	2.14	2.90	0.20	99.03
1H-4, 87-89	5.30	4.22	67.13	0.86	15.91	5.63	0.40	2.71	3.02	2.32	2.32	0.15	100.44
3H-6, 99-101	17.77	3.37	65.74	0.94	17.20	5.10	0.12	2.71	2.83	1.82	2.44	0.18	99.08
3H-8, 13-15	19.12	3.55	65.42	0.96	18.19	6.21	0.15	2.97	2.61	2.01	2.46	0.16	101.14
4H-2, 83-85	23.13	4.41	62.98	0.85	18.44	6.43	0.11	3.10	2.65	2.71	3.29	0.23	100.79
4H-5, 85-88	27.65	5.13	63.27	0.96	16.75	6.74	0.15	3.31	3.29	2.67	2.83	0.20	100.19
7H-1, 58-61	49.88	4.35	63.31	0.81	16.83	6.47	0.13	2.86	3.27	2.87	2.88	0.74	100.17
7H-2, 51-54	51.31	3.97	62.97	0.85	18.06	6.74	0.13	3.07	2.55	2.62	3.15	0.23	100.38
178-1095B-													
1H-5, 20-22	89.20	3.31	71.58	0.76	14.84	4.45	0.08	2.06	2.30	2.51	2.22	0.12	100.91
5H-5, 128-130	128.30	3.98	71.03	0.69	14.94	4.84	0.14	2.47	2.28	2.48	2.27	0.17	101.31
9H-3, 18-19	162.20	3.77	70.32	0.64	14.10	5.03	0.08	2.50	2.44	2.81	2.44	0.19	100.55
9H-5, 39-41	165.40	4.55	70.64	0.57	12.32	6.62	0.08	2.46	1.54	2.03	2.85	0.12	99.24
13H-3, 64-66	199.60	3.87	67.71	0.84	16.76	5.33	0.13	2.84	2.74	1.91	1.85	0.13	100.24
18X-3, 128-130	247.80	4.12	64.39	0.87	16.60	6.24	0.13	3.26	2.52	2.87	2.71	0.23	99.81
21X-2, 124-126	275.10	2.83	66.19	0.76	16.00	5.53	0.12	2.71	2.64	3.04	2.73	0.22	99.94
23X-3, 34-36	295.00	3.47	68.42	0.74	15.42	5.32	0.09	2.46	2.91	1.54	2.25	0.19	99.34
25X-2, 35-37	312.80	3.62	66.95	0.77	15.97	5.78	0.13	2.73	2.91	2.93	2.38	0.20	100.75
29X-4, 71-73	354.30	3.24	67.25	0.80	15.76	5.28	0.09	2.37	3.06	2.90	2.19	0.18	99.88
33X-3, 71-73	391.40	3.87	66.59	0.80	15.79	5.74	0.12	2.61	2.64	2.58	2.45	0.25	99.58
33X-3, 45-48	427.80	3.38	67.56	0.78	15.28	5.78	0.09	2.37	2.77	2.31	2.38	0.21	99.54
41X-3, 101-104	468.50	4.11	65.26	0.81	16.20	6.05	0.13	2.82	2.89	2.53	2.38	0.30	99.38
45X-1, 90-92	498.90	3.56	65.96	0.83	16.15	5.80	0.12	2.65	2.88	2.62	2.28	0.23	99.51

Table T6. Major element composition obtained by electron microprobe analyses of fused beads, Site 1096.

Core, section, interval (cm)	Depth (mbsf)	LOI (wt%)	SiO_2 (wt%)	TiO_2 (wt%)	Al_2O_3 (wt%)	FeO (wt%)	MnO (wt%)	MgO (wt%)	CaO (wt%)	Na_2O (wt%)	K_2O (wt%)	P_2O_5 (wt%)	Total (wt%)
178-1096A-													
3H-3, 15-17	20.35	3.53	64.59	0.93	16.02	6.20	0.12	3.13	3.13	2.40	2.70	0.24	99.46
3H-4, 110-112	22.80	4.04	61.11	0.96	17.34	7.05	0.14	3.35	3.00	2.77	2.86	0.24	98.81
5H-4, 85-87	41.55	4.10	62.39	0.96	18.13	6.59	0.15	3.19	3.10	2.23	2.65	0.11	99.51
7H-2, 49-52	57.19	3.58	62.62	0.85	18.79	5.66	0.20	2.78	2.34	2.73	3.65	0.20	99.83
14H-3, 60-63	125.30	4.29	61.71	0.90	18.67	7.03	0.13	3.20	2.33	2.18	2.85	0.16	99.15
178-1096B-													
1H-2, 136-139	2.86	3.84	63.11	0.80	18.01	6.86	0.12	3.08	2.45	2.52	2.90	0.21	100.05
13H-4, 66-68	113.46	4.74	60.94	0.87	18.69	6.92	0.13	3.34	2.83	2.51	2.84	0.23	99.29
19H-2, 80-83	153.00	4.04	62.32	0.79	18.40	6.23	0.18	3.09	2.59	2.50	2.86	0.12	99.09
27X-2, 109-111	215.09	5.30	64.71	0.86	17.16	7.05	0.10	3.21	2.60	3.20	2.91	0.19	101.98
27X-4, 37-39	217.37	4.48	64.99	0.90	16.69	6.28	0.11	2.86	2.08	2.67	3.10	0.17	99.87
30X-3, 64-68	244.94	3.86	66.79	0.74	15.88	5.62	0.11	2.72	2.35	2.50	2.70	0.17	99.57
178-1096C-													
2H-4, 90-91	172.40	5.36	61.39	0.79	17.57	6.68	0.14	3.18	2.93	2.79	2.88	0.17	98.53
5X-3, 65-67	215.85	4.27	65.96	0.82	15.84	6.22	0.08	2.55	2.15	2.43	2.73	0.16	98.93
8X-3, 14-16	264.04	3.98	66.88	0.77	15.77	5.93	0.11	2.66	2.48	2.55	2.62	0.19	99.96
11X-3, 91-93	293.51	4.42	66.72	0.76	16.22	5.64	0.10	2.71	2.43	2.32	2.46	0.19	99.55
14X-5, 87-89	324.26	3.98	68.77	0.75	15.71	5.08	0.13	2.55	2.49	1.89	1.99	0.15	99.50
17X-2, 83-85	349.83	4.02	68.05	0.73	14.80	5.40	0.10	2.70	2.58	2.12	2.26	0.19	98.94
20X-1, 102-104	377.62	4.53	73.97	0.60	12.66	4.51	0.10	2.27	2.13	2.00	1.98	0.16	100.39
23X-5, 67-70	412.17	4.31	68.34	0.74	14.54	5.54	0.11	2.77	2.68	2.39	2.24	0.17	99.50
26X-1 58-59	434.98	4.56	68.27	0.69	14.06	6.20	0.10	2.47	2.41	2.03	2.26	0.17	98.67
29X-2, 115-117	465.85	4.43	69.29	0.70	13.90	5.37	0.09	2.43	2.52	1.50	2.27	0.14	98.21
32X-3, 132-134	496.42	4.14	69.99	0.68	13.92	5.11	0.11	2.60	2.53	2.40	2.05	0.21	99.59
35X-3, 69-71	524.69	4.24	70.02	0.70	14.03	5.33	0.11	2.69	2.81	2.44	1.97	0.18	100.27
38X-3, 66-69	553.76	4.34	74.47	0.63	12.59	4.70	0.06	2.12	2.25	2.33	2.00	0.13	101.30
40X-1, 87-89	570.27	4.40	69.55	0.67	13.75	5.35	0.14	2.62	2.95	2.50	2.29	0.18	100.00

Table T7. Major element composition obtained by electron microprobe analyses of fused beads, Site 1097.

Core, section, interval (cm)	Depth (mbsf)	LOI (wt%)	SiO_2 (wt%)	TiO_2 (wt%)	Al_2O_3 (wt%)	FeO (wt%)	MnO (wt%)	MgO (wt%)	CaO (wt%)	Na_2O (wt%)	K_2O (wt%)	P_2O_5 (wt%)	Total (wt%)
178-1097A-													
9R-1, 6-10	72.86	3.05	64.44	0.80	16.53	5.79	0.12	2.61	4.21	3.43	1.93	0.23	100.08
27R-1, 101-102	218.31	5.03	66.81	0.85	14.80	6.06	0.16	2.99	3.98	2.38	1.81	0.15	99.99
35R-1, 142-144	295.32	2.83	68.96	0.73	14.86	4.46	0.09	2.13	4.25	2.48	1.45	0.15	99.55
44R-1, 98-100	362.18	2.66	67.80	0.76	15.98	4.89	0.10	2.19	4.81	2.25	1.28	0.37	100.44

Table T8. Major element composition obtained by electron microprobe analyses of fused beads, Site 1101.

Core, section, interval (cm)	Depth (mbsf)	LOI (wt%)	SiO_2 (wt%)	TiO_2 (wt%)	Al_2O_3 (wt%)	FeO (wt%)	MnO (wt%)	MgO (wt%)	CaO (wt%)	Na_2O (wt%)	K_2O (wt%)	P_2O_5 (wt%)	Total (wt%)
178-1101A-													
10H-2, 14-16	77.84	4.52	64.39	0.86	16.42	6.23	0.12	3.05	2.97	3.07	2.47	0.38	99.98
10H-2, 86-88	78.56	4.38	63.67	0.98	16.59	6.38	0.14	3.25	4.09	3.32	1.97	0.44	100.83
10H-3, 40-42	79.60	4.73	62.93	0.94	16.22	6.02	0.13	3.01	4.95	2.77	1.79	0.40	99.16
10H-3, 86-88	80.06	8.05	65.06	0.94	16.71	5.42	0.12	2.91	4.98	2.04	1.29	0.14	99.60
10H-3, 118-120	80.38	14.56	55.21	0.88	13.91	5.64	0.37	2.79	17.78	1.72	0.62	0.17	99.08
10H-3, 141-143	80.61	14.73	55.87	0.84	13.78	5.40	0.41	2.71	18.02	1.96	0.70	0.07	99.75
10H-4, 15-17	80.85	9.85	60.34	0.84	14.79	5.94	0.21	3.00	10.57	2.49	1.41	0.11	99.70
10H-4, 40-42	81.10	4.63	63.27	0.89	15.65	6.73	0.12	3.09	3.71	3.35	2.21	0.16	99.19
10H-4, 64-66	81.34	4.58	61.08	1.02	16.21	6.50	0.15	3.24	4.67	3.59	2.29	0.21	98.97
10H-4, 77-79	81.47	4.93	60.11	1.04	16.53	7.15	0.15	3.77	5.61	2.98	1.39	0.47	99.21
10H-4, 101-103	81.71	4.45	64.09	0.85	15.88	6.50	0.10	3.03	2.66	3.39	2.41	0.16	99.07
10H-4, 129-131	81.99	4.81	62.79	1.03	16.42	6.38	0.13	3.44	3.37	3.54	2.25	0.19	99.53
17X-2, 60-62	144.80	4.52	63.75	0.92	15.87	6.18	0.12	2.99	3.27	3.67	2.12	0.17	99.05
17X-4, 60-62	147.80	4.49	63.57	0.96	16.28	6.69	0.18	3.60	2.93	2.97	2.24	0.16	99.58
20X-5, 128-140	176.98	4.37	64.54	0.98	16.52	6.77	0.13	3.10	2.89	2.03	2.49	0.21	99.65
20X-6, 138-140	178.58	4.90	64.06	1.02	16.98	6.83	0.11	3.39	3.41	1.88	1.83	0.14	99.65