

# 11. DATA REPORT: SUMMARY OF REVISED ALTERATION PHASES FOR PACMANUS HYDROTHERMAL FIELD—X-RAY DIFFRACTION ANALYSES OF ALTERED FELSIC VOLCANIC ROCKS FROM HOLES 1188A, 1188F, 1189A, AND 1189B<sup>1</sup>

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## ABSTRACT

Postcruise X-ray diffraction (XRD) data for 95 whole-rock samples from Holes 1188A, 1188F, 1189A, and 1189B are presented. The samples represent alteration types recovered during Leg 193. The data set is incorporated into the shipboard XRD data set.

Based on the newly obtained XRD data, distribution of alteration phases were redrawn for Ocean Drilling Program Sites 1188 and 1189.

## INTRODUCTION

During Ocean Drilling Program (ODP) Leg 193, a series of holes was drilled in the PACMANUS hydrothermal field in the Manus Basin to characterize the volcanic architecture, structural and hydrologic properties, and mineralization and alteration patterns of a felsic-hosted hydrothermal system. The goals were to better understand factors that govern the nature and location of mineral deposition, to seek evidence concerning fluid and metal sources, and to investigate subsurface microbial life (Binns, Barriga, Miller, et al., 2002).

The Manus Basin in the eastern Bismarck Sea is a fast-opening (~10 cm/yr) backarc basin bound by the inactive Manus Trench to the north

<sup>1</sup>Lackschewitz, K.S., Asada, R., and Paulick, H., 2006. Data report: Summary of revised alteration phases for PACMANUS hydrothermal field—X-ray diffraction analyses of altered felsic volcanic rocks from Holes 1188A, 1188F, 1189A, and 1189B. *In* Barriga, F.J.A.S., Binns, R.A., Miller, D.J., and Herzig, P.M. (Eds.), *Proc. ODP, Sci. Results*, 193, 1–19 [Online]. Available from World Wide Web: <[http://www-odp.tamu.edu/publications/193\\_SR/VOLUME/CHAPTERS/213.PDF](http://www-odp.tamu.edu/publications/193_SR/VOLUME/CHAPTERS/213.PDF)>. [Cited YYYY-MM-DD]

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and the active New Britain Trench to the south (Fig. F1). The eastern Manus Basin is characterized by a series of isolated hydrothermal fields including the PACMANUS hydrothermal field located near the crest of the 500- to 700-m-high Pual Ridge.

In this report we present the results of postcruise X-ray diffraction analyses of whole-rock samples from two sites analyzed by three different principal investigators. The sites can be separated into two groups based on their geographic locality. Site 1188 was drilled in the Snowcap hydrothermal site, representing a diffuse venting area, and Site 1189 was drilled in the Roman Ruins site, containing numerous actively high-temperature venting chimneys (Fig. F2). Hydrothermal alteration varies with depth and is complicated by overprinting relationships. The main alteration features are summarized in Binns, Barriga, Miller, et al. (2002).

## METHODS

Samples analyzed in this study are from Holes 1188A and 1188F at Snowcap and 1189A and 1189B at Roman Ruins.

After air-drying, whole-rock mineralogy was determined by X-ray diffractometry. For mineral identification of powdered samples from principal investigator K. Lackschewitz, a Philips X-ray diffractometer PW 1710 with monochromatic  $\text{CuK}\alpha$  was used. Qualitative phase identification was performed using MacDiff software (version 4.2.5) from R. Petschick ([servermac.geologie.uni-frankfurt.de/Staff/Homepages/Petschick/RainerE.html](http://servermac.geologie.uni-frankfurt.de/Staff/Homepages/Petschick/RainerE.html)).

Another set of air-dried powdered samples from principal investigator H. Paulick was analyzed at the XRD Laboratory of the Mineralogical Institute, Freiberg University of Mining and Technology (Germany). Here, a Seifert-Freiburger Präzisionsmechanik GmbH RD7 instrument was used to generate X-ray diffractograms applying monochromatic  $\text{CuK}\alpha$  radiation. Qualitative phase identification was performed using Seifert-Analyze software.

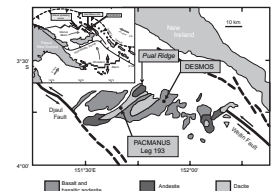
Principal investigator R. Asada analyzed microbiological rock samples for mineral composition. Mineralogical properties were analyzed by a Rigaku RINT2200 X-ray diffractometer with  $\text{CuK}\alpha$  generated at 40 kV and 30 mA. After air-drying the sample, the powders were pressed to fit the diffractometer sample holder. On the other hand, the XRD profiles of clay minerals were obtained from clay fractions deposited on glass slides in order. Furthermore, a fine mist of ethylene glycol (15% in water) was sprayed on dry clay fractions for supplemental information about clay mineral identification.

## RESULTS

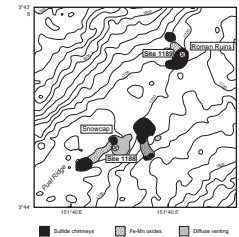
Bulk mineralogical analyses were compiled for two sites drilled during Leg 193. These results are shown for the Snowcap diffuse venting area (Site 1188) and the Roman Ruins high-temperature area (Site 1189) in Figures F3 and F4, respectively. In addition, data for both sites are shown in Tables T1, T2, T3, and T4.

With the exception of fresh glassy rhyodacite and dacite near the seafloor, hydrothermal alteration is ubiquitous in the subsurface at Snowcap and Roman Ruins (Binns, Barriga, Miller, et al., 2002). Hydrothermal alteration is complex and multistage and includes pervasive re-

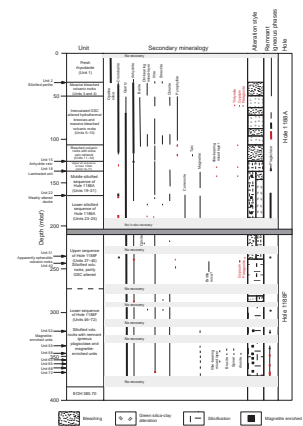
F1. Seafloor geology, p. 5.



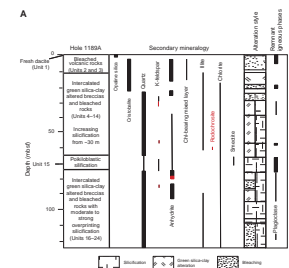
F2. Distribution of hydrothermal deposits, p. 6.



F3. Alteration, Site 1188, p. 7.



F4. Alteration, Holes 1189A and 1189B, p. 8.



T1. Identified minerals, Hole 1188A, p. 10.

T2. Identified minerals, Hole 1188F, p. 13.

placement of igneous material and alteration halos along anhydrite  $\pm$  pyrite  $\pm$  quartz veins. Mineral assemblages arising from hydrothermal alteration vary with depth and are complicated by overprinting relationships. At both sites, rocks are highly to completely altered to cristobalite and/or quartz, clay minerals (e.g., illite, chlorite, smectite, and mixed layers), anhydrite, and disseminated pyrite. In Hole 1188A a zone from ~50 to 120 mbsf is characterized by a chlorite  $\pm$  illite-cristobalite-plagioclase assemblage intercalated with a pyrophyllite assemblage (Fig. F3). A lower sequence below 120 mbsf in Hole 1189B comprises hydrothermal alteration features (Fig. F4B) that are distinctly different from those encountered at Snowcap (Site 1188). K-feldspar is abundant, and magnetite is rare. K-feldspar appears to be associated with quartz-chlorite alteration, which alternates with less strongly altered cristobalite-bearing rocks in the lower portion of Hole 1189B. A detailed description on clay mineral assemblages, clay and whole rock chemistry, and clay mineral isotopic compositions of the altered rocks from both sites is given in Lackschewitz et al. (2004).

## ACKNOWLEDGMENTS

We thank R. Fonseca and F. Barriga for their helpful reviews. This research used samples and/or data provided by the Ocean Drilling Program (ODP). ODP is sponsored by the U.S. National Science Foundation (NSF) and participating countries under management of Joint Oceanographic Institutions (JOI), Inc. Funding for this research was provided by postcruise research grants to K. Lackschewitz and H. Paulick from the Deutsche Forschungsgemeinschaft.

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T3. Identified minerals, Hole 1189A, p. 16.

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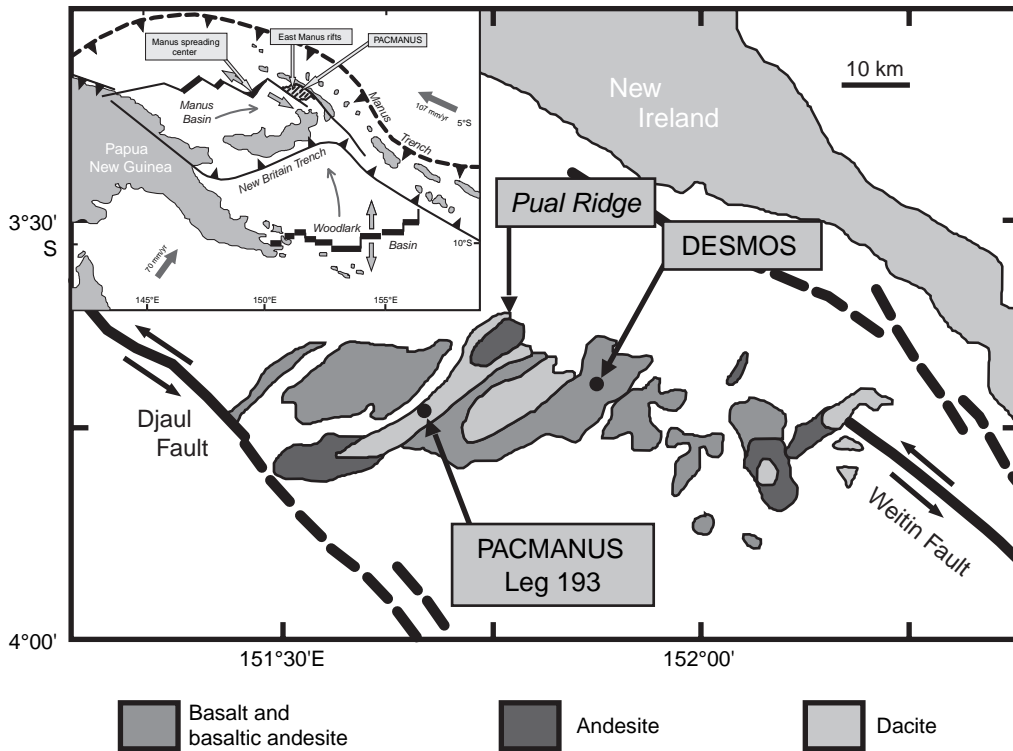
T4. Identified minerals, Hole 1189B, p. 18.

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**Figure F1.** Seafloor geology of the eastern Manus Basin. East-northeast-trending neovolcanic edifices, extending between the active ends of the Djaul and Weitin transform faults, have yielded lavas ranging from picritic basalt to rhyodacite in composition (modified after Binns, Barriga, Miller, et al., 2002). Inset shows the regional tectonic setting of the PACMANUS hydrothermal site in the eastern Manus Basin. PACMANUS lies in the eastern Manus Rift zone, a pull-apart structure between two major transform faults (modified after Binns, Barriga, Miller, et al., 2002).



**Figure F2.** Distribution of hydrothermal deposits within the PACMANUS field along the crest of Pual Ridge and location of ODP Leg 193 drill hole sites. The map is based on bottom-tow photography and submersible dive observations from several PACMANUS cruises (modified after Binns, Barriga, Miller, et al., 2002).

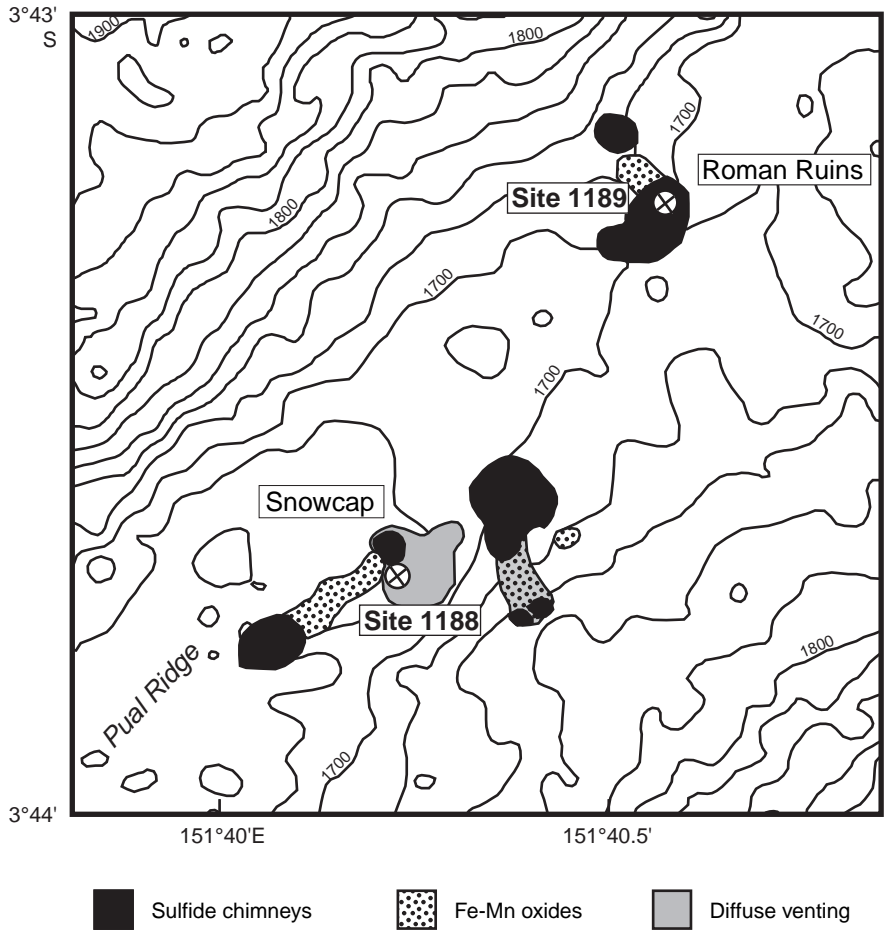
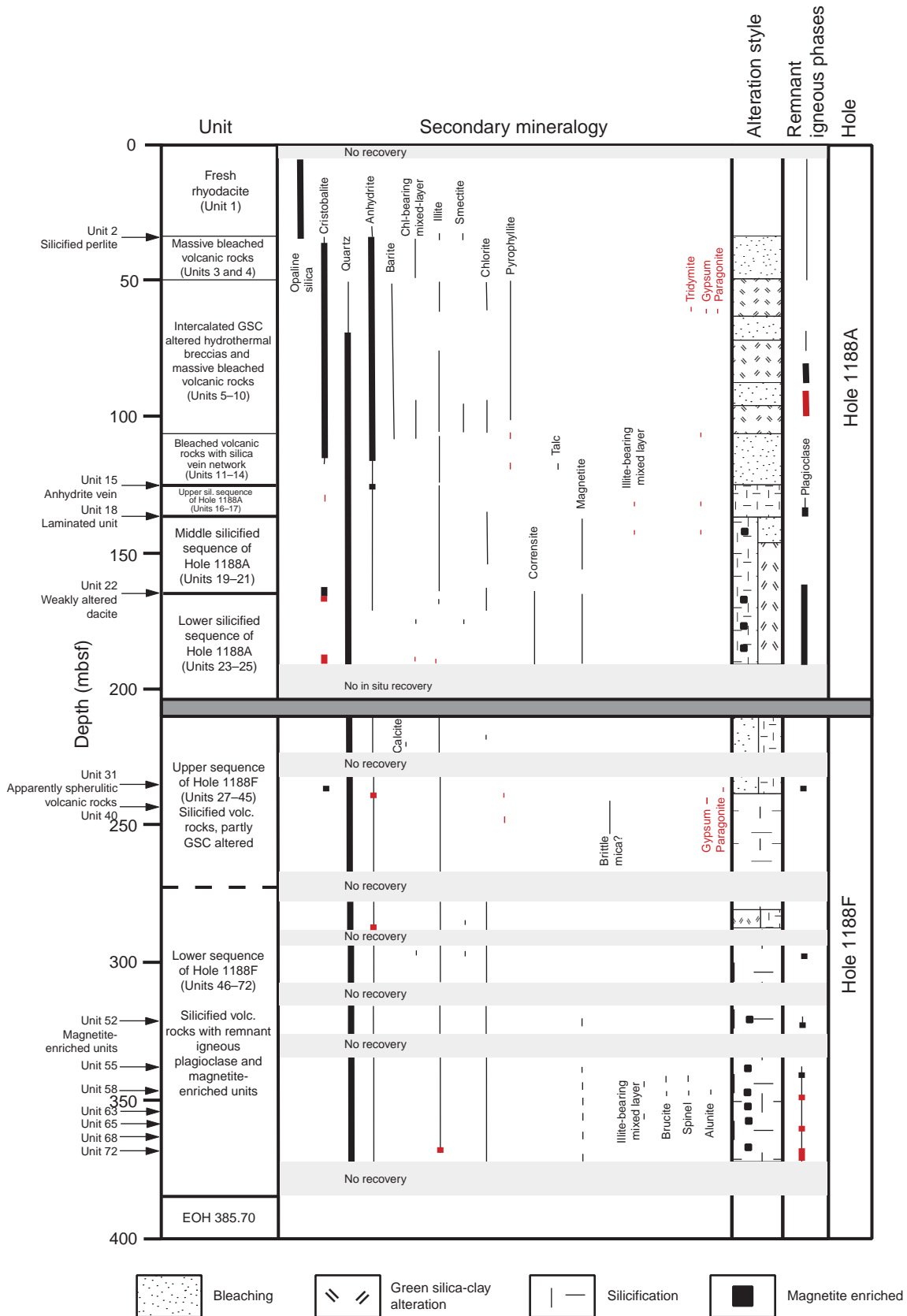


Figure F3. Summary of lithostratigraphic units, alteration style, and distribution of alteration phases at Site 1188, as a revision of fig. F16 in Shipboard Scientific Party (2002). Revised and newly obtained alteration phases are shown in red bars or lines. GSC = green silica clay, EOH = end of hole.



**Figure F4.** Summary of lithostratigraphic units, alteration style, and distribution of alteration phases as a revision of fig. F29 in Shipboard Scientific Party (2002). Revised and newly obtained alteration phases are shown in red bars or lines. **A.** Hole 1189A. (Continued on next page.)

**A**

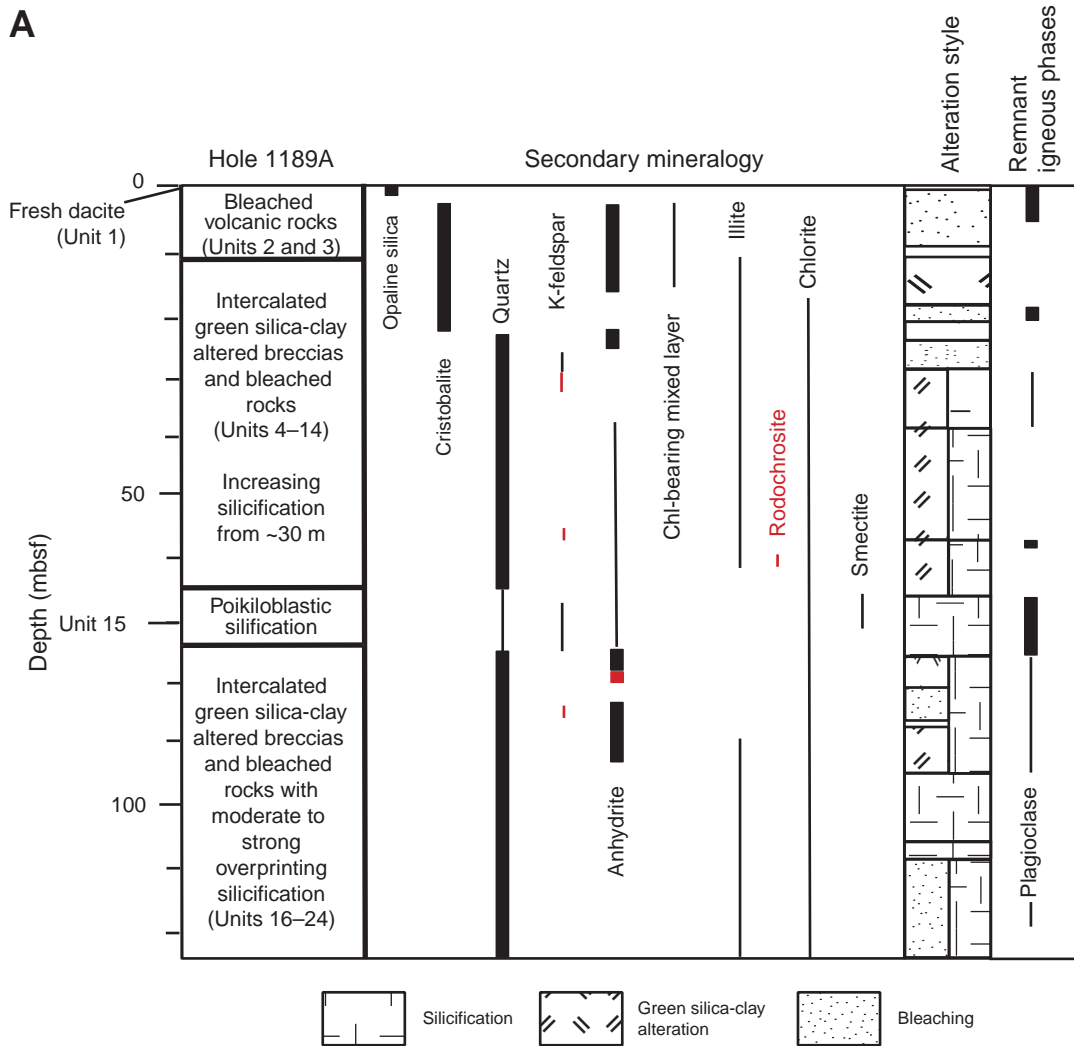




Figure F4 (continued). B. Hole 1189B.

**B**

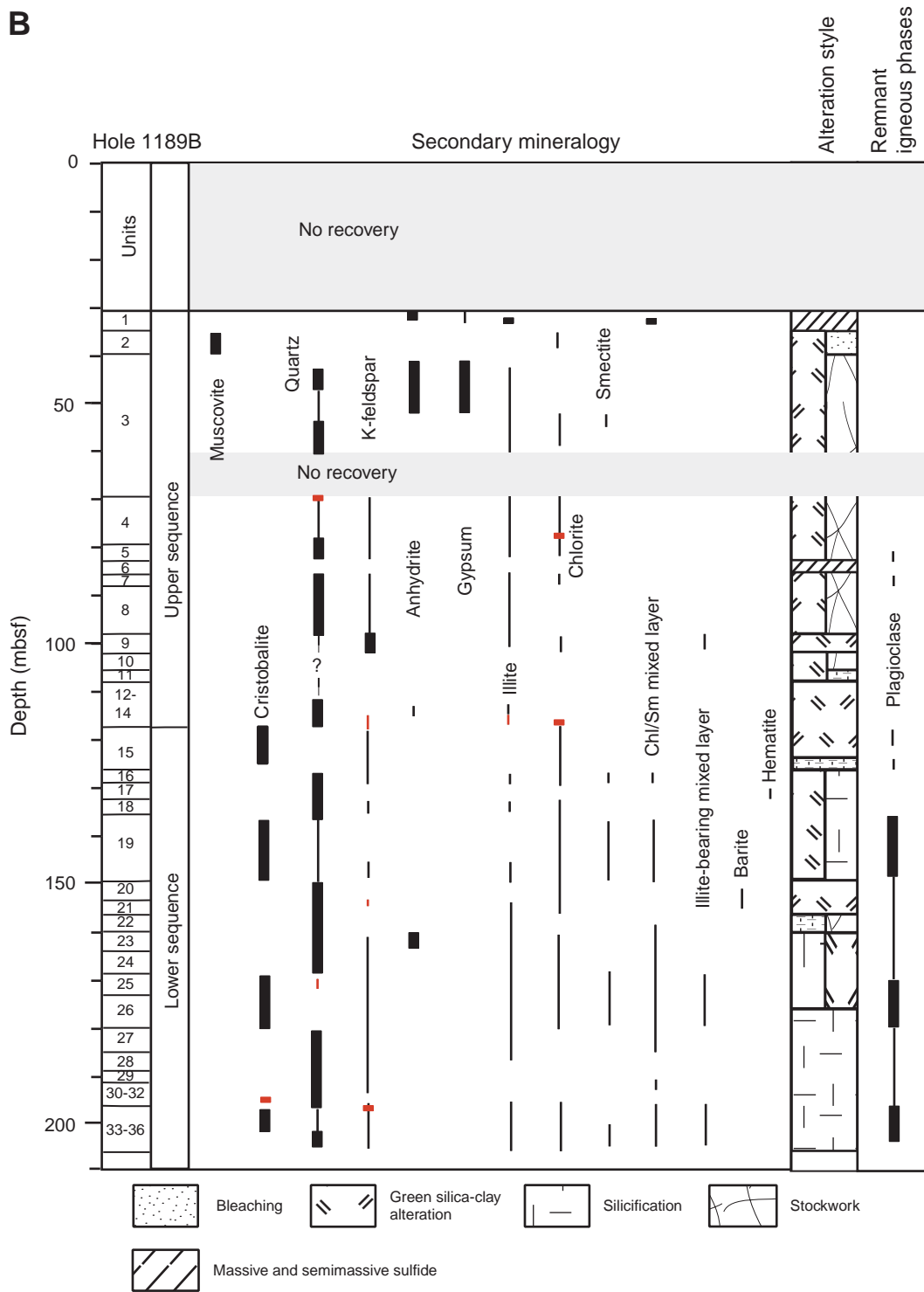


Table T1. Minerals identified in altered whole rocks by XRD analysis, Hole 1188A. (See table notes. Continued on next two pages.)

Core, section, interval (cm)	Depth (mbsf)	Unit	Lab	Description	XRD identification
193-1188A-					
2R-1, 9–12	9.69	1	SBD	Moderately vesicular rhyodacite	Opaline silica, plagioclase (augite, smectite)
5R-1, 17–21	33.80	2	RA	Sparsely plagioclase-phyric, moderately vesicular, rhyodacite	Opaline silica, plagioclase (cristobalite)
5R-1, 38–40	33.97	2	HP	Completely altered aphyric volcanic rock with perlitic texture; cores of perlite	Opaline silica/volcanic glass
5R-1, 38–40	33.97	2	HP	Completely altered aphyric volcanic rock with perlitic texture; margins of perlite	Opaline silica/volcanic glass
5R-1, 38–40	33.97	2	HP	Completely altered aphyric volcanic rock with perlitic texture; pseudomatrix between perlite kernels	Opaline silica/volcanic glass (mixed-layer clays)
5R-1, 38–40	33.98	2	SBD	Completely altered aphyric volcanic rock with perlitic texture	Opaline silica (illite, smectite, pyrite, plagioclase)
5R-1, 42–45	34.02	2	SBD	Completely altered aphyric volcanic rock with perlitic texture	Opaline silica (plagioclase, anorthite, sepiolite, K-feldspar, pyrite, smectite)
7R-1, 55–58	48.80	4	RA	Completely altered, moderately vesicular aphyric ?dacite	Cristobalite, pyrite (quartz, gypsum, illite, pyrophyllite)
7R-1, 62–64	48.82	4	SBD	Gray rock with anhydrite-pyrite veins	Cristobalite, anhydrite (pyrite, plagioclase)
7R-1, 92–93	49.12	4	SBD	Flow-banded rock with anhydrite-pyrite veins	Cristobalite (anhydrite, pyrite, plagioclase, smectite, chlorite-bearing mixed-layer, hematite)
7R-1, 114–119	49.34	5	HP	Domainal altered, aphyric volcanic rock; light gray perlitic(?) domain	Cristobalite (anhydrite, pyrite, illite, "chlorite, tridymite")
7R-1, 114–119	49.34	5	HP	Domainal altered, aphyric volcanic rock; dark gray pseudomatrix	Cristobalite, anhydrite, pyrite (mixed-layer clay, "tridymite")
7R-1, 119–120	49.39	5	SBD	Jigsaw breccia with textures replaced by anhydrite and chlorite	Anhydrite, cristobalite (pyrite, chlorite, illite)
7R-1, 145–147	49.65	5	SBD	Rock with a pseudoclastic texture	Anhydrite (cristobalite, pyrite, pyrophyllite, quartz)
7R-2, 39–41	50.09	6	SBD	Completely altered hydrofractured volcanic rock	Cristobalite (anhydrite, pyrite, chlorite, illite, barite)
7R-2, 51–53	50.21	6	SBD	Completely altered hydrofractured volcanic rock	Anhydrite, cristobalite (pyrite, quartz, illite, barite)
8R-1, 13–17	58.03	6	HP	Domainal altered, perlitic volcanic rock; white, remnant perlite	Cristobalite (tridymite, pyrite, mixed-layer clays, "anhydrite")
8R-1, 13–17	58.03	6	HP	Domainal altered, perlitic volcanic rock; dark gray pseudomatrix	Cristobalite, pyrite, (tridymite, mixed-layer clays, "anhydrite")
8R-1, 13–17	58.03	6	HP	Domainal altered, perlitic volcanic rock; bulk rock	Cristobalite (tridymite, pyrite, mixed-layer clays, "anhydrite")
8R-1, 66–70	58.56	6	HP	Completely altered hydrofractured, flow-banded volcanic rock	Cristobalite (chlorite, "pyrite, illite, anatase)
8R-1, 66–70	58.58	6	SBD	Completely altered hydrofractured volcanic rock	Cristobalite (anhydrite, pyrite, chlorite, illite, barite)
8R-1, 108–112	58.98	6	KL	Completely altered hydrofractured volcanic rock	Cristobalite (chlorite, smectite, anhydrite, pyrite)
8R-1, 124–127	59.14	6	SBD	Completely altered hydrofractured volcanic rock	Cristobalite (anhydrite, pyrite, illite, chlorite, barite)
8R-1, 147–148	59.37	7	SBD	Completely bleached vesicular volcanic rock with silification	Cristobalite, anhydrite (pyrite, quartz, illite, barite)
8R-2, 18–20	59.6	7	RA	Pervasively bleached, vesicular volcanic rock	Cristobalite (gypsum, pyrite, illite, chlorite, mixed-layer clays)
9R-1, 5–9	67.65	7	KL	Completely bleached vesicular volcanic rock with silification	Cristobalite, anhydrite, quartz (pyrophyllite, pyrite)
9R-1, 13–14	67.73	7	SBD	Completely bleached vesicular volcanic rock with silification	Cristobalite, anhydrite, quartz (pyrophyllite, pyrite, barite)
9R-1, 67–70	68.27	8	SBD	Completely altered hydrofractured volcanic rock	Cristobalite (pyrophyllite, pyrite, anhydrite, barite)
9R-1, 130–135	68.9	8	HP	Completely altered hydrofractured volcanic rock	Cristobalite, anhydrite (quartz, pyrite, pyrophyllite, paragonite, gypsum "halite, anatase")
9R-1, 137–140	69.0	8	RA	Pervasively bleached, vesicular volcanic rock	Cristobalite, anhydrite (gypsum, pyrophyllite, quartz)
9R-2, 79–81	69.89	8	SBD	Completely altered hydrofractured volcanic rock	Cristobalite (anhydrite, quartz, pyrite, illite)
10R-1, 35–37	77.65	8	SBD	Completely altered hydrofractured volcanic rock	Quartz, cristobalite (pyrophyllite, barite, pyrite)
10R-1, 39–43	77.69	8	KL	Completely altered hydrofractured volcanic rock	Quartz (cristobalite, anhydrite, pyrophyllite)
11R-1, 20–26	87.1	9	HP	Domainal altered, gray to white, massive volcanic rock; white margin	Cristobalite, quartz, anhydrite (tridymite, illite, gypsum, "?pyrophyllite")
11R-1, 20–26	87.1	9	HP	Domainal altered, gray to white, massive volcanic rock; gray central part	Cristobalite, plagioclase, pyrite (quartz, anhydrite, rutile, "chlorite?, mixed-layer clays")
11R-1, 35–38	87.25	9	SBD	Completely bleached vesicular volcanic rock with silification	Cristobalite (plagioclase, quartz, anhydrite, pyrite, chlorite)
11R-1, 56–57	87.46	9	SBD	Completely bleached vesicular volcanic rock with silification	Cristobalite, plagioclase, quartz (pyrite, anhydrite, illite, barite)
11R-1, 99–100	87.9	9	RA	Completely altered, bleached, sparsely vesicular volcanic rock	Cristobalite, pyrite (gypsum, anhydrite, quartz, illite)
12R-1, 51–52	97.11	10	SBD	Completely altered hydrofractured perlitic and flow-banded rock	Quartz, cristobalite, anhydrite (pyrophyllite, pyrite)
12R-1, 58–61	97.18	10	KL	Completely altered hydrofractured perlitic and flow-banded rock	Cristobalite, plagioclase (chlorite, illite, quartz, anhydrite)
12R-1, 69–70	97.29	10	SBD	Completely altered hydrofractured perlitic and flow-banded rock	Cristobalite (anhydrite, pyrite, illite, chlorite, chlorite-bearing mixed-layer, smectite, barite)
12R-1, 108–111	97.68	10	KL	Completely altered hydrofractured perlitic and flow-banded rock	Cristobalite, plagioclase (quartz, chlorite, illite, pyrite)
12R-1, 117–118	97.77	10	SBD	Completely altered hydrofractured perlitic and flow-banded rock	Cristobalite, plagioclase (quartz, pyrite, anhydrite, barite)
12R-1, 128–140	97.9	10	RA	Completely altered, bleached, sparsely vesicular volcanic rock	Cristobalite, plagioclase (quartz, pyrite, chlorite, illite)

Table T1 (continued).

Core, section, interval (cm)	Depth (mbsf)	Unit	Lab	Description	XRD identification
12R-2, 20–24	98.28	10	KL	Completely altered hydrofractured perlitic and flow-banded rock	Cristobalite, plagioclase (quartz, chlorite, illite, pyrite)
12R-2, 48–51	98.55	10	HP	Completely altered flow-banded rock; light gray layers	Cristobalite, plagioclase (quartz “tridymite, pyrite, chlorite”)
12R-2, 48–51	98.55	10	HP	Completely altered flow-banded rock; dark gray layers	Cristobalite, plagioclase (quartz “chlorite”)
12R-2, 48–51	98.56	10	SBD	Completely altered hydrofractured perlitic and flow-banded rock	Cristobalite, plagioclase (quartz, pyrite, anhydrite, barite, chlorite)
13R-1, 9–12	106.39	11	SBD	Completely altered, pervasively bleached volcanic rock	Cristobalite, plagioclase (quartz, pyrite, anhydrite, barite, chlorite-bearing mixed-layer)
13R-1, 50–53	106.8	11	RA	Completely altered, bleached, sparsely vesicular volcanic rock	Quartz, anhydrite (gypsum, pyrite, illite, pyrophyllite)
14R-1, 4–10	116.04	12	SBD	Completely altered volcanoclastic, granule to pebble breccia.	Quartz (illite, pyrite)
14R-1, 44–45	116.44	13	SBD	Pervasively bleached hydrofractured volcanic rock	Quartz (cristobalite, anhydrite, pyrite, illite, talc)
14R-1, 55–60	116.55	13	KL	Pervasively bleached hydrofractured volcanic rock	Quartz, anhydrite (pyrophyllite, gypsum)
14R-1, 86–89	116.86	13	HP	Pervasively bleached hydrofractured volcanic rock; average rock	Anhydrite (quartz, pyrite, gypsum, illite?, pyrophyllite?, mixed-layer clays?)
14R-1, 86–89	116.86	13	HP	Pervasively bleached hydrofractured volcanic rock; white pseudoclastic domains	Quartz (anhydrite, anatase, paragonite?, pyrophyllite?, “pyrite, halite”)
14R-1, 92–93	116.92	13	SBD	Pervasively bleached hydrofractured volcanic rock	Quartz, anhydrite (pyrite, illite, talc)
14R-1, 105–108	117.27	14	HP	Completely altered volcanoclastic breccia; cream-colored clast	Quartz, anhydrite (gypsum, paragonite?, mixed-layer clays? “tridymite, halite”)
14R-1, 105–108	117.27	14	HP	Completely altered volcanoclastic breccia; bulk rock	Quartz, anhydrite (gypsum, paragonite?, mixed-layer clays?, “illite?, tridymite, halite”)
14R-1, 105–108	117.29	14	SBD	Completely altered volcanoclastic breccia	Quartz (anhydrite, illite)
15R-1, 14–21	125.84	15	SBD	Anhydrite vein	Anhydrite
15R-1, 56–59	126.26	16	KL	Completely bleached and silicified, vesicular volcanic rock	Quartz, plagioclase (cristobalite, anhydrite, chlorite, illite-bearing mixed-layer)
15R-1, 76–80	126.46	16	SBD	Completely bleached and silicified, vesicular volcanic rock	Quartz (illite, pyrite, anhydrite)
15R-1, 80–81	126.50	16	RA	Crustiform anhydrite-pyrite vein	Quartz, pyrite, plagioclase (gypsum, anhydrite, illite, chlorite, mixed-layer clays, cristobalite)
16R-1, 77–78	136.17	17	SBD	Completely silicified, sparsely vesicular volcanic rock	Quartz (anhydrite, plagioclase, illite, pyrite, chlorite)
16R-1, 95–98	136.35	17	SBD	Completely silicified, sparsely vesicular volcanic rock	Quartz (anhydrite, plagioclase, illite, chlorite)
16R-1, 139–143	136.79	18	HP	Massive gray volcanic rock with anhydrite-vein; white vein	Quartz, anhydrite (illite “chlorite, gypsum, rutile”)
16R-1, 139–143	136.79	18	HP	Massive gray volcanic rock with anhydrite-vein; gray groundmass	Quartz, plagioclase (pyrite “chlorite”)
16R-2, 12–15	136.98	18	SBD	Gray-green finely laminated, strongly silicified volcanic rock	Quartz, plagioclase (pyrite, chlorite, anhydrite)
16R-2, 40–43	137.26	18	SBD	Gray-green finely laminated, strongly silicified volcanic rock	Quartz, plagioclase (pyrite, chlorite, anhydrite)
16R-2, 51–52	137.37	18	SBD	Gray-green finely laminated, strongly silicified volcanic rock	Quartz, plagioclase (chlorite, anhydrite, pyrite)
16R-2, 68–69	137.54	18	SBD	Gray-green finely laminated, strongly silicified volcanic rock	Quartz, plagioclase (chlorite, pyrite, anhydrite)
17R-1, 24–28	145.34	19	HP	Silicified, bleached volcanic rock	Quartz, anhydrite (pyrite, illite?, mixed-layer clays, gypsum “chlorite”)
17R-1, 38–41	145.48	19	KL	Silicified, bleached volcanic rock	Quartz (anhydrite, pyrite, chlorite, illite-bearing mixed-layer)
17R-1, 90–93	146.00	19	SBD	Silicified, bleached volcanic rock	Quartz (illite, pyrite, anhydrite, chlorite)
17R-1, 123–124	146.33	19	SBD	Silicified, bleached volcanic rock	Quartz (anhydrite, illite)
18R-1, 28–29	154.98	19	SBD	Silicified, bleached volcanic rock	Quartz, anhydrite (magnetite, illite)
18R-1, 87–97	155.57	20	SBD	Silicified and bleached moderately vesicular volcanic rock	Quartz (anhydrite)
19R-1, 41–46	164.71	21	HP	Silicified volcanic rock	Quartz (cristobalite, plagioclase, chlorite?, mixed-layer clays? “tridymite”)
19R-1, 51–57	164.81	21	SBD	Silicified volcanic rock	Cristobalite, plagioclase (quartz, chlorite)
19R-1, 73–76	165.03	22	SBD	Moderately altered, vesicular volcanic rock	Cristobalite, plagioclase (chlorite)
19R-1, 86–90	165.16	22	HP	Moderately altered, vesicular volcanic rock	Cristobalite, plagioclase (“anhydrite, chlorite”)
20R-1, 8–12	173.98	23	KL	Silicified, moderately chloritic magnetite-bearing volcanic rock	Cristobalite, quartz, plagioclase, chlorite-bearing mixed-layer (anhydrite, pyrite)
20R-1, 46–47	174.36	23	SBD	Silicified, moderately chloritic magnetite-bearing volcanic rock	Quartz (plagioclase, anhydrite, corrensite, magnetite, illite, pyrite)
20R-1, 68–72	174.58	23	KL	Silicified, moderately chloritic magnetite-bearing volcanic rock	Quartz, plagioclase (chlorite, pyrite)
20R-1, 75–76	174.65	23	SBD	Silicified, moderately chloritic magnetite-bearing volcanic rock	Quartz, plagioclase (magnetite, pyrite, chlorite)
20R-1, 92–95	174.82	24	SBD	Distinctive dark green silicified rock	Quartz, plagioclase (magnetite, pyrite, smectite, anhydrite, mixed-layers)
20R-1, 95–102	174.85	24	HP	Distinctive dark green silicified rock; abundant white dots	Quartz (plagioclase, pyrite)
20R-1, 95–102	174.85	24	HP	Distinctive dark green silicified rock; minor white dots	Quartz, plagioclase (pyrite “anhydrite, mixed-layer clays”)
20R-1, 102–103	174.92	24	SBD	Distinctive dark green silicified rock	Quartz, plagioclase (magnetite, pyrite, corrensite, anhydrite)
21R-1, 20–21	183.30	25	SBD	Green-black rock with green clay in a silica-pyrite stockwork	Quartz (plagioclase, magnetite, chlorite, corrensite, pyrite)
21R-1, 43–47	183.53	25	KL	Green-black rock with green clay in a silica-pyrite stockwork	Quartz, plagioclase (magnetite, chlorite-bearing mixed-layer)

Table T1 (continued).

Core, section, interval (cm)	Depth (mbsf)	Unit	Lab	Description	XRD identification
21R-1, 77–81	183.87	25	KL	Green-black rock with green clay in a silica-pyrite stockwork	Cristobalite, plagioclase (quartz, magnetite, chlorite-bearing mixed-layer, pyrite, anhydrite)
21R-1, 105–114	184.2	25	RA	Patchy quartz, magnetite, chlorite-clay bearing rock.	Quartz, plagioclase (cristobalite, pyrite, chlorite, illite, gypsum)
21R-1, 142–146	184.52	25	KL	Green-black rock with green clay in a silica-pyrite stockwork	Cristobalite, plagioclase (quartz, chlorite-bearing mixed-layer, illite, pyrite, anhydrite)

Notes: SBD = shipboard data, RA = postcruise data from R. Asada, HP = postcruise data from H. Paulick, KL = postcruise data from K. Lackschewitz. XRD = X-ray diffraction. The terms major (outside parenthesis), minor (inside parenthesis), and trace (inside both parenthesis and quotation marks) are applied to XRD analyses as explained in “Hydrothermal Alteration,” p. 8, in the “Explanatory Notes” chapter of Shipboard Scientific Party (2002) and do not imply quantitative abundances.

Table T2. Minerals identified in altered whole rocks by XRD analysis, Hole 1188F. (See table notes. Continued on next two pages.)

Core, section, interval (cm)	Depth (mbsf)	Unit	Lab	Description	XRD identification
193-1188F-					
1Z-1, 4-5	218.04	27	SBD	Completely altered massive rock	Quartz (anhydrite, illite, "pyrite")
1Z-1, 29-30	218.29	27	SBD	Completely altered massive rock	Quartz (anhydrite, illite, pyrite)
1Z-1, 87-88	218.87	27	SBD	Completely altered massive rock	Quartz (anhydrite, illite, pyrite)
1Z-2, 4-5	219.24	27	SBD	Completely altered massive rock	Quartz (anhydrite, illite)
1Z-2, 37-38	219.57	27	SBD	Completely altered massive rock	Quartz (anhydrite, illite, "pyrite")
1Z-3, 20-21	220.60	27	SBD	Completely altered massive rock	Quartz (anhydrite, illite)
1Z-3, 34-35	220.74	27	SBD	Completely altered massive rock	Quartz (anhydrite, illite)
1Z-3, 35-36	220.75	27	SBD	Completely altered massive rock (including anhydrite vein)	Quartz (anhydrite, illite)
1Z-3, 85-86	221.25	28	SBD	Completely altered, silicified, and green clay-bearing massive rock	Quartz (chlorite, illite, anhydrite, pyrite)
1Z-3, 106-108	221.46	28	SBD	Completely altered, silicified, and green clay-bearing massive rock	Quartz (anhydrite, illite, pyrite, "chlorite")
1Z-4, 63-65	222.2	28	RA	Completely altered, silicified aphyric volcanic rock	Quartz, anhydrite, pyrite (gypsum, illite)
1Z-4, 90-91	222.50	28	SBD	Completely altered, silicified, and green clay-bearing massive rock	Quartz (anhydrite, illite, "pyrite")
2Z-1, 44-45	221.94	29	SBD	Completely altered, silicified aphyric massive rock	Quartz (anhydrite, illite, pyrite)
2Z-1, 73-74	222.23	29	SBD	Completely altered, silicified aphyric massive rock	Quartz, calcite (anhydrite, illite, "kaolinite?")
3Z-1, 6-7	222.66	29	SBD	Completely altered, silicified aphyric massive rock	Quartz (illite, anhydrite, "pyrite")
3Z-2, 40-41	224.45	30	SBD	Completely altered, brecciated, clay-rich rock	Quartz (anhydrite, illite, pyrite)
3Z-2, 70-75	224.8	30	RA	Completely altered, brecciated, volcanic rock	Quartz (pyrite, chlorite, illite, mixed-layer clays, "anhydrite")
3Z-2, 144-145	225.49	30	SBD	Completely altered, brecciated, clay-rich rock	Quartz (anhydrite, chlorite, illite)
3Z-2, 150-151	225.55	30	SBD	Completely altered, brecciated, clay-rich rock	Quartz (anhydrite, illite, pyrite)
6Z-1, 20-21	233.30	30	SBD	Completely altered, brecciated, clay-rich rock	Quartz (anhydrite, illite, chlorite, pyrite)
6Z-1, 46-47	233.56	31	HP	Highly altered, spheroidal volcanic rock; spheroid-separate	Cristobalite, plagioclase (chlorite "quartz")
6Z-1, 46-47	233.56	31	HP	Highly altered volcanic rock; groundmass separate	Quartz, cristobalite (chlorite, pyrite "anhydrite, plagioclase")
6Z-1, 46-47	233.56	31	SBD	Highly altered volcanic rock	Cristobalite, plagioclase (chlorite, pyrite)
6Z-1, 77-78	233.87	32	SBD	Completely altered, silicified massive aphyric rock	Quartz (anhydrite, illite)
6Z-2, 47-48	234.81	33	SBD	Silicified volcanic fragments embedded in soft gray clay	Quartz (illite, pyrite, anhydrite)
7Z-1, 41-45	235.41	34	SBD	Silicified massive aphyric rock	Quartz (anhydrite, illite, "pyrite")
7Z-1, 104-107	236.04	35	SBD	Silicified, plagioclase-phyric rock	Quartz (anhydrite, illite)
7Z-2, 3-6	236.51	35	SBD	Silicified, plagioclase-phyric rock	Quartz (anhydrite, illite, "pyrite")
8Z-1, 16-20	236.40	36	RA	Completely altered, silicified, massive, aphyric volcanic rock	Quartz, anhydrite, pyrite (illite, pyrophyllite)
8Z-1, 26	236.46	36	HP	Silicified massive aphyric rock; light green, amygdaloidal central part	Quartz (anhydrite, pyrite "chlorite, illite?")
8Z-1, 26	236.46	36	HP	Silicified massive aphyric rock; white, alteration halo (piece margin)	Quartz, anhydrite (paragonite, mixed-layer clays, pyrophyllite?, illite? "rutile, gypsum")
8Z-1, 68-71	236.88	36	SBD	Silicified massive aphyric rock	Quartz (anhydrite, illite)
9Z-1, 9-12	237.80	37	HP	Silicified clastic rock; white clasts	Anhydrite (quartz, illite, paragonite "gypsum, halite")
9Z-1, 9-12	237.80	37	HP	Silicified clastic rock; gray groundmass	Quartz, illite (anhydrite)
9Z-1, 9-12	237.79	37	SBD	Silicified clastic rock	Quartz (anhydrite, illite)
11G-1, 53-56	239.43	38	SBD	Silicified massive aphyric rock	Quartz (anhydrite, illite, "pyrite")
11G-1, 138-141	240.28	39	SBD	Silicified plagioclase-phyric, slightly vesicular volcanic rock	Quartz (anhydrite, pyrite, illite)
13Z-1, 0-23	241.40	41	HP	Silicified plagioclase-phyric volcanic rock; white alteration halo (margin)	Anhydrite, quartz (pyrite, illite "halite")
13Z-1, 0-23	241.40	41	HP	Silicified plagioclase-phyric volcanic rock; gray central part	Quartz (pyrite, illite "anhydrite")
13Z-1, 74-78	242.1	41	RA	Silicified, sparsely plagioclase-phyric, sparsely vesicular rock	Quartz, anhydrite, gypsum, pyrite (plagioclase, illite, pyrophyllite)
13Z-1, 118-121	242.58	41	SBD	Silicified plagioclase-phyric volcanic rock	Quartz (anhydrite, pyrite, illite)
13Z-2, 51-55	243.27	41	SBD	Silicified plagioclase-phyric volcanic rock	Quartz (anhydrite, illite, "pyrite")
13Z-2, 55-70	243.31	41	SBD	Silicified plagioclase-phyric volcanic rock	Quartz (anhydrite, pyrite, illite, "chlorite")
14Z-1, 134-139	247.24	41	SBD	Silicified plagioclase-phyric volcanic rock	Quartz (anhydrite, brittle mica?, pyrite)
15Z-1, 66-69	251.06	42	SBD	Silicified, aphyric rock	Quartz (anhydrite, brittle mica?, pyrite)
15Z-1, 90-95	251.30	42	SBD	Silicified, aphyric rock	Quartz (anhydrite, illite, brittle mica?, pyrite)
16Z-1, 41-43	255.31	44	SBD	Silicified, brecciated, flow-banded, aphyric rock	Quartz (illite, pyrite, "anhydrite")

Table T2 (continued).

Core, section, interval (cm)	Depth (mbsf)	Unit	Lab	Description	XRD identification
16Z-1, 88–90	255.8	44	RA	Completely altered, silicified, sparsely plagioclase-phyric volcanic rock	Quartz, pyrite (illite, pyrophyllite)
16Z-1, 139–141	256.29	44	SBD	Silicified, brecciated, flow-banded, aphyric rock	Quartz (pyrite, illite, brittle mica?, “anhydrite”)
19Z-1, 0–41	268.67	45	HP	Silicified plagioclase-phyric volcanic rock	Quartz (anhydrite, pyrite, illite?, mixed-layer clays?)
22Z-1, 63–67	282.73	46	SBD	Completely altered, silicified, aphyric, volcanic rock	Quartz (anhydrite, pyrite, illite, chlorite)
22Z-1, 85–87	283.0	46	RA	Completely altered, silicified, aphyric, massive volcanic rock	Quartz, pyrite (gypsum, plagioclase, chlorite, illite, mixed-layer clays, “pyrophyllite”)
23Z-1, 25–26	286.85	48	SBD	White halo of Piece 3	Quartz (anhydrite, illite, pyrite, chlorite)
23Z-1, 26–27	286.86	48	SBD	Gray kernel of Piece 3	Quartz (chlorite, illite, pyrite, “anhydrite, smectite”)
23Z-1, 102–103	287.62	49	SBD	Silicified, green clay-bearing aphyric volcanic rock	Quartz (anhydrite, chlorite, illite, “pyrite”)
23Z-2, 13–14	288.23	49	SBD	White crust of Piece 2 (anhydrite vein)	Anhydrite (“quartz”)
23Z-2, 24–25	288.34	49	SBD	Silicified, green clay-bearing aphyric volcanic rock	Quartz (anhydrite, chlorite, illite, pyrite)
23Z-2, 45–46	288.55	49	SBD	Silicified, green clay-bearing aphyric volcanic rock	Quartz (anhydrite, chlorite, illite, “pyrite”)
23Z-2, 56–63	288.66	49	HP	Silicified, green clay-bearing aphyric volcanic rock; light green domain	Quartz, chlorite (anhydrite, illite “pyrite, rutile, gypsum”)
23Z-2, 56–63	288.66	49	HP	Silicified, green clay-bearing aphyric volcanic rock; light yellow domain	Quartz, anhydrite (pyrite, illite “rutile”)
25Z-1, 24–26	295.84	49	SBD	Silicified, green clay-bearing aphyric volcanic rock	Quartz, plagioclase (chlorite, pyrite, “anhydrite”)
26Z-1, 20–23	300.30	49	SBD	Silicified, green clay-bearing aphyric volcanic rock	Quartz (anhydrite, pyrite, illite, chlorite, chlorite-bearing mixed-layer, “smectite”)
26Z-2, 34–36	301.5	50	RA	Completely altered, silicified, sparsely plagioclase-phyric rock	Quartz, anhydrite, pyrite (gypsum, chlorite, illite)
26Z-2, 60–61	301.78	50	SBD	Silicified, plagioclase-phyric volcanic rock	Quartz (chlorite, illite, anhydrite, pyrite)
27Z-1, 22–23	304.82	50	SBD	Silicified, plagioclase-phyric volcanic rock	Quartz (anhydrite, pyrite, plagioclase, illite, chlorite)
30Z-1, 5–7	318.15	51	SBD	Completely altered, variably silicified breccia	Quartz (plagioclase, illite, chlorite, “pyrite”)
30Z-1, 13–20	318.23	51	HP	Completely altered, variably silicified, magnetite-bearing, breccia	Quartz (plagioclase, illite “chlorite, magnetite”)
31Z-1, 1–3	322.61	52	SBD	Silicified, slightly plagioclase-magnetite phyric volcanic rock	Quartz, plagioclase (chlorite, magnetite, pyrite, “anhydrite”)
31Z-1, 39–42	322.99	53	SBD	Completely altered, variably silicified breccia	Quartz (pyrite, illite, chlorite, “anhydrite”)
34Z-1, 22–23	336.62	54	SBD	Completely altered aphyric volcanic rock	Quartz (anhydrite, illite, pyrite, “plagioclase”)
34Z-1, 27–28	336.67	55	SBD	Completely altered volcanic rock and breccia with variable black, late-stage magnetite-bearing alteration	Magnetite (illite, quartz, plagioclase, chlorite, pyrite, Fe-spinel, “brucite”)
34Z-1, 40–41	336.80	55	SBD	Completely altered volcanic rock and breccia with variable black, late-stage magnetite-bearing alteration	Plagioclase, quartz (illite, chlorite, pyrite, magnetite, “illite-bearing mixed-layer”)
34Z-1, 89–90	337.29	56	SBD	Completely altered and variably silicified volcanic rock breccia	Quartz (chlorite, illite, “anhydrite, pyrite”)
34Z-1, 122–130	337.63	56	HP	Completely altered and variably silicified volcanic rock breccia	Quartz, plagioclase, illite (pyrite, chlorite “halite, rutile”)
35Z-1, 5–6	340.05	57	SBD	Silicified, sparsely vesicular, aphyric, massive volcanic rock	Quartz (plagioclase, pyrite, magnetite, illite, “anhydrite, chlorite”)
35Z-1, 46–48	340.46	57	SBD	Silicified, sparsely vesicular, aphyric, massive volcanic rock	Quartz (plagioclase, pyrite, chlorite, “illite, anhydrite, magnetite”)
35Z-1, 140–141	341.40	57	SBD	Silicified, sparsely vesicular, aphyric, massive volcanic rock	Quartz (anhydrite, illite, “pyrite, chlorite”)
35Z-2, 48–49	341.98	57	SBD	Silicified, sparsely vesicular, aphyric, massive volcanic rock	Quartz (anhydrite, illite, pyrite, “plagioclase”)
37Z-1, 6–7	344.56	57	SBD	Silicified, sparsely vesicular, aphyric, massive volcanic rock	Quartz, plagioclase (illite, “anhydrite, pyrite, magnetite, chlorite”)
37Z-2, 18–20	346.00	57	SBD	Silicified, sparsely vesicular, aphyric, massive volcanic rock	Quartz (plagioclase, illite, pyrite, anhydrite, chlorite)
37Z-2, 31–33	346.13	58	SBD	Magnetite-rich, clastic rock	Plagioclase (magnetite, illite, alunite, Fe-spinel, chlorite, pyrite, brucite)
37Z-2, 65–68	346.47	59	SBD	Silicified, locally magnetite-bearing, aphyric volcanic rock	Quartz (plagioclase, anhydrite, magnetite, “illite, chlorite, pyrite”)
38Z-2, 90–92	351.19	61	SBD	Completely altered, aphyric, amygdular volcanic rock	Quartz, plagioclase (illite, chlorite, anhydrite, “pyrite, magnetite”)
39Z-1, 7–8	353.57	62	SBD	Completely altered, sparsely plagioclase-phyric volcanic rock	Quartz (anhydrite, illite, “chlorite, plagioclase, pyrite”)
39Z-1, 41–43	353.91	62	SBD	Completely altered, sparsely plagioclase-phyric volcanic rock	Quartz (anhydrite, illite, chlorite, “pyrite”)
39Z-1, 83–87	354.32	63	HP	Completely altered, silicified, aphyric volcanic rock	Quartz, plagioclase (pyrite “anhydrite, chlorite”)
39Z-2, 18–19	355.10	64	SBD	Completely altered, aphyric volcanic rock	Quartz (anhydrite, illite, chlorite, pyrite, plagioclase, illite-bearing mixed-layer)
40Z-1, 3–5	358.03	65	SBD	Completely altered, magnetite-enriched, vesicular volcanic rock	Quartz (plagioclase, anhydrite, illite, chlorite, pyrite, magnetite)
40Z-1, 36–38	358.36	66	SBD	Completely altered, sparsely plagioclase-phyric volcanic rock	Quartz (anhydrite, illite, pyrite, “plagioclase, chlorite”)
40Z-2, 35–36	359.71	67	SBD	Completely altered, clastic-textured volcanic rock	Quartz (anhydrite, illite, pyrite, “plagioclase, chlorite”)
41Z-1, 46–47	362.96	69	SBD	Completely altered, aphyric, amygdular volcanic rock	Quartz (plagioclase, pyrite, illite, chlorite, “magnetite, anhydrite”)
41Z-2, 7–10	363.95	69	SBD	Completely altered, aphyric, amygdular volcanic rock	Quartz (plagioclase, pyrite, illite, chlorite, “magnetite, anhydrite”)
42Z-1, 30–31	367.30	70	SBD	Completely altered, aphyric, sparsely amygdaloidal volcanic rock	Quartz (anhydrite, illite, “pyrite”)
42Z-1, 72–74	367.72	70	SBD	Completely altered, aphyric, sparsely amygdaloidal volcanic rock	Quartz (anhydrite, chlorite, illite, pyrite, “plagioclase”)

Table T2 (continued).

Core, section, interval (cm)	Depth (mbsf)	Unit	Lab	Description	XRD identification
43Z-1, 6–8	371.56	71	SBD	Completely altered, aphyric, sparsely vesicular volcanic rock	Quartz (illite, pyrite, chlorite, “anhydrite, plagioclase”)
43Z-1, 21	371.71	71	HP	Completely altered, aphyric, sparsely vesicular volcanic rock; gray central part	Quartz, plagioclase (anhydrite, pyrite, chlorite, illite “halite, rutile”)
43Z-1, 21	371.71	71	HP	Completely altered, aphyric, sparsely vesicular volcanic rock; light gray margin of piece (alteration halo)	Quartz, illite (anhydrite, pyrite “rutile”)
43Z-1, 67–69	372.17	72	SBD	Completely altered, magnetite-bearing, aphyric volcanic rock	Quartz, plagioclase (chlorite, pyrite, magnetite, “anhydrite”)
43Z-1, 90–91	372.40	72	SBD	Completely altered, magnetite-bearing, aphyric volcanic rock	Quartz, plagioclase (chlorite, anhydrite, “pyrite, magnetite”)
44Z-1, 85–86	374.85	72	SBD	Completely altered, magnetite-bearing, aphyric volcanic rock	Quartz, plagioclase (chlorite, anhydrite, “pyrite, magnetite”)

Notes: SBD = shipboard data, RA = postcruise data from R. Asada, HP = postcruise data from H. Paulick. XRD = X-ray diffraction. The terms major (outside parenthesis), minor (inside parenthesis), and trace (inside both parenthesis and quotation marks) are applied to XRD analyses as explained in “Hydrothermal Alteration,” p. 8, in the “Explanatory Notes” chapter of Shipboard Scientific Party (2002) and do not imply quantitative abundances.

Table T3. Minerals identified in fresh to completely altered whole rocks by XRD analysis, Hole 1189A. (See table notes. Continued on next page.)

Core, section, interval (cm)	Depth (mbsf)	Unit	Lab	Description	XRD identification
193-1189A-					
1R-1, 0-4	0.02	1	SBD	Fresh, moderately vesicular, aphyric dacite	Plagioclase, opaline silica (augite, quartz, spinel)
1R-1, 12-17	0.12	1	HP	Fresh, moderately vesicular, aphyric dacite	Plagioclase, opaline silica/volcanic glass (augite)
2R-1, 0-6	9.70	2	HP	Moderately altered, dotted, vesicular aphyric dacite	Plagioclase (cristobalite)
2R-1, 34-35	10.04	2	SBD	Moderately to completely altered, vesicular aphyric dacite	Plagioclase, cristobalite (K-feldspar, pyrite, chlorite-bearing mixed-layer)
2R-1, 77-78	10.47	2	SBD	Moderately to completely altered, vesicular aphyric dacite	Anhydrite (cristobalite, plagioclase, pyrite, chlorite)
2R-1, 113-115	10.83	4	SBD	Hydrothermal breccia with completely altered volcanic clasts	Anhydrite, cristobalite (pyrite, chlorite-bearing mixed-layer, "illite")
2R-1, 126-137	10.97	4	HP	Hydrothermal breccia with completely altered volcanic clasts; green clast	Anhydrite, cristobalite (K-feldspar, chlorite, illite "mixed-layer clays, halite, rutile")
2R-1, 126-137	10.97	4	HP	Hydrothermal breccia with completely altered volcanic clasts; white clast	Cristobalite, K-feldspar, plagioclase (anhydrite, pyrite "chlorite?")
2R-1, 126-137	11.00	4	HP	Hydrothermal breccia with completely altered volcanic clasts; green clast	Cristobalite (K-feldspar, chlorite, illite "pyrite, halite")
3R-1, 0-6	19.40	5	HP	Highly to completely bleached, vesicular aphyric dacite	Cristobalite, plagioclase (pyrite, chlorite "K-feldspar, halite")
3R-1, 6-10	19.46	5	SBD	Highly to completely bleached, vesicular aphyric dacite	Plagioclase, cristobalite (pyrite, chlorite)
3R-1, 14-17	19.54	5	KL	Highly to completely bleached, vesicular aphyric dacite	Cristobalite, plagioclase (quartz, chlorite, chlorite-bearing mixed-layer)
3R-1, 20-22	19.60	5	SBD	Highly to completely bleached, vesicular aphyric dacite	Cristobalite, plagioclase (K-feldspar, pyrite, chlorite, illite)
3R-1, 59-63	19.99	6	SBD	Hydrothermally fractured volcanoclastic breccia	Quartz, anhydrite (pyrite, "illite")
3R-1, 70-73	20.10	7	SBD	Bleached and silicified, intensely veined dacite	Quartz (K-feldspar, pyrite, "chlorite, illite")
3R-1, 84-89	20.24	7	HP	Bleached and silicified, intensely veined dacite	Quartz (K-feldspar, pyrite)
4R-1, 14-17	29.24	8	KL	Completely altered dacite	Quartz, plagioclase (K-feldspar, chlorite, illite, "pyrite")
4R-1, 17-20	29.27	8	SBD	Completely altered dacite	Quartz (plagioclase, pyrite, chlorite, illite)
4R-1, 21-24	29.31	8	SBD	Completely altered dacite	Quartz (plagioclase, chlorite, pyrite, "illite")
5R-1, 14-16	38.94	9	SBD	Completely altered, hydrothermal breccia with flow-laminated clasts	Quartz (anhydrite, chlorite, pyrite, illite)
5R-1, 33-35	39.1	9	RA	Completely altered, hydrothermal breccia with flow-laminated clasts	Quartz, anhydrite, gypsum (chlorite, illite, "plagioclase")
5R-1, 41-50	39.24	9	HP	Completely, domainal, altered breccia with flow-laminated clasts; dominantly green	Quartz (anhydrite, chlorite, illite "plagioclase")
5R-1, 41-50	39.24	9	HP	Completely, domainal, altered breccia with flow-laminated clasts; dominantly white	Quartz, plagioclase (K-feldspar, chlorite, illite "pyrite")
6R-1, 0-5	48.6	9	RA	Completely altered, hydrothermal breccia with flow-laminated clasts	Anhydrite, gypsum (quartz, chlorite, illite)
7R-1, 4-12	58.41	10	HP	Completely altered, slightly vesicular volcanic rock	Quartz, plagioclase (K-feldspar, pyrite)
7R-1, 27-28	58.57	10	SBD	Completely altered, slightly vesicular volcanic rock	Quartz, plagioclase (pyrite, anhydrite, chlorite, illite)
7R-1, 30-33	58.60	10	KL	Completely altered, slightly vesicular volcanic rock	Quartz, K-feldspar (plagioclase, rhodochrosite, chlorite, illite)
7R-1, 58-59	58.88	11	SBD	Completely altered hydrothermal(?) breccia	Quartz (anhydrite, pyrite, "illite, chlorite")
7R-1, 95-96	59.25	13	SBD	Completely altered hydrothermal(?) breccia	Quartz (plagioclase, chlorite, "pyrite, anhydrite")
8R-1, 3-10	68.04	15	HP	Poikiloblastically silicified plagioclase-rich volcanic rock	Plagioclase, cristobalite (K-feldspar "quartz, pyrite, illite")
8R-1, 31-32	68.31	15	SBD	Poikiloblastically silicified plagioclase-rich volcanic rock	Plagioclase (quartz, pyrite, "anhydrite, chlorite")
8R-1, 39-41	68.4	15	RA	Volcanic rock with patchy silicification and prominent quartz-pyrite veining	Quartz, pyrite, plagioclase (cristobalite, chlorite, illite, mixed-layer clays)
8R-1, 42-44	68.42	15	SBD	Poikiloblastically silicified plagioclase-rich volcanic rock	Plagioclase (quartz, K-feldspar, pyrite, "anhydrite, smectite, chlorite")
8R-1, 90-92	68.90	15	SBD	Poikiloblastically silicified plagioclase-rich volcanic rock	Plagioclase, quartz (pyrite, K-feldspar, "anhydrite, chlorite, illite)
8R-1, 113-114	69.13	15	SBD	Poikiloblastically silicified plagioclase-rich volcanic rock	Quartz, plagioclase (chlorite, pyrite)
9R-1, 0-5	77.70	16	KL	Completely altered hydrothermal breccia	Quartz, plagioclase (anhydrite, chlorite, "illite, pyrite")
9R-1, 16-17	77.86	16	SBD	Completely altered hydrothermal breccia	Quartz, anhydrite (plagioclase, pyrite, "chlorite")
9R-1, 17-28	77.91	16	HP	Completely altered hydrothermal breccia	Quartz (plagioclase, anhydrite "pyrite, chlorite")
9R-1, 63-67	78.33	16	KL	Completely altered hydrothermal breccia	Anhydrite, quartz (plagioclase, gypsum, pyrite, chlorite, "illite")
10R-1, 0-1	87.30	17	SBD	Completely bleached moderately vesicular volcanic rock	Quartz (plagioclase, pyrite, "chlorite")
10R-1, 38-51	87.69	19	HP	Completely altered hydrothermal breccia; gray-green coherent part	Quartz, plagioclase, K-feldspar (pyrite)
10R-1, 38-51	87.69	19	HP	Completely altered hydrothermal breccia; clastic (siliceous matrix and clasts)	Quartz (K-feldspar, anhydrite, pyrite, illite)
10R-1, 38-51	87.69	19	HP	Completely altered hydrothermal breccia; green-gray mass	Quartz (K-feldspar, pyrite, chlorite, illite "anhydrite, halite, gypsum")
10R-1, 38-51	87.69	19	HP	Completely altered hydrothermal breccia; gray-green mass	Quartz, plagioclase (K-feldspar, pyrite, chlorite "halite")
10R-1, 50-51	87.80	19	SBD	Completely altered hydrothermal breccia	Quartz, anhydrite (plagioclase, pyrite, "chlorite, illite")
10R-1, 77-81	88.07	19	KL	Completely altered hydrothermal breccia	Quartz, K-feldspar (plagioclase, pyrite, chlorite, "illite")
10R-1, 103-115	88.3	19	RA	Completely bleached, moderately vesicular volcanic rock	Quartz, plagioclase (pyrite, gypsum, chlorite, illite, "mixed-layer clays")
11R-1, 37-38	97.27	20	SBD	Completely silicified, massive, vesicular volcanic rock	Quartz (pyrite, illite, chlorite, "anhydrite")



Table T3 (continued).

Core, section, interval (cm)	Depth (mbsf)	Unit	Lab	Description	XRD identification
12R-1, 41–50	106.9	20	RA	Completely bleached, moderately vesicular volcanic rock	Quartz, pyrite, chalcopyrite (illite, “chlorite”)
12R-1, 69–70	107.19	20	SBD	Completely silicified, massive, vesicular volcanic rock	Quartz (illite, pyrite)
12R-1, 83–86	107.33	20	KL	Completely silicified, massive, vesicular volcanic rock	Quartz (chlorite, illite, pyrite)
12R-1, 83–86	107.33	20	HP	Completely silicified, massive, vesicular volcanic rock	Quartz (chlorite, illite “pyrite, halite”)
12R-1, 120–128	107.70	21	HP	Mineralized pumice breccia; separate of pumice fragments	Quartz, illite (“anhydrite, pyrite”)
13R-1, 24–33	116.34	22	SBD	Pervasively bleached moderately vesicular volcanic rock	Quartz (chlorite, pyrite, illite)
13R-1, 51–53	116.61	23	HP	Polymict volcanoclastic breccia; bulk rock	Quartz (albite, pyrite, chlorite “illite”)
13R-1, 51–53	116.61	23	HP	Polymict volcanoclastic breccia; light green clast	Quartz, chlorite (pyrite, illite “halite”)
13R-1, 51–53	116.61	23	HP	Polymict volcanoclastic breccia; light gray clast	Quartz (pyrite, chlorite, illite “halite”)
13R-1, 51–53	116.61	23	SBD	Polymict volcanoclastic breccia	Quartz (plagioclase, pyrite, chlorite, “illite”)
13R-1, 62–71	116.72	24	SBD	Pervasively bleached sparsely vesicular volcanic rock	Quartz (pyrite, “chlorite, illite”)

Notes: SBD = shipboard data, HP = postcruise data from H. Paulick, KL = postcruise data from K. Lackschewitz, RA = postcruise data from R. Asada. XRD = X-ray diffraction. The terms major (outside parenthesis), minor (inside parenthesis), and trace (inside both parenthesis and quotation marks) are applied to XRD analyses as explained in “Hydrothermal Alteration,” p. 8, in the “Explanatory Notes” chapter of Shipboard Scientific Party (2002) and do not imply quantitative abundances.

Table T4. Minerals identified in altered whole rocks by XRD analysis, Hole 1189B. (See table notes. Continued on next page.)

Core, section, interval (cm)	Depth (mbsf)	Unit	Lab	Description	XRD identification
193-1189B-					
1R-1, 0	31.0		SBD	Hammer sample (for further explanation see text)	Pyrite (chalcopyrite, illite, "sphalerite")
1R-1, 0–2	31.0	1	SBD	Semimassive sulfide with sparse volcanic rock clasts	Anhydrite (pyrite, chalcopyrite, gypsum)
1R-1, 0–4	31.0	1	RA	Semimassive sulfide with sparse volcanic rock clasts	Anhydrite (gypsum, pyrite, chalcopyrite, chlorite)
1R-1, 20–30	31.20	1	SBD	Semimassive sulfide with sparse volcanic rock clasts	Pyrite, illite, chlorite/smectite-mixed-layer ("sphalerite")
1R-1, 30–31	31.30	2	SBD	Completely altered, moderately vesicular, aphyric rock	Pyrite, muscovite (chlorite)
2R-1, 11–20	40.21	3	SBD	Breccia of completely altered volcanic rock clasts in a pyrite-anhydrite stockwork matrix	Anhydrite (gypsum, pyrite)
2R-1, 11–20	40.21	3	SBD	Breccia of completely altered volcanic rock clasts in a pyrite-anhydrite stockwork matrix	Gypsum, pyrite (anhydrite, illite)
2R-1, 40–50	40.50	3	SBD	Pyrite-anhydrite stockwork matrix	Pyrite, anhydrite, quartz (gypsum)
2R-1, 40–50	40.50	3	SBD	Wallrock sample	Pyrite (illite, chlorite, kaolinite?, "smectite, quartz")
3R-1, 0–10	49.70	3	SBD	Breccia of completely altered volcanic rock clasts in a pyrite-anhydrite stockwork matrix	Quartz, pyrite ("illite")
5R-1, 11–22	69.41	4	SBD	Breccia of completely altered volcanic rock clasts in a pyrite-quartz matrix	Pyrite (quartz, k-feldspar, illite, "chlorite")
5R-1, 45–55	69.75	4	HP	Breccia of completely altered volcanic rock clasts in a pyrite-quartz matrix; separate of volcanic clast	Quartz (K-feldspar, chlorite, illite "halite")
6R-1, 0–12	79.00	5	HP	Breccia of completely altered volcanic rock clasts in quartz-hematite-pyrite matrix; separate of green volcanic clast	Chlorite (quartz, illite "K-feldspar, pyrite, halite")
6R-1, 23–33	79.23	5	SBD	Breccia of completely altered volcanic rock clasts in quartz-hematite-pyrite matrix	Quartz (K-feldspar, plagioclase, pyrite, chlorite, "illite")
6R-1, 64–74	79.64	7	SBD	Completely altered, aphyric volcanic rock	Quartz (plagioclase, K-feldspar, pyrite, chlorite, "illite")
7R-1, 0–10	88.70	8	SBD	Breccia of completely altered volcanic rock clasts	Quartz, pyrite (K-feldspar, "illite")
8R-1, 7–9	98.47	9	SBD	Completely altered, slightly vesicular, aphyric volcanic rock	K-feldspar (pyrite, chlorite, illite, "illite-bearing mixed-layer)
10R-1, 26–27	118.16	13	SBD	Silica-clay altered, aphyric volcanic rock	Quartz (chlorite, K-feldspar, plagioclase, pyrite)
10R-1, 57–60	118.47	14	SBD	Silica-chlorite altered, spherulitic, flow-banded aphyric volcanic rock	Quartz (chlorite, K-feldspar, anhydrite, pyrite, illite)
10R-1, 57–60	118.47	14	HP	Silica-chlorite altered, spherulitic, flow-banded aphyric volcanic rock; white bands	Chlorite (quartz, pyrite, illite "K-feldspar, halite")
10R-1, 57–60	118.47	14	HP	Silica-chlorite altered, spherulitic, flow-banded aphyric volcanic rock; green bands	Chlorite (quartz "K-feldspar, pyrite, illite, halite")
10R-1, 67–69	118.57	15	SBD	Completely altered, silicified, massive, aphyric volcanic rock	Cristobalite, plagioclase (K-feldspar, chlorite, "pyrite")
11R-1, 0–7	127.60	16	SBD	Breccia of completely altered volcanic clasts	Quartz (anhydrite, K-feldspar, chlorite, chlorite-bearing mixed-layer, smectite, illite, pyrite)
11R-1, 14–16	127.74	17	SBD	Jasperoidal breccia of completely altered volcanic clasts	Quartz (anhydrite, pyrite, "hematite")
11R-1, 19–20	127.79	18	SBD	Polymict breccia of completely altered green volcanic clasts	Quartz (k-feldspar, illite, chlorite, pyrite, "plagioclase")
11R-1, 22–27	127.82	18	HP	Polymict breccia of completely altered green volcanic clasts	Quartz (K-feldspar "anhydrite, pyrite")
11R-1, 63–65	128.23	19	SBD	Completely altered, moderately vesicular, aphyric volcanic rock	Cristobalite, plagioclase (quartz, "pyrite, chlorite, chlorite-bearing mixed-layer, smectite")
11R-2, 46–47	128.74	19	SBD	Completely altered, moderately vesicular, aphyric volcanic rock	Cristobalite, plagioclase (quartz, chlorite, "chlorite-bearing mixed-layer, smectite")
11R-2, 66–76	128.9	19	RA	Very highly altered, moderately vesicular, aphyric volcanic rock	Cristobalite, plagioclase (quartz, smectite)
11R-2, 89–91	129.17	19	SBD	Completely altered, moderately vesicular, aphyric volcanic rock	Cristobalite, plagioclase (quartz, smectite, "chlorite)
11R-3, 0–29	129.72	19	HP	Completely altered, moderately vesicular, aphyric volcanic rock	Cristobalite, plagioclase (K-feldspar)
12R-1, 114–115	138.44	19	SBD	Completely altered, moderately vesicular, aphyric volcanic rock	Plagioclase (K-feldspar, quartz, chlorite, "illite, pyrite")
12R-2, 55–57	139.26	19	SBD	Completely altered, moderately vesicular, aphyric volcanic rock	Cristobalite, plagioclase (K-feldspar, quartz, chlorite-bearing mixed-layer, "smectite, illite")
13R-1, 22–24	147.22	20	SBD	Breccia with completely altered volcanic clasts	Quartz (plagioclase, pyrite, "chlorite")
13R-1, 34–36	147.34	20	SBD	Breccia with completely altered volcanic clasts	Quartz (pyrite, "barite")
13R-1, 48	147.48	21	HP	Completely altered, massive, perlitic, aphyric volcanic rock	Quartz (K-feldspar, plagioclase "chlorite?, mixed layer clays?")
13R-1, 52–54	147.52	21	SBD	Completely altered, massive, aphyric volcanic rock	Quartz (plagioclase, chlorite, illite, pyrite")
14R-1, 0–10	156.50	22	SBD	Silicified and mineralized, aphyric volcanic rock	Quartz (pyrite, "illite")
14R-1, 57–58	157.07	23	SBD	Breccia of completely altered volcanic rock fragments	Anhydrite, quartz ("plagioclase, chlorite")
14R-1, 87	157.37	23	HP	Breccia of completely altered, flow-banded, volcanic rock fragments	Quartz, anhydrite (plagioclase, K-feldspar, chlorite, illite "pyrite")
14R-1, 117–119	157.67	23	SBD	Breccia of completely altered volcanic rock fragments	Anhydrite, quartz (K-feldspar, plagioclase, chlorite)
14R-2, 10–11	157.89	23	SBD	Breccia of completely altered volcanic rock fragments	Quartz (plagioclase, pyrite, "chlorite")

Table T4 (continued).

Core, section, interval (cm)	Depth (mbsf)	Unit	Lab	Description	XRD identification
14R-2, 29–35	158.08	24	SBD	Completely altered, brecciated, silicified, aphyric volcanic rock	Quartz (pyrite, plagioclase, K-feldspar)
15R-1, 16–17	166.26	25	SBD	Breccia completely altered and silicified volcanic rock	Cristobalite, plagioclase (K-feldspar, illite, chlorite, "smectite, chlorite-bearing mixed-layer, illite-bearing mixed-layer, pyrite")
15R-1, 25	166.35	25	HP	Breccia completely altered and silicified, flow-banded, volcanic rock; large clast	Cristobalite, plagioclase (K-feldspar "chlorite, illite")
15R-1, 25	166.35	25	HP	Breccia completely altered and silicified, flow-banded, volcanic rock; groundmass + small clasts	Quartz, cristobalite, plagioclase (K-feldspar, pyrite, chlorite, illite)
15R-1, 124	167.34	25	HP	Breccia completely altered and silicified, flow-banded, volcanic rock; green clast	Cristobalite (plagioclase, pyrite, chlorite "illite, K-feldspar")
15R-1, 124	167.34	25	HP	Breccia completely altered and silicified, flow-banded, volcanic rock; gray clast	Cristobalite (quartz, K-feldspar, plagioclase, chlorite, illite "pyrite, halite")
15R-1, 128–129	167.38	25	SBD	Breccia completely altered and silicified volcanic rock	Cristobalite, plagioclase (K-feldspar, illite, chlorite, "smectite, chlorite-bearing mixed-layer, illite-bearing mixed-layer, pyrite")
15R-2, 61–64	168.21	26	SBD	Silicified, sparsely vesicular, aphyric volcanic rock	Cristobalite, plagioclase (K-feldspar, illite, "chlorite, smectite, chlorite-bearing mixed-layer, pyrite)
16R-1, 36–39	176.06	26	SBD	Silicified, sparsely vesicular, aphyric volcanic rock	Cristobalite, plagioclase (K-feldspar, "illite, illite-bearing mixed-layer, chlorite, smectite, chlorite-bearing mixed-layer)
16R-1, 74–81	176.45	27	HP	Very highly altered, moderately vesicular, aphyric volcanic rock	Quartz (K-feldspar, plagioclase "pyrite")
16R-1, 130–131	177.00	27	SBD	Very highly altered, moderately vesicular, aphyric volcanic rock	Quartz (plagioclase, pyrite, chlorite-bearing mixed-layer)
16R-2, 9–10	177.22	27	SBD	Very highly altered, moderately vesicular, aphyric volcanic rock	Quartz (plagioclase, K-feldspar, chlorite-bearing mixed-layer, "pyrite, illite")
17R-1, 19–20	185.49	28	SBD	Silicified, moderately vesicular, aphyric volcanic rock	Quartz (plagioclase, K-feldspar, pyrite)
17R-1, 56–60	185.87	30	HP	Silicified, flow-banded volcanic rock	Quartz, plagioclase (K-feldspar, pyrite)
17R-1, 60–63	185.90	30	SBD	Silicified, flow-banded volcanic rock	Quartz (plagioclase, K-feldspar, pyrite, chlorite-bearing mixed-layer)
17R-1, 65–66	189.95	30	SBD	Silicified, flow-banded volcanic rock	Quartz (plagioclase, K-feldspar, pyrite, chlorite-bearing mixed-layer)
17R-1, 96–98	186.26	31	SBD	Normal graded, thinly bedded, volcanoclastic sandstone	Quartz (plagioclase, pyrite, illite)
17R-1, 118–122	186.48	32	SBD	Flow-banded silicified volcanic rock	Quartz (plagioclase, K-feldspar, pyrite, chlorite, "illite, illite-bearing mixed-layer, chlorite/smectite mixed-layer)
18R-1, 4–12	195.05	32	HP	Breccia of completely altered, flow-banded volcanic rock; light gray clasts + silica matrix	Quartz, cristobalite, plagioclase (K-feldspar "pyrite")
18R-1, 4–12	195.05	32	HP	Breccia of completely altered, flow-banded volcanic rock; dark green clasts + silica matrix	Quartz, plagioclase (K-feldspar "pyrite")
18R-1, 24–25	195.24	33	SBD	Breccia of completely altered, flow-banded volcanic rock	Cristobalite, plagioclase (quartz, K-feldspar, illite, chlorite, (illite-bearing mixed-layer, pyrite")
18R-1, 45–50	195.45	34	HP	Breccia of completely altered flow-banded volcanic rock; spherulitic clast	K-feldspar (cristobalite, plagioclase "chlorite")
18R-1, 45–50	195.45	34	HP	Breccia of completely altered flow-banded volcanic rock; groundmass (small clasts + siliceous matrix)	Quartz (cristobalite, K-feldspar, plagioclase "pyrite")
18R-1, 70–71	195.70	34	SBD	Breccia of completely altered flow-banded volcanic rock	Cristobalite, plagioclase (quartz, K-feldspar, pyrite, illite, chlorite, chlorite-bearing mixed-layer, "illite-bearing mixed-layer, talc?")
18R-1, 107–108	196.07	34	SBD	Breccia of completely altered flow-banded volcanic rock	Cristobalite, plagioclase (quartz, K-feldspar, pyrite, illite, chlorite-bearing mixed-layer, "smectite, illite-bearing mixed-layer, actinolite?")
18R-1, 124–131	196.25	34	HP	Breccia of completely altered flow-banded volcanic rock; bulk rock	Cristobalite, plagioclase (K-feldspar "chlorite")
18R-1, 124–131	196.25	34	HP	Breccia of completely altered flow-banded volcanic rock; light gray-green clast	Cristobalite (plagioclase, chlorite "tridymite, K-feldspar, illite")
18R-2, 0–4	196.42	34	HP	Breccia of completely altered flow-banded volcanic rock	Cristobalite, plagioclase (quartz, K-feldspar "chlorite, illite")
18R-2, 23–24	196.65	34	SBD	Breccia of completely altered flow-banded volcanic rock	Cristobalite, plagioclase (quartz, K-feldspar, pyrite, illite, chlorite, chlorite-bearing mixed-layer, "smectite, illite-bearing mixed-layer, actinolite?")
18R-2, 42–43	196.84	35	SBD	Completely altered, clast-supported polymict breccia	Quartz (plagioclase, K-feldspar, chlorite, "illite, pyrite")
18R-2, 48–59	196.91	35	HP	Completely altered, clast-supported polymict breccia; spherulitic clast	Cristobalite (K-feldspar, plagioclase, chlorite, illite "tridymite, pyrite, halite")
18R-2, 48–59	196.91	35	HP	Completely altered, clast-supported polymict breccia; flow-banded clast	Plagioclase (quartz, K-feldspar, chlorite, illite "pyrite, halite")
18R-2, 48–59	196.91	35	HP	Completely altered, clast-supported polymict breccia; average groundmass	Plagioclase, quartz (K-feldspar "pyrite")
18R-2, 48–59	196.91	35	HP	Completely altered, clast-supported polymict breccia; small, green clast	Quartz (plagioclase, K-feldspar, chlorite, illite "halite")

Notes; SBD = shipboard data, RA = postcruise data from R. Asada, HP = postcruise data from H. Paulick. XRD = X-ray diffraction. The terms major (outside parenthesis), minor (inside parenthesis), and trace (inside both parenthesis and quotation marks) are applied to XRD analyses as explained in "Hydrothermal Alteration," p. 8, in the "Explanatory Notes" chapter of Shipboard Scientific Party (2002) and do not imply quantitative abundances.