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3. Data Report: Sulfide and Oxide Mineral Chemistry of an Active Backarc Hydrothermal System: PACMANUS, ODP Holes 1188A, 1188F, 1189A, and 1189B[1]

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ABSTRACT

Ocean Drilling Program (ODP) Leg 193 recovered core from the active PACMANUS hydrothermal field (eastern Manus Basin, Papua New Guinea) that provided an excellent opportunity to study mineralization related to a seafloor hydrothermal system hosted by felsic volcanic rocks. The purpose of this work is to provide a data set of mineral chemistry of the sulfide-oxide mineralization and associated gold occurrence in samples drilled at Sites 1188 and 1189. PACMANUS consists of five active vent sites, namely Rogers Ruins, Roman Ruins, Satanic Mills, Tsukushi, and Snowcap. In this work two sites were studied: Snowcap and Roman Ruins. Snowcap is situated in a water depth of 1670 meters below sea level [mbsl], covers a knoll of dacite-rhyodacite lava, and is characterized by low-temperature diffuse venting. Roman Ruin lies in a water depth of 1693–1710 mbsl, is 150 m across, and contains numerous large, active and inactive, columnar chimneys. Sulfide mineralogy at the Roman Ruins site is dominated by pyrite with lesser amounts of chalcopyrite, sphalerite, pyrrhotite, marcasite, and galena. Sulfide minerals are relatively rare at Snow Cap. These are dominated by pyrite with minor chalcopyrite and sphalerite and traces of pyrrhotite. Native gold has been found in a single sample from Hole 1189B (Roman Ruins). Oxide minerals are represented by Ti magnetite, magnetite, il-

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menite, hercynite (Fe spinel), and less abundant Al–Mg rich chromite (average = 10.6 wt% Al_2O_3 and 5.8 wt% MgO), Fe-Ti oxides, and a single occurrence of pyrophanite ($MnTiO_3$). Oxide mineralization is more developed at Snowcap, whereas sulfide minerals are more extensive and show better development at Roman Ruins. The mineralogy was obtained mainly by a detailed optical microscopy study. Oxide mineral identifications were confirmed by X-ray diffraction, and mineral chemistry was determined by electron probe microanalyses.

INTRODUCTION

The purpose of this work is to provide a data set of mineral chemistry of the sulfide-oxide mineralization and associated gold occurrences in samples drilled at Sites 1188 and 1189 in the PACMANUS hydrothermal field.

The PACMANUS hydrothermal field constitutes one of the most important active hydrothermal sites where it is possible to study recent sulfide mineralization related to felsic volcanic rocks. PACMANUS is located in Manus Basin, which is the backarc of the active New Britain volcanic arc, situated in the Bismarck Sea east of the Island of Papua New Guinea. PACMANUS consists of five active vent sites, namely Rogers Ruins, Roman Ruins, Satanic Mills, Tsukushi, and Snowcap. Ocean Drilling Program Leg 193 (November 2000–January 2001) was dedicated to drilling this hydrothermal field. Snowcap (Site 1188; 1654–1670 meters below sea level [mbsl]) is one of the major active hydrothermal sites at PACMANUS. It covers a knoll of altered dacite-rhyodacite lava and is characterized by low-temperature diffuse venting (Binns et al., 1997; Moss and Scott, 2001; Binns, Barriga, Miller, et al., 2002). Roman Ruins (Site 1189; 1693–1710 mbsl; 150 m across) contains numerous large columnar chimneys (as tall as 20 m). Many chimneys are broken and some show later regrowth. Although many chimneys are inactive, there are active structures including black smokers and diffuser-style chimneys that emit clear fluid (Binns, Barriga, Miller, et al., 2002). Roman Ruins constitutes a high-temperature, focused discharge hydrothermal area.

METHODS

Samples were prepared as polished thin sections for transmitted and reflected light microscopy. Optical microscopy was used for transmitted light studies using a range of objectives from 4× to 63×. Reflected light microscopy was conducted using a range of objectives from 2× to 100× in air. Oil immersion studies were performed using 20×, 50×, and 125× objectives. The ocular lens was 10× in both cases. Hercynite required a special technique to achieve the condition that permits the detection of this mineral in the characteristic assemblage of occurrence. Hercynite is commonly surrounded by magnetite, which renders the assemblage opaque and obscures the appearance of hercynite. Light conditions required to observe hercynite are as follows:

1. Reflected light objectives in transmitted light conditions,
2. High-magnification objectives (preferably oil immersion) to reduce focal distance to the minimum, and
3. Plane-polarized light.

Because of the grain size and the association with opaque oxides, hercynite is not observable if the focal distance is >1 or 2 mm.

Selected samples with high oxide contents were studied by X-ray powder diffraction (XRD). XRD was performed with a Philips PW 1710 diffractometer using a copper tube and operating at 40 kV and 40 mA at the University of Lisbon and the University of Toronto. XRD confirmed the presence of magnetite and Ti magnetite and was used to test for the possible presence of maghemite. Samples were ground using an agate mortar. Details of the XRD results will be presented elsewhere.

Chemical microanalyses of gold, sulfide, and oxide minerals were carried out using two different electron microprobe analyzers: a Cameca Camebax at IGM (Instituto Geológico e Mineiro) Porto, Portugal, and a Cameca SX-50 at University of Toronto, Canada. Analytical conditions used for both electron microprobes are presented in Table T1.

T1. EMPA analytical conditions for Au, sulfides, and oxides, p. 7.

RESULTS

The mineral chemistry data of sulfide-oxide mineralization and associated gold occurrences for Sites 1188 and 1189 were collected from different samples at different depths. Table T2 summarizes the minerals analyzed with the electron microprobe with respect to their origin site and depth.

T2. EMPA: minerals, origin, and depth, p. 8.

Sulfide Mineralization

Pyrite is the dominant sulfide mineral throughout the drilled cores. Pyrite composition is nearly stoichiometric. No cobalt or nickel were detected. Trace amounts of arsenic and, more rarely, copper and/or zinc were detected in a few analyses. Tables T3, T4, T5, and T6 present the data collected from each studied sample.

We attempted, without success, to analyze pyrrhotite in a single sample. The mineral is extremely fine grained (<2 µm) and occurs as inclusions in pyrite.

Chalcopyrite is more common in samples from Site 1189 (Roman Ruins). Chalcopyrite commonly occurs in association with pyrite, sphalerite, and quartz. Chalcopyrite is also present as isolated anhedral grains within strongly chloritized zones and/or in the groundmass. Tables T7, T8, and T9 present the chemical composition of the analyzed chalcopyrite that occurs, respectively, at Site 1188 and in Holes 1189A and 1189B.

Sphalerite is present both in veins and vesicle linings. Sphalerite was seen associated with chalcopyrite and, in some cases, on the edge of pyrite crystals. Chemical compositions of sphalerite were obtained in samples from Roman Ruins only (Hole 1189B). These analyses are presented in Table T10.

Galena was described in a single sample from Site 1189 (Roman Ruins), at 147.4 meters below seafloor (mbsf) in Hole 1189B. Galena occurs in close association with sphalerite, pyrite, and lesser amounts of chalcopyrite. It occurs as irregular bodies in the groundmass, in sphalerite, or in pyrite next to sphalerite. The galena grains are usually very small with poor polish quality, which makes them very hard to identify. A few larger grains were found both associated with sphalerite and in the groundmass. Electron microprobe analyses (EPMA) included arsenic, selenium, and silver in addition to lead and sulfur elements. Sil-

T3. Chemical composition of pyrite, Hole 1188A, p. 9.

T4. Chemical composition of pyrite, Hole 1188F, p. 10.

T5. Chemical composition of pyrite, Hole 1189A, p. 11.

T6. Chemical composition of pyrite, Hole 1189B, p. 12.

T7. Chemical composition of chalcopyrite, Holes 1188A and 1188F, p. 15.

T8. Chemical composition of chalcopyrite, Hole 1189A, p. 16.

T9. Chemical composition of chalcopyrite, Hole 1189B, p. 17.

T10. Chemical composition of sphalerite, Hole 1189B, p. 18.

ver contents are low (0.10–0.25 wt%), and no arsenic or selenium were detected. Table T11 presents the chemical compositions.

Gold Occurrences

Subsurface gold mineralization occurs in the Roman Ruins site at 118 mbsf, as micrometric grains of silver-poor (0.4–2.5 wt% Ag) native gold grains. It occurs as fine inclusions in three different minerals: (1) on the edge of sphalerite grains associated with hydrothermal silica vein, (2) filling voids and/or lining vesicles in quartz, and (3) as inclusions in pyrite. All these grains contain silver (0.4–2.5 wt%) as well as trace amounts of copper. No mercury was detected. Silver content varies with the gold grain mineral association. Those gold grains associated with sphalerite show the minimum silver content (0.36 wt%). Gold in pyrite contains on average 1.23 wt% silver, and gold in quartz shows the highest silver composition (2.48 wt%). Gold grain compositions are presented in Tables T12, T13, and T14. Low totals are a result of the difficulty in analyzing the very small grains of gold, 90% of which are <5 µm across. Table T15 summarizes the gold data obtained for each occurrence type.

Oxide Mineralization

Oxide minerals are represented by Ti magnetite, magnetite, ilmenite, hercynite (Fe spinel), hematite, and less abundant chromite (average = 10.6 wt% Al_2O_3 and 5.8 wt% MgO), Fe-Ti oxides, and a single occurrence of pyrophanite ($MnTiO_3$). Electron probe microanalyses were performed on samples from Holes 1188A and 1188F. No samples from Site 1189 were used in this analytical investigation. Hematite was not analyzed because of its grain size and shape. It occurs as platy inclusions in quartz <3–5 µm across.

Magnetite is a trace component of the rocks but is the dominant iron oxide mineral throughout the drilled cores. Ti magnetite is, in some cases, closely associated with magnetite. Magnetite is present within veins of intergrown quartz, brown clay, and pyrite. Detailed microscopic observations reveal a few examples of Ti magnetite–ilmenite exsolution. Magnetite also is present as remnants in leucoxene within the groundmass (Binns, Barriga, Miller, et al., 2002; Pinto et al., 2003). Tables T16 and T17 present the chemical compositions of the analyzed magnetite and Ti magnetite in samples from Holes 1188A and 1188F.

Chromite was found only once, occurring as a big relict crystal in Sample 193-1188A-21R-1 (Piece 3, 29–34 cm) at 183.4 mbsf. Table T18 provides the chemical composition data set obtained by the electron microprobe for this mineral.

Ilmenite is present at Snowcap, Hole 1188F, between 336 and 346 mbsf. Ilmenite is associated with hercynite (Fe spinel) and magnetite. Less commonly, coarser ilmenite is intergrown with magnetite. Table T19 shows the composition of ilmenite from Hole 1188F.

A transparent to translucent spinel occurs enclosed within quartz and coarser grains of magnetite and ilmenite. The color of the mineral varies in plane-polarized transmitted light from bright apple green to a dark greenish brown. The spinel has been identified as a hercynite (Fe spinel), contains tiny inclusions of magnetite, and is rimmed by a thin film of magnetite. Hercynite has been observed only in samples from Hole 1188F at depths ranging from 336 to 346 mbsf. Table T20 presents EPMA results.

A single sample from Snowcap (193-1188F-34Z-1 [Piece 9A, 45–47 cm]) revealed a few crystals of Fe-Ti oxides (average = 0.56 wt% Al_2O_3 and 4.49 wt% FeO with traces of V_2O_3). EPMA results are presented in Table T21.

Another rare occurrence is pyrophanite ($MnTiO_3$) in Sample 193-1188F-34Z-1 (Piece 9B, 46–49 cm) from Hole 1188F. The single chemical analysis obtained is shown in Table T22.

T21. Chemical composition of Fe-Ti oxides, Hole 1188F, p. 30.

T22. Chemical composition of the single pyrophanite, Hole 1188F, p. 31.

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Table T1. Analytical conditions used in the electron microprobe analyses of gold, sulfides, and oxides.

Parameter	Cameca Camebax		Cameca SX-50		
	Sulfides	Oxides	Sulfides	Gold	Oxides
Take-off angle (°)	40	40	40	40	40
Acceleration voltage (keV)	20	15	20	20	15
Beam current (nA)	30	20	30	30	20
Beam size (µm)	1	1	1	1	1
Standards:	Pure metal for Au, Ag, Cu, and Cd Synthetic FeS_2 and ZnS	MgO, albite, apatite, MnTi, Cr_2O_3, and Fe_2O_3	Arsenopyrite, pyrite, pure Co, pentlandite, chalcopyrite, sphalerite, NIST $AuAg_{80}$ alloy, stibnite, galena, $AuAg_{40}$, and Bi_2Se_3	Pure Au and Cu, $AuAg_{20}$, and cinnabar	Pure synthetic oxides of Cu, Ti, V, Cr, Mg, and Al Synthetic $MnTiO_3$; gahnite (Zn); bustamite (Si).

Note: Analyses performed at Instituto Geológico Mineiro (IGM), Portugal, and University of Toronto, Canada.

Table T2. Electron probe microanalyses: minerals, their origin, and depth of occurrence.

Hole	Depth (mbsf)	Pyrite	Pyrrhotite	Chalcopyrite	Sphalerite	Galena	Gold	Hercynite	Magnetite, Ti magnetite	Ilmenite	Chromite	Iron-titanium oxides	Pyrophanite
1188A	58.1	x											
	174.5	x		x									
	183.4								x		x		
1188F	236.1	x	x(?)										
	336.7								x	x			
	336.9							x	x	x		x	x
	337.1							x	x				
	346.1	x		x				x	x	x			
1189A	88.6	x											
	107.7	x		x									
1189B	31.0	x		x	x								
	40.1	x											
	49.8	x											
	69.8	x											
	79.6	x											
	88.7	x											
	118.1	x		x	x		x						
	118.4	x		x	x								
	127.8	x		x	x								
	147.4	x			x	x							
	157.6			x	x								

Note: x = present, blank cell = absent.

Table T3. Chemical composition of pyrite, Hole 1188A.

Core, section, piece, interval (cm)	Depth (mbsf)	Element (wt%)										
		As	Fe	Co	Ni	Cu	Zn	Au	S	Ag	Sb	Total
193-1188A-												
8R-1 (Piece 4, 20–25)	58.1											
568*		ND	46.21	ND	ND	0.06	ND	ND	53.51	ND	ND	99.79
569		ND	46.74	ND	0.02	ND	ND	ND	53.67	ND	ND	100.43
570		ND	46.65	ND	0.03	ND	ND	0.02	54.52	ND	ND	101.23
571		ND	46.76	ND	ND	ND	ND	ND	54.26	0.09	ND	101.11
572		ND	46.30	0.03	ND	0.10	ND	ND	53.58	0.02	ND	100.03
573		ND	46.38	ND	ND	0.03	ND	ND	53.15	ND	ND	99.56
575		ND	46.33	ND	ND	0.03	0.53	ND	52.96	ND	ND	99.86
576		ND	46.33	ND	ND	0.04	ND	ND	53.87	ND	ND	100.25
Average:		ND	46.46	ND	ND	0.05	ND	ND	53.69	ND	ND	100.21
20R-1 (Piece 8, 59–62)	174.5											
577		ND	47.02	ND	ND	ND	ND	ND	53.51	ND	ND	100.53
580		ND	46.64	0.02	ND	0.05	ND	ND	53.91	0.04	ND	100.65
582		ND	46.44	ND	0.11	ND	ND	ND	53.27	ND	ND	99.82
586		ND	46.55	0.02	0.02	ND	ND	ND	53.40	ND	ND	99.98
587		ND	46.86	ND	ND	ND	ND	ND	53.64	0.03	ND	100.52
588		ND	46.81	ND	0.02	ND	ND	0.02	53.63	0.02	ND	100.50
Average:		ND	46.72	ND	0.05	ND	ND	ND	53.56	0.03	ND	100.36

Note: ND = not detected (below detection limit of 99% confidence). * = reference number

Table T4. Chemical composition of pyrite, Hole 1188F.

Core, section, piece, interval (cm)	Depth (mbsf)	Element (wt%)										Total
		As	Fe	Co	Ni	Cu	Zn	Au	S	Ag	Sb	
193-1188F-												
7Z-1 (Piece 2A, 106–107)	236.1											
590		ND	47.15	ND	ND	ND	ND	ND	53.55	ND	ND	100.70
592		ND	46.72	0.02	ND	ND	ND	ND	53.42	ND	ND	100.16
593		ND	46.96	0.02	ND	ND	ND	0.03	53.73	ND	ND	100.74
594		ND	47.12	ND	ND	ND	ND	ND	54.20	ND	ND	101.32
596		ND	47.56	ND	ND	ND	ND	0.04	52.68	0.03	ND	100.32
597		ND	47.01	ND	0.03	ND	ND	ND	53.25	ND	ND	100.29
599		ND	47.50	ND	ND	0.04	ND	0.02	52.96	ND	ND	100.52
600		ND	48.86	ND	ND	0.05	ND	ND	49.97	ND	ND	98.88
602		ND	46.93	0.04	ND	ND	ND	ND	53.75	0.03	ND	100.76
603		ND	46.94	ND	ND	ND	ND	ND	53.75	ND	ND	100.69
Average:		ND	47.28	ND	ND	ND	ND	ND	53.13	ND	ND	100.40
37Z-2 (Piece 3, 28–33)	346.1											
606		ND	46.13	ND	0.12	ND	ND	ND	53.21	0.03	ND	99.50
608		ND	47.02	ND	0.03	ND	ND	ND	53.08	ND	ND	100.13
609		ND	46.47	ND	0.09	ND	ND	ND	53.22	ND	ND	99.78
610		ND	45.99	ND	0.07	ND	ND	ND	53.63	ND	ND	99.69
614		ND	46.79	0.03	ND	ND	ND	ND	53.23	0.03	ND	100.09
615		ND	46.27	0.11	0.16	ND	ND	ND	53.54	ND	ND	100.08
Average:		ND	46.45	ND	0.09	ND	ND	ND	53.32	ND	ND	99.86

Note: ND = not detected (below detection limit of 99% confidence).

Table T5. Chemical composition of pyrite, Hole 1189A.

Core, section, piece, interval (cm)	Depth (mbsf)	Element (wt%)										Total
		As	Fe	Co	Ni	Cu	Zn	Au	S	Ag	Sb	
193-1189A-												
10R-1 (Piece 13, 125–130)	88.6											
541		0.52	47.17	ND	ND	0.04	0.05	ND	53.13	ND	0.02	100.93
542		0.74	45.78	ND	ND	ND	ND	0.03	52.72	ND	ND	99.26
543		0.55	46.52	ND	ND	ND	ND	ND	53.15	ND	ND	100.23
544		0.21	46.85	0.02	ND	ND	ND	ND	53.49	ND	ND	100.58
545		0.54	46.44	ND	ND	ND	ND	ND	52.98	ND	ND	99.97
546		0.17	46.66	0.03	ND	ND	ND	ND	53.30	ND	ND	100.16
547		0.22	45.81	ND	ND	0.05	0.05	ND	53.05	ND	ND	99.18
548		0.19	46.35	ND	0.02	ND	ND	ND	53.50	ND	ND	100.06
549		0.19	46.47	ND	ND	0.06	ND	0.02	53.85	0.02	ND	100.62
550		ND	46.56	ND	ND	ND	ND	ND	54.24	ND	ND	100.79
Average:		0.37	46.46	ND	ND	ND	ND	ND	53.34	ND	ND	100.17
12R-1 (Piece 16, 120–130)	107.7											
511		ND	45.64	ND	ND	ND	ND	ND	53.60	0.03	ND	99.26
513		ND	45.45	ND	ND	ND	ND	ND	53.68	ND	ND	99.13
514		ND	45.48	ND	ND	0.06	ND	ND	53.74	0.02	ND	99.31
517		ND	46.37	0.18	ND	0.05	ND	ND	53.69	ND	ND	100.29
525		0.39	46.23	0.04	ND	ND	ND	0.02	53.05	ND	ND	99.74
529		0.59	44.56	0.22	ND	0.09	ND	ND	53.06	0.04	0.03	98.60
530		ND	45.39	0.12	ND	ND	ND	ND	53.37	ND	ND	98.88
531		ND	45.62	ND	ND	ND	ND	0.06	53.61	ND	ND	99.28
532		ND	45.61	ND	ND	ND	ND	ND	53.91	0.02	ND	99.54
533		0.25	45.59	0.06	ND	0.12	0.06	ND	53.28	0.02	ND	99.37
534		ND	45.69	0.06	ND	0.18	ND	ND	53.24	ND	ND	99.17
538		ND	45.96	0.03	ND	0.55	ND	ND	53.46	ND	ND	100.00
Average:		0.10	45.63	0.06	ND	0.09	ND	ND	53.47	ND	ND	99.36

Note: ND = not detected (below detection limit of 99% confidence).

Table T6. Chemical composition of pyrite, Hole 1189B. (See table note. Continued on next two pages.)

Core, section, piece, interval (cm)	Depth (mbsf)	Element (wt%)										
		As	Fe	Co	Ni	Cu	Zn	Au	S	Ag	Sb	Total
193-1189B-												
1R-1 (Piece 1, 0–4)	31.0											
477		ND	43.50	ND	ND	4.14	ND	ND	51.75	0.03	ND	99.42
478		ND	45.71	0.11	ND	0.61	ND	ND	52.86	ND	ND	99.29
479		ND	46.67	ND	ND	0.36	ND	ND	53.28	ND	ND	100.30
482		0.83	45.60	ND	0.02	ND	ND	0.03	53.34	ND	ND	99.82
484		ND	45.80	ND	ND	ND	ND	ND	53.66	ND	ND	99.46
486		ND	46.14	ND	ND	ND	0.05	ND	54.39	0.03	ND	100.61
487		ND	45.33	ND	ND	ND	ND	ND	54.23	ND	ND	99.56
488		ND	45.57	ND	ND	ND	ND	ND	53.79	ND	ND	99.35
501		ND	46.14	ND	ND	0.04	ND	ND	53.39	ND	ND	99.57
505		ND	45.41	0.02	ND	ND	ND	ND	54.07	ND	ND	99.50
Average:		ND	45.59	ND	ND	0.51	ND	ND	53.48	ND	ND	99.58
2R-1 (Piece 1, 0–10)	40.1											
616		ND	47.03	ND	ND	ND	ND	0.03	53.58	ND	ND	100.64
617		ND	46.75	ND	ND	ND	ND	0.02	53.37	ND	ND	100.15
618		0.12	46.89	ND	ND	ND	ND	ND	53.88	0.02	ND	100.91
619		ND	46.80	ND	ND	ND	ND	0.02	53.26	0.04	ND	100.12
620		ND	46.94	0.02	ND	ND	ND	ND	53.66	ND	ND	100.62
621		0.11	45.69	0.07	0.06	ND	ND	ND	52.63	ND	ND	98.56
622		ND	46.42	ND	ND	ND	ND	ND	53.67	ND	ND	100.08
623		ND	46.98	ND	ND	ND	ND	ND	53.70	ND	ND	100.68
624		ND	46.61	ND	ND	ND	0.04	ND	53.42	ND	ND	100.07
625		ND	46.70	ND	ND	ND	ND	ND	53.56	ND	ND	100.25
Average:		ND	46.68	ND	ND	ND	ND	ND	53.47	ND	ND	100.15
3R-1 (Piece 2, 12–23)	49.8											
551		0.81	46.37	ND	ND	ND	ND	ND	52.96	ND	ND	100.13
552		0.79	46.59	ND	0.02	ND	ND	ND	52.88	ND	ND	100.27
553		0.64	46.36	ND	0.02	ND	ND	ND	52.99	0.03	ND	100.04
554		0.94	46.00	ND	ND	ND	ND	ND	52.56	ND	ND	99.51
555		0.50	45.71	ND	ND	ND	ND	ND	53.01	ND	ND	99.22
556		0.68	46.10	ND	ND	ND	ND	ND	52.58	ND	ND	99.36
Average:		0.73	46.19	ND	ND	ND	ND	ND	52.83	ND	ND	99.74
5R-1 (Piece 5, 45–55)	69.8											
557		0.16	45.98	ND	ND	ND	ND	ND	54.27	ND	ND	100.41
558		ND	46.28	ND	ND	ND	ND	ND	54.05	ND	ND	100.33
559		0.22	46.82	ND	ND	ND	ND	0.02	53.82	ND	ND	100.88
560		ND	46.27	ND	ND	ND	ND	ND	53.91	ND	ND	100.19
561		ND	45.97	0.03	ND	ND	ND	ND	53.96	ND	ND	99.97
Average:		0.08	46.27	ND	ND	ND	ND	ND	54.00	ND	ND	100.34
6R-1 (Piece 6, 5–67)	79.6											
562		ND	46.74	ND	ND	ND	ND	ND	53.41	0.04	ND	100.19
563		0.38	46.22	ND	ND	ND	ND	ND	53.54	ND	ND	100.13
564		ND	47.29	ND	ND	0.03	ND	ND	53.74	ND	ND	101.07
565		ND	46.34	ND	ND	0.24	ND	ND	53.74	ND	ND	100.31
566		ND	47.24	0.03	ND	0.03	ND	ND	53.56	ND	ND	100.86
567		ND	47.06	0.03	ND	ND	ND	0.04	54.1	ND	ND	101.24
Average:		ND	46.82	ND	ND	0.05	ND	ND	53.68	ND	ND	100.55
7R-1 (Piece 1, 0–11)	88.7											
627		ND	45.55	ND	ND	ND	ND	ND	52.90	0.03	ND	98.47
628		ND	45.43	0.10	ND	ND	ND	0.04	53.76	0.05	ND	99.37
629		ND	46.67	0.02	ND	ND	ND	0.02	53.71	ND	ND	100.42
630		ND	46.15	ND	ND	ND	ND	ND	53.77	ND	ND	99.92
631		ND	46.15	ND	ND	ND	0.03	ND	53.59	ND	ND	99.78
633		ND	46.31	ND	ND	ND	ND	0.02	53.26	ND	ND	99.59
634		ND	45.99	ND	ND	ND	ND	ND	53.50	ND	ND	99.49
635		ND	46.15	ND	ND	ND	ND	ND	53.12	ND	ND	99.26
636		ND	46.02	ND	0.02	ND	ND	ND	53.36	ND	ND	99.41
637		ND	46.71	ND	0.11	ND	ND	ND	53.21	0.03	ND	100.06
638		ND	46.55	ND	ND	ND	ND	ND	52.76	0.02	ND	99.34
639		0.40	46.56	0.04	0.06	0.04	ND	0.03	52.97	ND	ND	100.08
640		ND	47.20	ND	ND	ND	ND	0.03	53.71	ND	ND	100.95
642		ND	46.72	ND	0.10	0.03	ND	ND	53.15	ND	ND	100.00
643		0.35	45.71	ND	ND	ND	ND	ND	53.38	ND	ND	99.44
644		ND	45.58	0.17	0.02	ND	ND	0.03	52.84	ND	ND	98.64

Table T6 (continued).

Core, section, piece, interval (cm)	Depth (mbsf)	Element (wt%)										
		As	Fe	Co	Ni	Cu	Zn	Au	S	Ag	Sb	Total
645		ND	46.31	ND	0.03	ND	ND	ND	53.29	ND	ND	99.63
646		ND	45.80	0.18	ND	ND	ND	ND	53.46	0.02	ND	99.46
647		ND	46.88	ND	ND	0.05	ND	ND	53.81	0.02	ND	100.75
Average:		ND	46.23	ND	ND	ND	ND	ND	53.34	ND	ND	99.58
10R-1 (Piece 3, 24–34)	118.1											
233		ND	45.92	ND	ND	ND	0.30	0.13	52.86	ND	ND	99.20
234		0.12	46.50	ND	0.02	ND	ND	0.10	53.23	ND	ND	99.98
235		ND	45.64	ND	ND	ND	0.20	ND	53.23	0.19	ND	99.26
236		0.13	46.00	ND	ND	0.05	ND	ND	52.76	ND	ND	98.92
240		0.11	44.86	ND	ND	ND	0.64	ND	53.60	ND	ND	99.21
248		0.19	45.38	ND	0.03	ND	ND	0.13	52.57	0.18	0.04	98.51
249		0.14	44.43	0.03	0.05	ND	ND	ND	53.71	0.17	0.03	98.54
251		0.12	45.41	ND	ND	0.10	ND	0.16	52.61	0.14	ND	98.55
265		ND	44.80	ND	0.07	0.08	0.30	0.17	53.77	0.19	ND	99.37
270		ND	44.99	ND	ND	0.04	0.11	0.10	53.13	0.14	0.04	98.55
272		0.12	45.11	0.02	ND	ND	0.13	0.14	53.01	0.03	0.04	98.60
282		ND	45.01	ND	0.15	ND	ND	ND	53.17	0.15	ND	98.49
291		ND	45.45	ND	ND	ND	ND	ND	53.05	ND	ND	98.50
294		ND	45.72	ND	0.07	ND	0.08	0.14	53.47	0.09	ND	99.57
296		ND	45.48	0.04	0.07	0.10	0.11	ND	53.28	0.20	ND	99.26
299		ND	45.15	0.03	ND	ND	ND	ND	53.75	0.21	ND	99.15
300		ND	45.83	0.04	0.08	ND	ND	ND	53.31	ND	0.07	99.34
301		ND	45.47	ND	0.02	ND	0.13	ND	53.25	0.15	ND	99.01
302		ND	44.92	ND	ND	1.52	ND	0.09	52.55	0.02	ND	99.10
303		0.13	45.41	0.02	0.02	0.09	ND	0.15	54.03	0.04	ND	99.88
306		0.13	46.45	ND	0.04	ND	ND	ND	53.41	0.07	ND	100.11
307		ND	46.19	ND	ND	ND	ND	0.13	53.38	0.02	ND	99.72
309		ND	45.93	ND	0.08	ND	ND	ND	53.41	0.04	0.06	99.52
310		ND	45.70	ND	0.12	ND	ND	0.17	53.51	ND	ND	99.49
312		ND	46.12	ND	ND	ND	ND	ND	53.57	ND	ND	99.75
317		0.13	45.34	0.04	0.19	ND	0.12	0.08	53.12	0.25	ND	99.27
328		0.25	45.55	ND	ND	0.14	ND	ND	53.04	ND	ND	98.98
329		0.14	45.52	ND	ND	0.06	ND	0.14	53.62	ND	ND	99.48
330		ND	45.96	ND	ND	ND	ND	0.07	53.46	ND	ND	99.49
331		ND	46.01	ND	ND	ND	ND	ND	53.62	0.02	ND	99.66
334		ND	45.63	0.03	ND	ND	ND	ND	53.15	ND	ND	98.81
335		0.61	45.84	ND	0.02	ND	ND	ND	52.45	0.17	0.04	99.12
336		0.46	45.98	ND	0.11	ND	ND	0.18	53.62	0.19	ND	100.55
337		0.17	46.67	0.03	ND	ND	0.09	ND	53.38	ND	ND	100.33
340		ND	45.96	0.03	ND	ND	ND	0.17	53.52	0.14	0.02	99.85
341		0.13	45.59	ND	ND	ND	0.09	0.05	53.40	0.11	0.07	99.45
342		0.13	45.95	0.03	ND	ND	0.10	ND	53.56	ND	0.02	99.81
343		ND	45.36	ND	0.11	ND	0.22	0.09	53.40	0.09	ND	99.27
344		ND	46.14	0.04	0.05	ND	0.18	ND	53.23	ND	ND	99.65
345		ND	46.25	ND	0.07	ND	0.10	0.15	53.71	ND	ND	100.28
346		ND	46.01	0.04	ND	ND	ND	0.04	53.35	ND	ND	99.45
356		ND	45.71	0.02	0.11	ND	0.33	0.11	53.13	0.08	ND	99.50
359		ND	46.03	ND	ND	ND	0.05	ND	53.71	ND	0.04	99.84
360		ND	46.49	0.03	ND	ND	ND	ND	53.46	0.19	ND	100.16
362		0.17	45.38	ND	0.09	ND	ND	0.13	53.80	0.21	0.10	99.86
Average:		0.07	45.79	ND	0.03	0.05	0.07	0.07	53.39	0.08	ND	99.56
10R-1 (Piece 6, 50–57)	118.4											
654		ND	46.61	ND	ND	ND	ND	0.03	53.56	0.02	ND	100.22
655		ND	46.37	ND	0.02	ND	ND	ND	53.83	0.03	ND	100.25
656		ND	46.54	0.03	ND	ND	ND	ND	53.86	ND	ND	100.42
657		ND	46.89	ND	ND	ND	ND	ND	53.77	ND	ND	100.66
658		ND	46.68	ND	ND	ND	ND	ND	53.85	ND	ND	100.52
663		ND	46.21	0.04	0.29	ND	ND	ND	54.01	ND	ND	100.55
Average:		ND	46.55	ND	0.05	ND	ND	ND	53.81	ND	ND	100.41
11R-1 (Piece 4, 17–22)	127.8											
669		ND	46.63	ND	0.02	ND	ND	ND	54.02	ND	ND	100.68
670		ND	46.78	0.02	ND	ND	ND	ND	53.53	0.03	ND	100.36
674		0.64	46.83	0.08	0.02	ND	ND	ND	53.10	ND	ND	100.67
675		ND	46.39	0.06	0.02	ND	ND	0.05	54.14	0.03	ND	100.68
678		ND	46.33	ND	ND	ND	ND	ND	53.82	0.02	ND	100.18
679		ND	46.87	ND	ND	ND	ND	ND	53.98	0.02	ND	100.87
680		0.14	47.14	ND	0.07	ND	ND	ND	54.11	ND	ND	101.46
682		0.11	46.90	0.02	0.04	ND	ND	ND	53.80	0.03	ND	100.90

Table T6 (continued).

Core, section, piece, interval (cm)	Depth (mbsf)	Element (wt%)										Total
		As	Fe	Co	Ni	Cu	Zn	Au	S	Ag	Sb	
684		ND	47.52	0.03	ND	ND	ND	ND	53.04	ND	ND	100.58
686		ND	46.79	ND	0.03	ND	ND	ND	53.76	ND	ND	100.58
687		0.18	47.05	ND	ND	ND	ND	ND	53.96	ND	ND	101.18
Average:		0.10	46.84	0.02	0.02	ND	ND	ND	53.75	ND	ND	100.72
13R-1 (Piece 7, 35–38)	147.4											
420		ND	46.06	ND	ND	ND	ND	ND	53.54	ND	ND	99.59
422		0.13	46.89	ND	ND	ND	ND	ND	53.32	ND	ND	100.34
423		0.86	45.62	ND	0.02	ND	ND	ND	52.93	ND	ND	99.44
424		0.68	46.23	ND	ND	ND	ND	ND	52.97	ND	ND	99.88
425		0.73	45.80	0.04	ND	ND	ND	0.07	52.51	ND	ND	99.16
426		0.91	45.54	ND	0.02	ND	ND	ND	52.74	0.03	ND	99.24
427		1.25	44.62	0.10	0.39	0.04	ND	ND	52.52	0.04	0.10	99.07
428		1.51	45.41	ND	ND	ND	ND	0.02	52.37	ND	ND	99.31
429		4.26	44.16	ND	ND	ND	ND	ND	50.93	ND	ND	99.35
430		4.57	43.80	ND	0.05	ND	ND	0.06	51.24	0.04	0.06	99.83
431		0.66	45.85	ND	ND	ND	ND	ND	53.01	0.03	ND	99.55
432		1.22	45.38	ND	ND	ND	ND	ND	52.41	0.02	0.02	99.05
433		1.23	45.37	ND	ND	ND	ND	0.04	52.40	0.03	0.05	99.12
434		0.84	45.47	ND	ND	ND	ND	ND	52.47	ND	0.02	98.80
435		2.28	45.48	ND	0.02	ND	ND	ND	51.36	0.02	0.09	99.25
436		0.82	45.75	ND	ND	ND	0.05	ND	53.21	ND	ND	99.83
437		0.87	45.29	ND	ND	ND	ND	0.03	52.66	ND	ND	98.84
444		0.30	45.63	ND	0.02	ND	0.06	ND	53.18	ND	ND	99.19
445		1.00	46.07	0.03	ND	ND	ND	0.04	52.12	ND	ND	99.26
Average:		1.34	45.50	ND	0.03	ND	ND	ND	52.52	ND	0.02	99.40

Note: ND = not detected (below detection limit of 99% confidence).

Table T7. Chemical composition of chalcopyrite, Holes 1188A and 1188F.

Core, section, piece, interval (cm)	Depth (mbsf)	Element (wt%)										
		As	Fe	Co	Ni	Cu	Zn	Au	S	Ag	Sb	Total
193-1188A-												
20R-1 (Piece 8, 59–62)	174.5											
578		ND	30.25	ND	ND	34.83	ND	ND	36.06	ND	ND	101.13
581		ND	29.75	ND	ND	35.14	ND	ND	35.59	ND	ND	100.48
584		ND	30.20	ND	ND	34.87	ND	ND	36.18	ND	ND	101.25
Average:		ND	30.06	ND	ND	34.95	ND	ND	35.94	ND	ND	100.95
193-1188F-												
37Z-2 (Piece 3, 28–33)	346.1											
604		ND	30.51	ND	ND	34.74	0.04	ND	35.72	0.04	ND	101.04
605		ND	29.70	ND	ND	34.31	ND	0.04	35.39	ND	ND	99.44
611		ND	29.73	ND	ND	34.13	ND	0.03	35.49	ND	ND	99.39
612		ND	29.52	ND	ND	33.83	0.04	0.04	35.54	ND	0.02	98.99
Average:		ND	29.87	ND	ND	34.25	0.02	0.03	35.53	ND	ND	99.70

Note: ND = not detected (below detection limit of 99% confidence).

Table T8. Chemical composition of chalcopyrite, Hole 1189A.

Core, section, piece, interval (cm)	Depth (mbsf)	Element (wt%)										Total
		As	Fe	Co	Ni	Cu	Zn	Au	S	Ag	Sb	
193-1189A-												
12R-1 (Piece 16, 120–122)	107.7											
509		ND	29.27	ND	0.02	34.41	ND	ND	35.67	ND	ND	99.36
512		ND	29.41	ND	0.02	34.75	ND	ND	35.63	ND	ND	99.81
515		ND	29.17	ND	ND	34.32	ND	ND	35.73	0.03	ND	99.25
516		ND	29.32	ND	ND	34.36	ND	ND	35.63	ND	ND	99.31
518		ND	29.03	ND	ND	34.15	ND	ND	35.47	ND	ND	98.65
519		ND	29.73	ND	ND	35.25	ND	ND	35.51	ND	ND	100.50
520		ND	29.22	ND	0.02	34.31	ND	ND	36.16	ND	ND	99.70
521		ND	29.95	ND	ND	35.11	ND	ND	35.46	ND	ND	100.52
522		ND	29.03	ND	ND	34.57	ND	ND	35.67	ND	ND	99.26
523		ND	29.05	ND	ND	34.41	ND	ND	35.83	ND	ND	99.29
524		ND	29.04	ND	ND	34.31	ND	ND	36.07	ND	ND	99.42
527		ND	29.78	ND	0.02	35.06	ND	ND	36.01	ND	ND	100.86
528		ND	29.93	ND	ND	35.00	ND	ND	35.77	ND	ND	100.70
535		ND	29.70	ND	ND	34.92	ND	ND	35.98	ND	ND	100.60
536		ND	29.54	ND	ND	34.91	ND	ND	35.88	ND	ND	100.34
537		ND	28.95	ND	ND	34.82	ND	ND	35.54	ND	ND	99.32
Average:		ND	29.38	ND	ND	34.67	ND	ND	35.75	ND	ND	99.80

Note: ND = not detected (below detection limit of 99% confidence).

Table T9. Chemical composition of chalcopyrite, Hole 1189B.

Core, section, piece, interval (cm)	Depth (mbsf)	Element (wt%)										
		As	Fe	Co	Ni	Cu	Zn	Au	S	Ag	Sb	Total
193-1189B-												
1R-1 (Piece 1, 0–4)	31.0											
475		ND	29.37	ND	ND	34.35	ND	ND	35.82	ND	ND	99.55
476		ND	29.35	ND	ND	34.57	ND	0.02	36.09	0.04	ND	100.07
480		ND	29.70	ND	ND	34.59	ND	ND	36.50	ND	0.02	100.81
481		ND	29.48	ND	ND	34.77	ND	ND	36.46	ND	ND	100.72
483		ND	29.42	ND	ND	34.25	ND	ND	36.35	0.02	ND	100.04
489		ND	28.79	ND	ND	34.06	ND	ND	35.75	ND	ND	98.61
492		ND	29.49	ND	ND	34.32	ND	ND	35.99	ND	0.02	99.83
493		ND	29.42	ND	ND	34.28	ND	ND	36.05	ND	ND	99.74
494		ND	29.19	ND	ND	34.21	ND	ND	36.12	ND	ND	99.52
495		ND	29.49	ND	ND	34.34	ND	ND	35.89	ND	ND	99.72
496		ND	29.27	ND	ND	34.04	ND	ND	36.14	ND	ND	99.45
497		ND	29.41	ND	ND	34.84	ND	ND	36.18	0.02	ND	100.45
498		ND	28.90	ND	ND	34.35	ND	ND	35.79	ND	ND	99.04
499		ND	29.07	ND	ND	34.17	ND	ND	35.28	ND	0.02	98.54
500		ND	29.02	ND	ND	34.20	ND	ND	36.02	0.02	ND	99.27
502		ND	29.11	ND	ND	34.09	ND	ND	35.90	ND	ND	99.11
503		ND	28.96	ND	ND	34.01	ND	0.03	35.78	ND	ND	98.78
506		ND	29.01	ND	ND	34.34	ND	ND	35.74	ND	ND	99.09
507		ND	28.95	ND	0.02	34.39	ND	ND	35.73	0.02	ND	99.12
508		ND	29.38	ND	ND	34.44	ND	0.03	35.88	ND	ND	99.73
Average:		ND	29.24	ND	ND	34.33	ND	ND	35.97	ND	ND	99.54
10R-1 (Piece 3, 24–34)	118.1											
284		ND	29.54	ND	ND	33.90	0.05	ND	36.34	0.20	0.06	100.09
285		ND	29.57	ND	ND	34.22	0.21	0.17	35.83	0.12	0.08	100.21
287		0.13	29.66	ND	0.04	34.06	ND	ND	36.25	0.03	0.03	100.19
292		ND	29.61	ND	ND	34.02	0.18	ND	35.63	0.25	ND	99.69
293		0.13	29.27	ND	0.07	33.74	0.11	0.14	36.61	0.22	ND	100.29
313		ND	29.20	ND	0.07	34.10	ND	0.12	35.99	ND	ND	99.47
315		0.14	29.01	ND	0.08	34.21	0.06	0.11	35.07	ND	0.05	98.74
Average:		0.06	29.41	ND	0.04	34.04	0.09	0.08	35.96	0.12	0.03	99.81
10R-1 (Piece 6, 50–57)	118.4											
661		ND	29.96	ND	ND	34.21	0.11	0.02	35.53	ND	ND	99.83
662		ND	29.55	ND	ND	34.65	0.13	0.02	36.36	0.02	ND	100.73
Average:		ND	29.75	ND	ND	34.43	0.12	0.02	35.95	ND	ND	100.27
11R-1 (Piece 4, 17–22)	127.8											
664		ND	38.53	ND	0.02	21.98	2.80	ND	36.00	ND	ND	99.33
665		ND	38.89	ND	ND	24.09	1.01	ND	36.78	ND	ND	100.77
666		ND	39.10	ND	ND	24.44	1.00	ND	35.97	ND	ND	100.52
676		ND	29.65	ND	ND	34.97	ND	0.02	34.77	0.04	ND	99.45
677		ND	29.62	ND	ND	34.95	ND	ND	35.61	0.02	ND	100.20
681		ND	29.26	ND	ND	34.95	ND	ND	35.65	0.03	ND	99.90
683		ND	29.49	ND	ND	34.92	ND	0.03	35.83	ND	ND	100.28
Average:		ND	33.51	ND	ND	30.04	0.69	ND	35.80	ND	ND	100.04
14R-1 (Piece 15, 107–119)	157.6											
472		ND	29.50	0.02	ND	34.81	0.29	ND	35.84	ND	ND	100.46
473		ND	29.19	ND	ND	34.65	0.24	ND	35.58	0.04	ND	99.69
Average:		ND	29.35	ND	ND	34.73	0.27	ND	35.71	0.02	ND	100.07

Note: ND = not detected (below detection limit of 99% confidence).

Table T10. Chemical composition of sphalerite, Hole 1189B.

Core, section, piece, interval (cm)	Depth (mbsf)	Element (wt%)										Total
		As	Fe	Co	Ni	Cu	Zn	Au	S	Ag	Sb	
193-1189B-												
1R-1 (Piece 1, 0–4)	31.0											
485		ND	5.42	ND	ND	3.88	55.47	0.05	34.86	ND	ND	99.69
10R-1 (Piece 3, 24–34)	118.1											
277		0.24	3.90	ND	ND	0.17	61.08	0.19	34.14	ND	ND	99.72
278		ND	2.59	ND	ND	0.13	62.55	0.12	34.16	ND	0.09	99.64
281		ND	1.78	ND	ND	0.34	63.23	0.10	34.29	ND	ND	99.74
322		ND	4.43	ND	0.04	0.17	60.57	0.17	34.61	0.19	ND	100.18
323		ND	4.52	ND	0.02	0.12	61.04	0.12	34.46	ND	ND	100.28
324		ND	2.50	ND	0.03	0.52	62.71	0.17	34.59	0.19	0.04	100.75
325		ND	3.12	ND	ND	0.34	62.51	ND	34.73	0.12	ND	100.83
326		ND	3.18	ND	0.04	ND	62.82	0.15	34.22	0.20	0.03	100.63
347		ND	3.30	ND	0.02	ND	63.16	ND	34.18	ND	0.03	100.70
348		ND	3.21	ND	0.08	ND	62.94	0.10	34.70	0.06	ND	101.09
349		ND	3.38	ND	0.02	0.31	62.49	ND	34.17	ND	ND	100.37
351		0.16	3.75	ND	ND	1.94	60.94	0.13	33.78	0.08	ND	100.79
Average:		ND	3.30	ND	0.02	0.45	62.17	0.11	34.34	0.07	0.02	100.47
10R-1 (Piece 6, 50–57)	118.4											
648		ND	3.85	ND	ND	0.98	61.11	ND	34.51	ND	ND	100.46
650		ND	6.71	ND	ND	2.92	56.64	ND	35.00	ND	0.03	101.29
651		ND	5.25	ND	ND	0.09	60.85	ND	34.43	ND	ND	100.62
652		ND	4.97	ND	ND	0.08	61.19	ND	34.57	ND	ND	100.82
653		ND	5.03	ND	ND	ND	61.27	0.03	34.01	ND	0.04	100.38
Average:		ND	5.16	ND	ND	0.81	60.21	ND	34.51	ND	ND	100.69
11R-1 (Piece 4, 17–22)	127.8											
671		ND	18.25	ND	ND	0.09	46.17	0.02	34.87	ND	ND	99.40
13R-1 (Piece 7, 35–38)	147.4											
417		ND	2.83	ND	ND	1.84	61.73	ND	34.85	ND	ND	101.25
438		0.12	2.49	ND	ND	1.42	62.65	ND	33.66	ND	ND	100.35
439		ND	2.62	ND	ND	1.87	61.82	ND	34.36	ND	0.03	100.70
440		ND	3.48	ND	ND	2.82	59.78	ND	34.84	ND	ND	100.93
441		ND	2.05	ND	ND	0.58	63.69	ND	34.28	ND	ND	100.61
442		ND	1.65	ND	ND	0.78	62.91	0.06	34.55	ND	ND	99.96
443		ND	1.21	ND	ND	0.16	64.20	0.03	34.17	ND	0.02	99.79
458		ND	5.27	ND	0.02	ND	60.15	ND	34.55	ND	ND	99.99
459		ND	6.36	ND	ND	0.36	58.21	ND	35.37	ND	ND	100.30
460		ND	7.11	ND	ND	1.25	57.32	ND	34.48	0.02	ND	100.17
462		ND	6.82	ND	ND	0.11	58.81	ND	34.36	ND	ND	100.10
463		ND	3.98	ND	ND	0.43	61.32	ND	35.00	ND	ND	100.74
464		ND	3.78	ND	ND	0.26	61.20	ND	34.27	ND	ND	99.51
Average:		ND	3.82	ND	ND	0.99	61.06	ND	34.52	ND	ND	100.39
14R-1 (Piece 15, 107–119)	157.6											
468		ND	3.74	ND	ND	0.85	61.57	ND	34.83	ND	ND	100.99
469		ND	3.89	ND	ND	ND	61.57	0.04	34.16	ND	ND	99.66
470		ND	4.00	ND	ND	ND	62.12	0.03	34.29	ND	ND	100.43
471		ND	3.94	ND	ND	ND	61.99	ND	34.56	ND	ND	100.48
Average:		ND	3.89	ND	ND	0.21	61.81	0.02	34.46	ND	ND	100.39

Note: ND = not detected (below detection limit of 99% confidence).

Table T11. Chemical composition of galena, Hole 1189B.

Core, section, piece, interval (cm)	Depth (mbsf)	Element (wt%)					Total
		As	S	Ag	Pb	Se	
193-1189B-							
13R-1 (Piece 7, 35–38)	147.4						
381		ND	13.40	ND	87.76	ND	101.16
383		ND	13.40	ND	87.02	ND	100.42
384		ND	13.52	ND	86.64	ND	100.15
386		ND	13.46	0.18	86.60	ND	100.24
388		ND	13.55	0.18	86.58	ND	100.31
389		ND	13.50	0.18	86.64	ND	100.33
390		ND	13.54	0.32	88.12	ND	101.99
393		ND	13.60	0.15	86.93	ND	100.68
394		ND	13.52	0.19	86.22	ND	99.92
395		ND	13.58	0.26	86.66	ND	100.49
396		ND	13.50	0.09	85.87	ND	99.46
397		ND	13.35	0.18	86.85	ND	100.37
403		ND	13.23	0.11	85.32	ND	98.66
406		ND	13.22	0.21	85.82	ND	99.25
407		ND	13.23	0.22	85.79	ND	99.25
409		ND	13.35	ND	87.21	ND	100.56
411		ND	13.10	ND	85.50	ND	98.60
413		ND	13.78	ND	86.77	ND	100.55
415		ND	13.57	0.22	85.94	ND	99.73
446		ND	13.81	ND	87.20	ND	101.01
447		ND	13.85	ND	86.97	ND	100.82
456		ND	13.73	ND	87.70	ND	101.43
457		ND	13.67	0.12	86.68	ND	100.46
465		ND	13.50	ND	85.67	ND	99.17
466		ND	13.46	ND	86.31	ND	99.77
467		ND	13.40	0.08	85.59	ND	99.08
Average:		ND	13.49	0.10	86.55	ND	100.15

Note: ND = not detected (below detection limit of 99% confidence).

Table T12. Chemical composition of gold grains in inclusions in sphalerite, Hole 1189B.

Core, section, piece interval (cm)	Depth (mbsf)	Element (wt%)				Total
		Au	Ag	Cu	Hg	
193-1189B-						
10R-1 (Piece 3, 24–34)	118.1					
314		99.15	0.28	0.20	ND	99.64
315		98.64	0.22	0.21	ND	99.07
316		98.65	0.27	0.16	ND	99.08
317		98.45	0.35	0.17	ND	98.96
318		98.54	0.23	0.23	ND	99.01
319		95.50	0.43	0.17	ND	96.09
320		94.71	0.55	0.18	ND	95.44
321		94.97	0.47	0.18	ND	95.63
322		96.57	0.37	0.30	ND	97.24
323		94.14	0.38	0.30	ND	94.83
325		94.70	0.37	0.33	ND	95.40
Average:		96.73	0.36	0.22	—	97.31

Notes: ND = not detected (below detection limit of 99% confidence). Average composition of the gold associated with sphalerite = $Au_{0.986}$ $Ag_{0.007}$ $Cu_{0.007}$. — = not applicable.

Table T13. Chemical composition of the gold grains filling voids and/or lining vesicles in quartz, Hole 1189B.

Core, section, piece, interval (cm)	Depth (mbsf)	Element (wt%)				
		Au	Ag	Cu	Hg	Total
193-1189B-						
10R-1(Piece 3, 24–34)	118.1					
326		93.90	0.18	0.13	ND	94.21
327		94.47	0.25	0.14	ND	94.85
331		92.62	2.51	0.10	ND	95.23
332		93.61	2.32	0.09	ND	96.02
333		92.86	2.51	0.08	ND	95.45
289		93.91	2.50	0.11	ND	96.52
290		94.19	2.45	0.09	ND	96.73
309		92.32	3.63	0.07	ND	96.01
310		92.45	3.66	0.07	ND	96.18
311		91.13	3.71	0.08	ND	94.92
313		91.61	3.62	ND	ND	95.23
Average:		93.01	2.48	0.10	—	95.58

Notes: ND = not detected (below detection limit of 99% confidence). Average composition of the gold associated with quartz = $Au_{0.95}$ $Ag_{0.05}$, traces of Cu (0.07–0.14 wt%). — = not applicable.

Table T14. Chemical composition of the gold grains in inclusions in pyrite, Hole 1189B.

Core, section, piece, interval (cm)	Depth (mbsf)	Element (wt%)				Total
		Au	Ag	Cu	Hg	
193-1189B-						
10R-1 (Piece 3, 24–34)	118.1					
299		96.70	1.18	0.07	ND	97.95
300		96.34	1.22	0.10	ND	97.66
301		95.45	1.33	0.09	ND	96.87
302		95.85	1.17	0.08	ND	97.10
Average:		96.08	1.23	0.09	—	97.40

Notes: ND = not detected (below detection limit of 99% confidence). Average composition of the gold associated with pyrite = $Au_{0.97}$ $Ag_{0.02}$, traces of Cu (0.07–0.10 wt%). — = not applicable.

Table T15. Gold at Roman Ruins site, 118 mbsf.

Found in	*N*	Maximum Au (wt%)	Determined chemical composition
Sphalerite	11	99.15	$Au_{0.986}$ $Ag_{0.007}$ $Cu_{0.007}$
Quartz	11	94.47	$Au_{0.95}$ $Ag_{0.05}$, Cu (0.07–0.14 wt%)
Pyrite	4	96.70	$Au_{0.97}$ $Ag_{0.02}$, Cu (0.07–0.10 wt%)

Note: *N* = number of analyses.

Table T16. Chemical composition of magnetite, Hole 1188A.

Core, section, piece, interval (cm)	Depth (mbsf)	Element oxide (wt%)							Total
		Al_2O_3	MgO	MnO	TiO_2	ZnO	FeO	Cr_2O	
193-1188A-									
21R-1 (Piece 3, 29–34)	183.4								
2		0.69	0.02	0.06	3.33	0.09	88.71	0.01	92.90
4		0.75	0.06	0.10	3.16	0.35	87.45	ND	91.87
33		1.72	ND	0.14	4.42	0.07	84.22	0.31	90.89
Average:		1.05	0.04	0.10	3.64	0.17	86.79	0.16	91.95

Note: ND = not detected (below detection limit of 99% confidence).

Table T17. Chemical composition of magnetite, Hole 1188F. (**See table notes.** Continued on next page.)

Core, section, piece, interval (cm)	Depth (mbsf)	Element oxide (wt%)												Total
		Al_2O_3	MgO	MnO	TiO_2	ZnO	FeO	Cr_2O_3	SiO_2	Cu_2O	V_2O_3	CaO	K_2O	
193-1188F-														
34Z-1 (Piece 5, 25–28)	336.7													
36		0.50	0.04	0.18	0.05	0.01	90.27	0.02	—	—	—	—	—	91.06
38		0.48	0.01	0.14	ND	ND	91.28	0.04	—	—	—	—	—	91.94
39		0.49	0.04	ND	0.82	ND	90.36	0.01	—	—	—	—	—	91.72
40		1.89	0.04	0.06	0.87	ND	86.61	0.09	—	—	—	—	—	89.55
41		2.44	0.04	0.11	0.96	ND	77.96	ND	—	—	—	—	—	81.52
45		0.45	0.04	0.24	0.08	ND	90.68	ND	—	—	—	—	—	91.49
46		0.55	0.04	0.15	0.05	0.16	91.09	0.04	—	—	—	—	—	92.08
47		0.37	0.03	0.07	0.10	0.05	91.33	ND	—	—	—	—	—	91.94
50		0.41	0.06	ND	0.12	0.20	89.53	ND	—	—	—	—	—	90.32
Average:		0.84	0.04	0.11	0.38	0.05	88.79	0.02	—	—	—	—	—	90.23
34Z-1 (Piece 9B, 46–49)	336.9													
28		1.34	0.02	0.07	1.70	ND	89.35	0.04	ND	—	—	—	—	92.53
31		2.05	0.04	0.15	2.92	0.10	87.66	ND	ND	—	—	—	—	92.93
26		2.25	0.07	0.08	3.01	0.01	86.23	0.11	ND	—	—	—	—	91.76
25		2.49	0.03	0.21	3.12	0.01	86.55	0.11	ND	—	—	—	—	92.51
27		2.86	0.12	0.25	3.42	ND	87.10	0.02	ND	—	—	—	—	93.76
24		1.24	0.02	0.19	4.79	0.36	86.38	0.04	ND	—	—	—	—	93.03
32		2.15	0.07	0.37	6.10	ND	84.64	0.03	ND	—	—	—	—	93.35
334		2.99	0.08	0.24	2.63	ND	86.23	ND	0.13	ND	0.41	—	—	92.72
335		2.91	0.04	0.22	3.18	ND	85.40	ND	0.15	ND	0.39	—	—	92.28
336		2.15	ND	0.22	2.59	ND	86.05	ND	0.19	ND	0.36	—	—	91.56
337		2.33	ND	0.31	4.32	ND	84.50	0.06	0.14	ND	0.54	—	—	92.20
338		2.84	0.07	0.48	7.99	0.09	80.69	ND	0.20	ND	0.16	—	—	92.52
339		3.41	0.16	0.14	1.94	ND	84.56	ND	0.53	ND	0.64	—	—	91.38
340		2.01	0.06	0.17	1.37	ND	87.12	0.07	0.15	ND	0.64	—	—	91.59
342		3.56	0.10	0.25	2.62	ND	83.74	0.05	0.12	ND	1.82	—	—	92.26
343		1.89	ND	0.09	1.22	ND	88.46	ND	0.12	ND	0.35	—	—	92.14
Average:		2.40	0.06	0.22	3.31	0.04	85.92	0.03	0.11	ND	0.33	—	—	92.41
34Z-1 (Piece 12), 64–67	337.1													
9		0.91	0.20	0.11	0.05	ND	91.54	ND	—	—	—	—	—	92.81
12		3.39	0.18	0.15	0.08	ND	90.48	0.02	—	—	—	—	—	94.31
7		0.75	0.04	0.02	0.09	ND	91.10	0.04	—	—	—	—	—	92.04
9		1.79	0.06	0.05	0.10	ND	91.25	ND	—	—	—	—	—	93.26
11		3.65	0.17	0.03	0.13	ND	90.99	0.02	—	—	—	—	—	94.99
8		2.47	0.12	0.16	0.16	ND	91.18	ND	—	—	—	—	—	94.10
10		4.67	0.23	0.08	0.18	ND	89.51	0.07	—	—	—	—	—	94.74
6		4.07	0.21	ND	0.20	ND	89.32	ND	—	—	—	—	—	93.79
27		1.27	0.04	0.07	0.27	ND	89.82	ND	—	—	—	—	—	91.46
19		4.98	0.12	0.27	0.34	ND	88.57	0.06	—	—	—	—	—	94.33
17		4.72	0.17	0.23	0.35	ND	88.29	ND	—	—	—	—	—	93.76
15		4.13	0.15	0.06	0.45	ND	88.34	ND	—	—	—	—	—	93.14
13		1.70	0.08	0.30	0.59	ND	90.42	ND	—	—	—	—	—	93.08
5		4.79	0.25	0.20	0.64	ND	88.53	ND	—	—	—	—	—	94.42
21		3.55	0.07	0.07	0.77	ND	89.51	0.06	—	—	—	—	—	94.03
20		4.05	0.25	0.13	0.83	ND	87.91	0.02	—	—	—	—	—	93.19
5		4.56	0.29	0.09	0.83	ND	88.68	ND	—	—	—	—	—	94.46
4		4.25	0.21	ND	0.89	ND	90.17	ND	—	—	—	—	—	95.52
30		4.16	0.22	0.22	0.90	ND	85.76	0.02	—	—	—	—	—	91.28
32		14.37	0.23	0.13	0.91	ND	75.66	0.02	—	—	—	—	—	91.32
12		5.47	1.26	0.25	0.94	ND	83.21	0.01	—	—	—	—	—	91.14
31		5.00	0.23	0.26	0.99	ND	86.50	ND	—	—	—	—	—	92.97
6		5.39	0.21	0.15	1.13	ND	87.32	ND	—	—	—	—	—	94.19
16		2.84	0.53	0.16	1.20	ND	85.38	0.02	—	—	—	—	—	90.14
23		7.68	0.42	0.15	1.24	ND	83.83	0.02	—	—	—	—	—	93.35
18		0.47	0.05	0.14	1.33	ND	90.39	ND	—	—	—	—	—	92.39
24		0.39	0.03	0.14	1.48	ND	87.51	0.03	—	—	—	—	—	89.56
8		0.34	0.06	0.02	1.84	ND	89.82	0.07	—	—	—	—	—	92.15
22		0.40	0.05	0.19	1.89	ND	86.53	ND	—	—	—	—	—	89.06
28		5.91	0.25	0.10	2.40	ND	83.28	0.02	—	—	—	—	—	91.97
7		0.40	0.04	0.12	2.71	ND	88.33	ND	—	—	—	—	—	91.61
26		0.36	0.05	0.19	3.25	ND	86.29	0.06	—	—	—	—	—	90.19
344		1.67	0.13	0.14	ND	ND	82.73	ND	0.27	ND	ND	—	—	84.94
345		2.42	0.07	0.15	0.37	ND	87.15	ND	1.22	ND	ND	—	—	91.38
346		1.47	0.04	0.10	0.31	0.15	85.57	ND	0.22	ND	ND	—	—	87.86
347		0.43	0.05	0.25	1.39	ND	84.03	ND	0.33	ND	0.08	—	—	86.57

Table T17 (continued).

Core, section, piece, interval (cm)	Depth (mbsf)	Element oxide (wt%)											Total
		Al_2O_3	MgO	MnO	TiO_2	ZnO	FeO	Cr_2O_3	SiO_2	Cu_2O	V_2O_3	CaO	K_2O	
348		6.50	0.43	0.19	0.98	ND	83.79	ND	1.19	ND	0.08	—	—	93.16
349		1.91	0.07	0.26	0.24	ND	87.64	ND	0.68	ND	ND	—	—	90.81
350		1.87	0.10	0.15	0.86	0.23	85.63	ND	0.49	ND	0.11	—	—	89.44
351		0.72	0.07	0.20	0.18	0.09	88.74	ND	0.30	ND	0.07	—	—	90.38
352		0.73	0.03	0.13	0.11	ND	79.22	ND	1.48	ND	0.09	—	—	81.80
353		2.05	0.06	0.25	0.24	ND	88.98	ND	1.24	ND	ND	—	—	92.83
354		0.35	ND	0.13	0.88	ND	81.42	ND	0.52	ND	0.07	—	—	83.37
361		0.35	0.03	0.15	1.83	ND	79.89	ND	0.44	ND	ND	—	—	82.68
362		0.67	ND	0.31	1.66	0.10	81.82	ND	0.35	ND	0.07	—	—	84.99
364		0.41	0.04	0.24	1.03	ND	82.25	ND	0.55	ND	0.07	—	—	84.60
Average:		2.92	0.17	0.16	0.87	ND	86.83	ND	0.20	ND	ND	—	—	91.16
37Z-2 (Piece 3, 28–33)	346.1													
7		3.47	0.03	0.04	1.77	ND	87.67	ND	—	0.19	—	ND	0.03	93.20
8		0.93	0.05	0.43	2.70	0.14	88.28	0.03	—	0.26	—	ND	0.04	92.86
9		4.21	0.06	0.29	1.87	ND	86.39	ND	—	0.35	—	0.02	0.07	93.26
10		7.21	0.22	0.03	2.72	0.19	83.84	ND	—	0.11	—	ND	0.03	94.35
11		4.77	0.11	0.41	3.37	ND	84.84	ND	—	0.14	—	0.04	0.05	93.73
Average:		4.12	0.09	0.24	2.49	0.07	86.20	ND	—	0.21	—	ND	0.04	93.46

Notes: ND = not detected (below detection limit of 99% confidence). — = not analyzed.

Table T18. Chemical composition of chromite, Hole 1188A.

Core, section, piece, interval (cm)	Depth (mbsf)	Element oxide (wt%)							Total
		Al_2O_3	MgO	MnO	TiO_2	ZnO	FeO	Cr_2O_3	
193-1188A-									
21R-1 (Piece 3, 29–34)	183.4								
13		11.48	6.49	ND	0.22	—	29.51	50.29	98.00
14		10.25	5.49	ND	0.27	—	31.49	51.07	98.57
15		9.69	4.49	ND	0.28	—	33.70	51.13	99.29
16		12.20	7.83	ND	0.24	—	26.66	51.34	98.28
17		11.01	5.91	ND	0.25	—	29.30	52.08	98.55
18		10.56	5.55	ND	0.22	—	31.37	50.90	98.60
19		7.26	3.53	ND	0.84	—	38.18	48.16	97.97
25		10.72	5.54	ND	0.22	—	30.98	50.72	98.18
31		11.46	5.86	ND	0.24	—	30.24	50.20	98.01
Average:		10.51	5.63	ND	0.31	—	31.27	50.65	98.38

Notes: ND = not detected (below detection limit of 99% confidence). — = not analyzed.

Table T19. Chemical composition of ilmenite, Hole 1188F.

Core, section, piece, interval (cm)	Depth (mbsf)	Element oxide (wt%)											Total
		Al_2O_3	MgO	MnO	TiO_2	ZnO	FeO	Cr_2O_3	CaO	SiO_2	Cu_2O	V_2O_3	
193-1188F-													
34Z-1 (Piece 5, 25–28)	336.7												
44		1.38	0.15	3.47	40.48	0.25	46.51	ND	—	2.19	—	—	94.47
403		0.90	0.08	3.38	57.56	ND	34.61	ND	—	0.22	ND	ND	96.76
404		0.63	0.15	3.57	39.21	ND	45.33	ND	—	1.58	ND	ND	90.46
405		0.21	0.13	3.80	42.40	ND	47.99	ND	—	0.35	ND	ND	94.87
406		0.24	0.06	1.35	64.71	ND	28.18	ND	—	0.23	ND	ND	94.77
407		0.20	0.04	0.40	52.93	ND	39.74	ND	—	0.14	ND	0.07	93.52
408		1.23	0.44	3.46	45.17	0.10	41.38	ND	—	1.46	ND	ND	93.23
409		0.22	ND	0.60	66.04	ND	25.95	ND	—	0.28	ND	0.09	93.16
410		0.79	0.06	0.80	71.21	ND	18.17	0.05	—	1.02	ND	ND	92.09
411		1.11	0.10	1.99	54.07	ND	36.66	ND	—	0.81	ND	ND	94.74
413		0.27	0.07	1.50	61.28	ND	32.49	ND	—	0.18	ND	0.06	95.85
414		3.39	0.16	1.91	64.65	ND	19.45	ND	—	4.60	ND	ND	94.15
415		7.06	0.95	0.09	50.72	ND	35.76	ND	—	ND	ND	0.15	94.73
416		7.20	1.01	ND	50.14	ND	36.04	ND	—	0.13	ND	0.15	94.67
417		0.80	0.16	3.32	46.00	ND	43.87	ND	—	1.31	ND	ND	95.45
419		1.07	0.13	1.59	52.66	ND	36.56	ND	—	1.54	ND	ND	93.56
420		22.20	9.66	0.28	ND	ND	22.25	ND	—	40.41	ND	ND	94.80
422		0.43	0.05	1.97	54.94	ND	33.09	ND	—	0.34	ND	ND	90.83
Average:		2.74	0.79	1.97	53.77	ND	34.67	ND	—	3.34	ND	0.03	97.31
34Z-1 (Piece 9B, 46–49)	336.9												
15		2.86	2.72	0.13	58.76	ND	33.52	0.03	0.01	0.05	—	—	98.08
16		2.60	2.66	0.06	55.61	ND	34.62	0.10	ND	1.44	—	—	97.08
17		2.77	2.62	0.14	57.02	0.04	34.56	0.17	0.03	0.09	—	—	97.44
20		2.04	2.75	0.15	58.54	ND	34.29	0.01	0.03	0.05	—	—	97.86
21		2.42	2.51	0.11	57.49	ND	35.09	0.03	0.04	0.05	—	—	97.74
22		1.84	2.75	0.19	58.56	ND	34.39	0.01	ND	0.10	—	—	97.75
329		4.20	2.39	ND	49.66	ND	33.55	ND	—	3.75	ND	0.28	93.82
330		0.20	0.13	2.76	41.06	ND	49.14	ND	—	0.20	ND	0.18	93.66
331		0.21	0.16	3.63	40.65	ND	49.60	ND	—	0.26	ND	ND	94.50
332		5.35	0.70	2.52	30.09	ND	40.78	ND	—	11.54	ND	0.08	91.05
Average:		2.45	1.94	1.08	50.74	ND	37.95	0.04	ND	1.75	ND	0.05	96.00
34Z-1 (Piece 9A, 45–47)	336.9												
380		2.72	3.35	0.09	55.19	ND	34.19	0.22	—	0.20	ND	0.07	96.03
381		2.95	3.45	0.14	55.78	ND	34.30	0.21	—	0.13	ND	0.17	97.13
382		4.36	4.14	ND	50.58	ND	31.19	0.25	—	6.76	ND	ND	97.28
383		2.83	3.46	0.09	55.55	ND	33.69	0.16	—	0.65	ND	ND	96.43
384		3.33	3.27	0.15	54.97	ND	34.06	0.14	—	0.22	ND	ND	96.14
385		3.26	2.75	ND	52.98	ND	34.67	0.25	—	0.64	ND	0.11	94.66
386		3.20	3.29	ND	54.69	ND	33.71	0.19	—	0.11	ND	0.06	95.25
387		2.34	3.60	ND	55.60	ND	34.42	0.12	—	0.50	ND	ND	96.58
388		4.09	2.73	ND	53.26	ND	33.65	ND	—	1.29	ND	0.12	95.14
389		3.52	2.17	0.12	46.98	ND	33.62	0.08	—	2.29	ND	0.12	88.90
390		3.54	2.86	ND	54.00	ND	34.46	ND	—	0.54	ND	0.13	95.53
393		6.10	2.92	0.12	54.09	ND	31.04	0.08	—	2.39	ND	0.37	97.11
Average:		3.52	3.17	0.06	53.64	ND	33.58	0.14	—	1.31	—	0.10	95.52
37Z-2 (Piece 3, 28–33)	346.1												
1		3.16	0.34	0.11	52.76	ND	39.63	0.01	0.01	0.12	—	—	96.14
3		0.04	0.10	3.29	43.84	ND	51.54	ND	ND	0.03	—	—	98.84
4		2.88	0.35	0.01	52.86	ND	40.60	ND	0.01	0.02	—	—	96.73
12		0.14	0.09	1.67	39.29	ND	55.32	ND	0.01	0.09	—	—	96.61
424		0.94	0.13	3.04	42.28	ND	49.00	ND	—	0.31	ND	ND	95.70
425		0.54	0.11	2.82	41.08	ND	49.34	ND	—	0.41	ND	ND	94.30
Average:		1.28	0.19	1.82	45.35	ND	47.57	ND	ND	0.16	ND	ND	96.38

Notes: ND = not detected (below detection limit of 99% confidence). — = not analyzed.

Table T20. Chemical composition of iron spinel (hercynite), Hole 1188F.

Core, section, piece, interval (cm)	Depth (mbsf)	Element oxide (wt%)												Total
		Al_2O_3	MgO	MnO	TiO_2	ZnO	FeO	Cr_2O_3	CaO	Si_2O	K_2O	Cu_2O	V_2O_3	
193-1188F-														
34Z-1 (Piece 9B, 46–49)	336.9													
5		54.55	7.65	0.26	0.45	0.16	36.34	0.01	0.03	—	0.03	—	—	99.48
6		54.03	7.33	0.16	0.26	0.23	36.07	0.10	0.03	—	0.01	—	—	98.22
7		53.99	7.46	0.32	0.48	0.19	36.82	ND	0.03	—	0.07	—	—	99.36
8		53.46	8.39	0.24	0.43	0.26	36.43	0.10	0.05	—	0.04	—	—	99.40
10		53.71	9.00	0.23	0.53	0.25	34.93	0.10	0.03	—	0.02	—	—	98.80
11		53.32	9.24	0.13	0.48	0.20	34.58	0.13	0.02	—	0.02	—	—	98.12
29		47.20	7.48	0.24	0.89	0.14	43.25	ND	0.05	—	0.02	—	—	99.27
315		55.13	8.84	0.17	0.41	0.19	36.10	ND	—	0.12	—	ND	0.07	101.03
316		55.43	7.84	0.31	0.49	0.22	36.71	ND	—	0.11	—	ND	0.13	101.25
317		54.99	9.35	0.14	0.42	0.10	34.97	ND	—	0.17	—	ND	0.07	100.20
318		54.77	7.65	0.18	0.96	0.14	36.39	0.05	—	0.64	—	ND	ND	100.78
319		56.50	8.12	0.19	0.35	ND	35.58	ND	—	0.13	—	ND	0.10	100.97
320		56.19	7.76	0.45	0.39	0.10	35.32	ND	—	0.25	—	ND	ND	100.46
321		54.75	7.70	0.31	0.58	0.25	33.81	ND	—	1.62	—	ND	0.10	99.13
322		48.49	8.29	0.31	0.58	0.23	30.50	ND	—	5.92	—	ND	ND	94.32
323		55.43	7.67	0.34	0.43	0.14	35.85	ND	—	0.76	—	ND	0.08	100.70
324		48.48	9.06	0.24	0.78	0.15	29.04	ND	—	6.51	—	ND	ND	94.27
325		56.78	6.91	0.10	0.45	0.19	35.28	0.06	—	0.50	—	ND	0.21	100.47
328		51.13	6.43	0.20	2.08	0.24	38.54	ND	—	1.70	—	ND	0.09	100.41
Average:		53.60	8.01	0.24	0.60	0.19	35.61	0.03	0.01	0.97	0.01	ND	0.04	99.31
34Z-1 (Piece 9A, 45–47)	336.9													
368		58.54	6.69	0.12	0.30	0.33	34.53	0.05	—	0.70	—	ND	0.08	101.34
369		59.73	10.03	0.16	0.36	0.20	29.92	0.09	—	0.11	—	ND	ND	100.60
370		59.20	9.56	0.13	0.36	0.17	30.52	ND	—	0.19	—	ND	0.10	100.23
373		60.03	10.33	0.20	0.22	0.11	29.93	ND	—	0.08	—	ND	0.10	101.00
395		59.45	9.20	0.18	0.24	0.15	31.24	ND	—	0.07	—	ND	0.13	100.66
396		58.10	8.91	0.17	0.30	0.12	31.28	ND	—	0.12	—	ND	0.13	99.13
397		57.17	7.89	0.13	4.70	0.09	29.64	0.08	—	1.14	—	ND	0.12	100.96
398		59.02	8.30	0.14	0.30	0.20	31.08	ND	—	1.37	—	ND	0.11	100.52
399		60.43	10.72	0.17	0.23	0.11	28.93	ND	—	0.11	—	ND	0.09	100.79
400		59.26	9.18	ND	0.31	0.15	30.90	ND	—	0.37	—	ND	0.14	100.31
402		58.60	7.67	0.14	0.34	0.18	33.08	ND	—	0.51	—	ND	0.13	100.65
Average:		59.05	8.95	0.15	0.70	0.16	31.00	0.02	—	0.43	—	ND	0.10	100.58
34Z-1 (Piece 12, 64–67)	337.1													
3		44.78	2.83	0.17	1.07	0.12	43.55	0.10	0.03	—	—	—	—	92.65
37Z-2 (Piece 3, 28–33)	346.1													
2		45.66	2.11	0.28	0.84	0.11	50.30	ND	0.01	0.17	0.08	—	—	99.56
5		42.36	1.40	0.19	1.07	0.18	52.48	0.04	0.04	0.03	0.06	—	—	97.85
6		41.83	1.31	0.26	1.20	0.17	52.61	ND	0.03	0.07	0.06	—	—	97.54
13		43.13	1.22	0.13	0.48	0.00	53.76	ND	0.03	0.31	0.06	—	—	99.12
426		35.01	1.37	0.29	0.97	0.09	53.28	ND	—	6.03	—	—	—	97.04
Average:		41.60	1.48	0.23	0.91	0.11	52.49	ND	0.02	1.32	0.05	—	—	98.21

Notes: ND = not detected (below detection limit of 99% confidence). — = not analyzed.

Table T21. Chemical composition of the iron-titanium oxides, Hole 1188F.

Core, section, piece, interval (cm)	Depth (mbsf)	Element oxide (wt%)										Total
		Al_2O_3	MgO	MnO	TiO_2	ZnO	FeO	Cr_2O_3	Si_2O	Cu_2O	V_2O_3	
1193-1188F-												
34Z-1 (Piece 9A, 45–47)	336.9											
376		0.25	ND	ND	94.80	ND	1.09	ND	0.33	ND	0.30	96.77
374		0.70	0.03	ND	93.11	ND	1.13	0.08	1.27	ND	0.20	96.52
392		1.06	0.05	0.11	86.85	ND	4.74	ND	1.88	ND	0.14	94.83
375		0.22	ND	ND	81.49	ND	11.01	0.14	1.92	ND	0.12	94.90
Average:		0.56	0.02	0.02	89.06	ND	4.49	0.04	1.35	ND	0.19	95.73

Note: ND = not detected (below detection limit of 99% confidence).

Table T22. Chemical composition of the single pyrophanite, Hole 1188F.

Core, section, piece, interval (cm)	Depth (mbsf)	Element oxide (wt%)								Total
		MgO	MnO	TiO_2	ZnO	FeO	Cr_2O_3	CaO	Si_2O	
193-1188F-34Z-1(Piece 9B, 46–49) 18	336.9	ND	47.45	51.52	ND	ND	0.06	ND	0.63	99.66

Notes: ND = not detected (below detection limit of 99% confidence). Pyrophanite = $Mn_{2.03}Ti_{1.95}O_{6.02}$.