Chemical Data for Rock, Sediment, Biological, Precipitate, and Water Samples from Abandoned Copper Mines in Prince William Sound, Alaska

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Conversion Factors

Multiply	By	To obtain
Length		
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
Volume		
liter (L)	33.82	ounce, fluid (fl. oz)
liter (L)	61.02	cubic inch (in^3)
Mass		
milligram (mg)	3.215×10^{-5}	ounce, troy (oz)
milligram (mg)	3.527×10^{-5}	ounce, avoirdupois (oz)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows: °F=(1.8×°C)+32

Datum

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27)

Chapter A. Introduction

By Randolph A. Koski, LeeAnn Munk, Wayne C. Shanks, III,
Lisa L. Stillings, and Andrea L. Foster

In the early 20th century, approximately 6 million metric tons of copper ore were mined from numerous deposits located along the shorelines of fjords and islands in Prince William Sound, Alaska. At the Beatson, Ellamar, and Threeman mine sites (fig. 1), rocks containing Fe, Cu, Zn, and Pb sulfide minerals are exposed to chemical weathering in abandoned mine workings and remnant waste piles that extend into the littoral zone. Field investigations in 2003 and 2005 as well as analytical data for rock, sediment, precipitate, water, and biological samples reveal that the oxidation of sulfides at these sites is resulting in the generation of acid mine drainage and the transport of metals into the marine environment (Koski and others, 2008; Stillings and others, 2008).

At the Ellamar and Threeman sites, plumes of acidic and metal-enriched water are flowing through beach gravels into the shallow offshore environment. Interstitial water samples collected from beach sediment at Ellamar have low pH levels (to ~3) and high concentrations of metals including iron, copper, zinc, cobalt, lead, and mercury. The abundant precipitation of the iron sulfate mineral jarosite in the Ellamar gravels also signifies a low-pH environment. At the Beatson mine site (the largest copper mine in the region) seeps containing iron-rich microbial precipitates drain into the intertidal zone below mine dumps (Foster and others, 2008). A stream flowing down to the shoreline from underground mine workings at Beatson has near-neutral pH, but elevated levels of zinc, copper, and lead (Stillings and others, 2008). Offshore sediment samples at Beatson are enriched in these metals. Preliminary chemical data for tissue from marine mussels collected near the Ellamar, Threeman, and Beatson sites reveal elevated levels of copper, zinc, and lead compared to tissue in mussels from other locations in Prince William Sound (Koski and others, 2008).

Three papers presenting results of this ongoing investigation of sulfide oxidation in Prince William Sound are in press. Koski and others (2008) provide an overview of rock alteration, surface water chemistry, and the distribution of metals at the Ellamar, Threeman, and Beatson mine sites. Based on a 60-day, stream-discharge experiment at

Beatson in 2005, Stillings and others (2008) analyze changes in water chemistry during storm events and the flux of metals to the shoreline. Foster and others (2008) investigate the biomass and diversity of microbial communities present in surface waters (streams, seeps, pore waters) using fatty acid methyl ester (FAMES) data and principal component analysis. The publications cited above contain a subset of the total chemical data for rock, sediment, biological, precipitate, and water samples collected from the three mine sites in 2003 and 2005. The purpose of this report is the presentation of complete chemical data sets for all samples collected during the two field periods of fieldwork. Data for a small number of samples collected at two other mines (Schlosser and Fidalgo, fig. 1), visited in 2003, are also included in the tables.

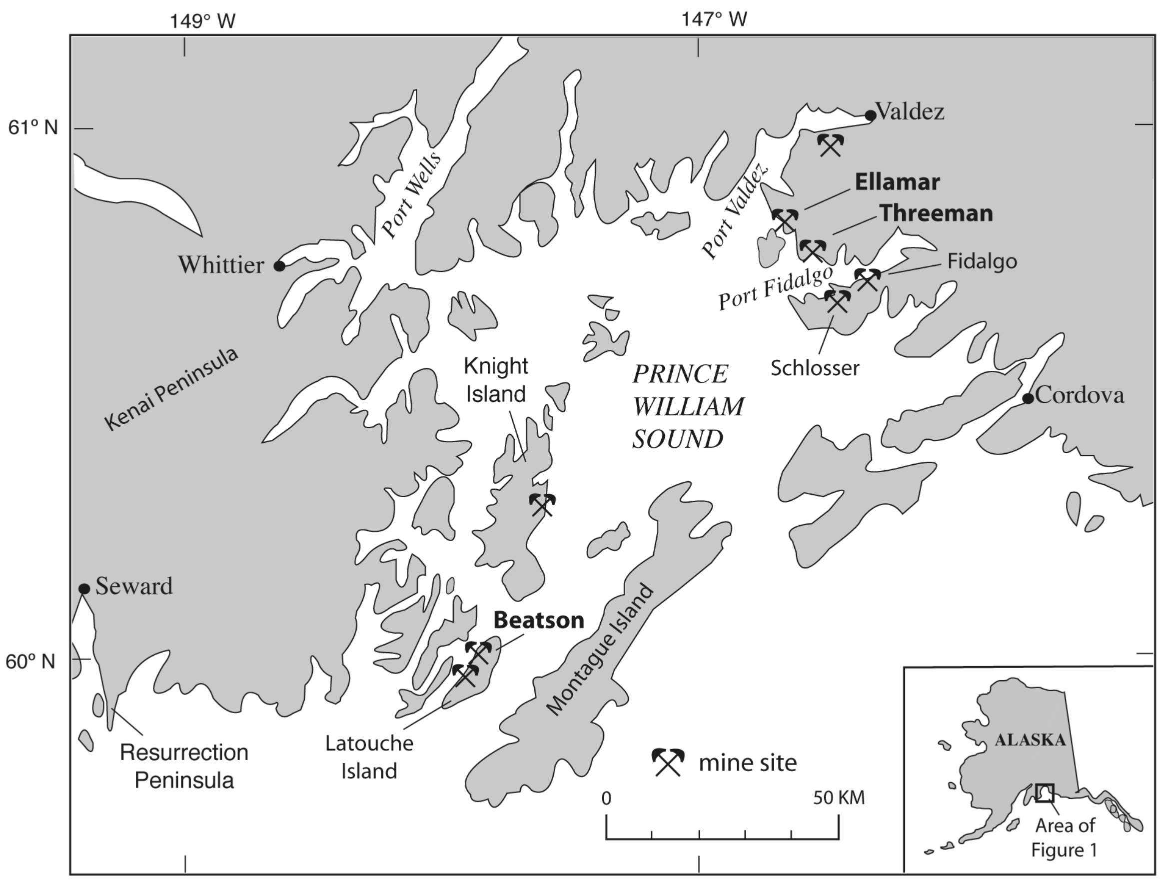

Figure 1. Location of abandoned copper mines in Prince William Sound. Chemical data for samples from named mines are presented in this report.

Chapter B. Chemical data for sulfide-rich rock samples

By Randolph A. Koski

During fieldwork in Prince William Sound in 2003 and 2005, sulfide-bearing rock samples were collected at five mine sites from surface and underground mine workings, mine talus, ore bunkers, ore and waste dumps, and beach gravels (table1). Most samples are massive sulfide dominated by sulfide minerals including pyrrhotite, pyrite, chalcopyrite and sphalerite or semi-massive sulfide composed of sulfide minerals plus variable amounts of quartz, chlorite, talc, and carbonate minerals (Koski and others, 2008). Three of the samples (two from Threeman, one from Beatson) are deeply weathered, and contain abundant amorphous iron oxyhydroxide.

Twenty rock samples were analyzed in laboratories of the U.S. Geological Survey in Denver, Colorado (table 2). Most major and trace elements were determined by inductively coupled plasma-mass spectrometry following multi-acid (HCl-HNO_3-$HClO_4$-HF) digestion (Briggs and Meier, 2002). Mercury was determined by cold-vapor atomic absorption spectroscopy (Brown et al., 2002a), Se by hydride-generation atomic absorption spectrophotometry (Hageman et al., 2002), total S and total C by combustion (Brown and Curry, 2002a,b), and CO_2 and carbonate carbon by coulometric titration (Brown et al., 2002b). Additional details regarding sample preparation and detection limits are found in Taggert (2002). In addition, gold in fourteen samples was analyzed by the fire assay technique at XRAL Laboratories, Toronto, Canada. Detailed mineralogical descriptions and electron microprobe data for sulfide minerals are presented in Koski and others (2008).

Table 1. Locations and descriptions of rock samples.

Sample number	Mine site	Latitude	Longitude	Sample location	Sample description; major minerals
PWS-03-100	Ellamar	60°53.674'	-146°42.082'	beach gravel, intertidal	massive sulfide; pyrite
PWS03R-1	Ellamar	60°53.674'	-146°42.082'	beach gravel at low tide line	massive sulfide; pyrite, carbonate
PWS03R-8A2	Ellamar	60°53.682'	-146°42.080'	beach gravel, intertidal	massive sulfide; chalcopyrite, pyrite, carbonate
PWS03R-8A3	Ellamar	60°53.682'	-146°42.080'	beach gravel, intertidal	massive sulfide; pyrite, sphalerite
PWS03R-8C	Ellamar	60°53.682'	-146°42.080'	beach gravel above high tide line	massive sulfide; pyrite, chalcopyrite, quartz
PWS03R-9	Ellamar	60°53.696	-146°42.120'	outcrop, eastern edge of glory hole	massive pyrite; pyrite
05PWSE006R	Ellamar	60°53.679'	-146°42.085'	beach gravel, intertidal	massive sulfide; pyrite
05PWSBR001Ra	Ellamar	60°53.678'	-146°49.304'	Busby Reef [a]	massive sulfide; pyrite, chalcopyrite
PWS03R-3A	Threeman	60°51.266'	-146°34.600'	ore bunker on beach	semi-massive sulfide; chalcopyrite, pyrrhotite, quartz
PWS03R-4A	Threeman	60°51.203'	-146°32.281'	mine talus below lowest adit	massive sulfide; pyrrhotite, chalcopyrite, quartz, chlorite
PWS03R-5A	Threeman	60°51.186'	-146°32.266'	rubbly ore pile at base of slope	massive sulfide, oxidized; pyrrhotite chalcopyrite
05PWST003R	Threeman	60°51.186'	-146°32.266'	rubbly ore pile at base of slope	massive sulfide, oxidized; sulfur, chlinochlore, chalcopyrite, goethite
05PWSB002R	Beatson	60°03.189'	-147°54.143'	mine dump	massive sulfide; chalcopyrite; pyrrhotite
05PWSB004Rb	Beatson	60°03.238'	-147°54.035'	mine dump	massive sulfide; chalcopyrite, talc
05PWSB005R	Beatson	60°03.167'	-147°54.078'	mine dump	massive sulfide; quartz, chalcopyrite
05PWSB007Ra	Beatson	60°02.890'	-147°54.250'	mine dump	semi-massive sulfide; quartz, chalcopyrite, pyrite
05PWSB007Rb	Beatson	60°02.890'	-147°54.250'	mine dump	semi-massive sulfide; quartz, carbonate, chalcopyrite, sphalerite
05PWSB011R	Beatson	60°02.962'	-147°54.272'	mine dump	massive sulfide, oxidized; quartz, pyrite, chlinochlore
PWS03R-2C	Fidalgo	60°47.905'	-146°18.204'	ore bunker on beach	semi-massive sulfide; pyrrhotite, chalcopyrite, chlinochlore
SM-1	Schlosser	n.r.	n.r.	mine talus below adit	massive sulfide; pyrite

[a]Ellamar ore sample collected from ship wreck site on Busby Reef

n.r. = not recorded

Table 2. Chemical data for rock samples.

Sample numbers			PWS-03-100	PWS03R-1	PWS03R-8A2	PWS03R-8A3	PWS03R-8C	PWS03R-9	05PWSE006R	05PWSBR001Ra	PWS03R-3A	PWS03R-4A
Mine site			Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Threeman	Threeman
Element	Method	Units										
Al	ICPMS	wt. %	0.077	1.3	0.121	0.399	0.166	0.049	0.293	0.215	1.04	1.09
CO_2	CT	wt. %	n.a.	n.a.	3.42	3.09	6.72	0.03	0.01	0.05	n.a.	n.a.
CARB C	CT	wt. %	n.a.	n.a.	0.93	0.84	1.83	0.01	<0.003	0.01	n.a.	n.a.
C(total)	COMB	wt. %	n.a.	n.a.	1.1	0.97	1.89	0.1	0.09	0.09	n.a.	n.a.
Ca	ICPMS	wt. %	0.035	4.16	0.505	2.43	4.21	0.028	0.007	0.003	0.112	0.636
Fe	ICPMS	wt. %	38	23	26	28	30	42	41	24	33	20
K	ICPMS	wt. %	<0.002	0.036	<0.002	0.004	<0.002	<0.002	0.107	<0.002	0.220	0.003
Mg	ICPMS	wt. %	0.068	0.362	0.202	0.205	0.209	0.0206	0.0146	0.0749	0.487	0.834
Na	ICPMS	wt. %	0.004	0.011	0.004	0.027	0.002	0.010	0.078	0.009	0.052	0.003
P	ICPMS	wt. %	<0.0008	0.007	<0.0008	0.001	0.001	<0.0008	<0.0008	<0.0008	0.005	0.002
S	COMB	wt. %	n.a.	n.a.	34.6	38.2	35.7	49.9	52	34	n.a.	n.a.
Ti	ICPMS	wt. %	0.004	0.021	<0.004	0.004	<0.004	<0.004	0.026	0.008	0.054	0.046
Ag	ICPMS	mg/kg	n.a.	n.a.	27	28	21	17	26	12	n.a.	n.a.
As	ICPMS	mg/kg	380	75	88	1000	120	320	280	250	800	98
Au	FA	mg/kg	n.a.	n.a.	1.17	20.3	1.48	2.91	1.8	1.77	n.a.	n.a.
Ba	ICPMS	mg/kg	24	272	13	156	57	13	54	2.7	53	3.7
Be	ICPMS	mg/kg	0.008	0.07	0.01	0.08	0.02	0.006	0.02	0.008	0.05	0.06
Bi	ICPMS	mg/kg	n.a.	n.a.	11	0.11	4.5	3.7	5.8	3.6	n.a.	n.a.
Cd	ICPMS	mg/kg	5.9	5.8	9.8	477	7.4	18	2.7	3.6	6.4	17
Ce	ICPMS	mg/kg	<0.05	10	<0.5	0.84	2.3	<0.5	<0.5	2.4	3	2.6
Co	ICPMS	mg/kg	25.5	416	786	7.7	435	62	14	529	854	323
Cr	ICPMS	mg/kg	3.4	17	1.6	1.6	0.8	0.4	2.8	2.6	34	47
Cs	ICPMS	mg/kg	0.02	0.11	0.05	0.03	0.03	0.02	0.06	0.02	0.11	0.02
Cu	ICPMS	mg/kg	7760	67200	122000	2010	58200	3140	1360	150000	23600	104000
Ga	ICPMS	mg/kg	1.6	6.1	6.4	120	1.8	3.6	2.3	2	3.7	3.3
Hg	CVAA	mg/kg	n.a.	n.a.	0.64	61	0.05	4.4	7.2	0.48	n.a.	n.a.
La	ICPMS	mg/kg	<0.3	5.1	<0.3	0.71	1.7	<0.3	<0.3	1.2	1.3	1.4
Li	ICPMS	mg/kg	<0.2	38	<0.2	1.2	<0.2	<0.2	<0.2	<0.2	2.5	<0.2
Mn	ICPMS	mg/kg	68	638	334	359	453	255	6.3	14	228	337
Mo	ICPMS	mg/kg	14	4.4	13	18	15	16	16	0.92	1.9	0.97
Nb	ICPMS	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Ni	ICPMS	mg/kg	8.2	29	1.5	4.8	2.6	1.7	4.6	3.4	82	130
Pb	ICPMS	mg/kg	93	23	23	325	42	185	258	32	1570	15
Rb	ICPMS	mg/kg	0.06	1.5	0.05	0.11	0.03	0.06	3.2	0.05	6.6	0.2
Sb	ICPMS	mg/kg	9.7	1.4	1.6	23	4.2	16	6.4	7.7	1.4	0.05
Sc	ICPMS	mg/kg	0.4	2.4	<0.3	0.3	<0.3	<0.3	0.6	0.5	4.8	4.8
Se	HYD	mg/kg	n.a.	n.a.	200	7.2	170	17	140	440	n.a.	n.a.
Sr	ICPMS	mg/kg	2.3	39	4.3	24	30	1.1	2.3	4.6	6	11
Ta	ICPMS	mg/kg	n.a.	n.a.	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	n.a.	n.a.
Th	ICPMS	mg/kg	0.03	1.9	0.06	0.08	0.06	<0.03	0.38	0.49	0.59	0.28
Tl	ICPMS	mg/kg	22	2.6	2.4	17	3.9	8.5	0.59	1.9	<0.003	<0.003
U	ICPMS	mg/kg	0.26	2.1	4.6	4.9	2.8	1.7	0.97	0.16	0.16	0.08
V	ICPMS	mg/kg	5.3	27	7.4	42	4.6	8.8	9.3	4.5	37	29
Y	ICPMS	mg/kg	<0.3	4.9	<0.3	0.58	0.94	<0.3	<0.3	<0.3	3	1.1
Zn	ICPMS	mg/kg	1880	1800	3740	169000	2460	7700	679	1030	2400	4760

ICPMS = Inductively coupled plasma-mass spectrometry; CT = Coulometric titration; COMB = Combustion in Leco analyzer; FA = Fire assay; CVAA = Cold vapor-atomic absorption spectrometry; HYD = Hydride generation-atomic absorption spectrophotometry; CARB C = carbonate carbon; n.a. = not analyzed

Table 2. (cont.)

Sample numbers			PWS03R-5A	05PWST003R	05PWSB002R	05PWSB004Rb	05PWSB005R	05PWSB007Ra	05PWSB007Rb	05PWSB011R	PWS03R-2C	SM-1
Mine site			Threeman	Threeman	Beatson	Beatson	Beatson	Beatson	Beatson	Beatson	Fidalgo	Schlosser
Element	Method	Units										
Al	ICPMS	wt. %	0.900	1.18	0.083	1.8	0.436	0.828	0.20	5.69	1.39	0.016
CO_2	CT	wt. %	<0.01	0.04	0.17	0.02	0.13	<0.01	4.64	1.08	n.a.	n.a.
CARB C	CT	wt. %	<0.003	0.01	0.05	0.01	0.04	<0.003	1.27	0.29	n.a.	n.a.
C(total)	COMB	wt. %	<0.01	0.67	0.06	0.05	0.03	0.03	1.27	0.46	n.a.	n.a.
Ca	ICPMS	wt. %	0.078	0.213	0.068	0.054	0.064	0.036	1.86	0.799	0.060	0.005
Fe	ICPMS	wt. %	44	40	22	21	16	19	23	14	26	38
K	ICPMS	wt. %	0.003	0.060	<0.002	<0.002	<0.002	<0.002	0.003	0.043	0.113	<0.002
Mg	ICPMS	wt. %	0.0625	0.578	0.106	4.53	0.516	1.18	0.987	8.97	1.04	0.0060
Na	ICPMS	wt. %	0.010	0.107	0.006	0.003	0.004	0.003	0.006	0.007	0.058	0.002
P	ICPMS	wt. %	<0.0008	0.002	<0.0008	0.038	0.011	0.016	<0.0008	0.045	0.008	0.001
S	COMB	wt. %	35.3	14.3	32.2	19.7	22.3	29.8	24	3.59	n.a.	n.a.
Ti	ICPMS	wt. %	<0.004	0.064	<0.004	0.006	0.005	0.005	<0.004	0.063	0.055	<0.0002
Ag	ICPMS	mg/kg	7.5	4.8	54	45	64	64	47	7.7	n.a.	n.a.
As	ICPMS	mg/kg	8.7	13	22	24	9.5	340	9100	66	17	160
Au	FA	mg/kg	0.042	0.013	0.082	0.069	0.066	0.157	1.61	0.015	n.a.	n.a.
Ba	ICPMS	mg/kg	<0.5	13	9.8	14	8.6	9.8	66	147	71	9.1
Be	ICPMS	mg/kg	0.004	0.03	0.009	0.08	0.04	0.04	0.03	0.22	0.06	0.02
Bi	ICPMS	mg/kg	2.7	1.9	12	45	21	16	59	3.7	n.a.	n.a.
Cd	ICPMS	mg/kg	5.1	1.8	24	13	7.3	14	153	3.1	4.5	1.5
Ce	ICPMS	mg/kg	<0.5	0.95	<0.5	0.84	0.8	1.5	1.9	29	2.2	1.1
Co	ICPMS	mg/kg	580	97	143	114	52	268	70	18	109	31
Cr	ICPMS	mg/kg	0.3	49	<0.2	5.9	2.2	4.5	1.2	69	11	<0.2
Cs	ICPMS	mg/kg	0.01	0.06	0.02	0.04	0.03	0.03	0.07	0.25	0.20	0.008
Cu	ICPMS	mg/kg	36200	26700	155000	95600	150000	106000	73600	10400	84000	2020
Ga	ICPMS	mg/kg	0.45	2.9	1.6	14	2.6	3.9	2.8	15	6.9	0.28
Hg	CVAA	mg/kg	0.04	0.04	0.06	0.02	<0.02	<0.02	<0.02	2.9	n.a.	n.a.
La	ICPMS	mg/kg	<0.3	0.45	<0.3	0.41	0.41	0.6	1.1	16	1.2	0.56
Li	ICPMS	mg/kg	<0.2	<0.2	<0.2	1.3	2.1	0.2	<0.2	7.5	1.6	<0.2
Mn	ICPMS	mg/kg	73	380	132	184	128	114	1350	1450	344	11
Mo	ICPMS	mg/kg	1.8	19	0.93	11	1.2	0.68	2.1	0.67	11	6.3
Nb	ICPMS	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Ni	ICPMS	mg/kg	129	19	45	5	17	12	17	12	15	<1
Pb	ICPMS	mg/kg	5.1	4.7	27	52	404	559	4150	69	22	53
Rb	ICPMS	mg/kg	0.28	1.1	0.11	0.07	0.07	0.06	0.11	1.3	4.2	0.08
Sb	ICPMS	mg/kg	0.08	0.42	4.3	1.9	3.1	7.1	134	2.1	<0.02	5.6
Sc	ICPMS	mg/kg	<0.3	4.5	<0.3	1.1	0.5	0.8	0.6	9	2.1	<0.3
Se	HYD	mg/kg	380	170	200	210	280	210	78	16	n.a.	n.a.
Sr	ICPMS	mg/kg	1.5	11	5.1	4.1	2.4	1.8	128	109	3.8	1.4
Ta	ICPMS	mg/kg	<0.2	<0.2	<0.2	0.28	<0.2	<0.2	<0.2	0.33	n.a.	n.a.
Th	ICPMS	mg/kg	<0.03	0.16	0.04	0.35	0.33	0.33	0.1	4.7	1.2	0.1
Tl	ICPMS	mg/kg	0.02	0.03	0.2	0.09	0.2	0.71	0.75	0.07	<0.003	5.6
U	ICPMS	mg/kg	0.05	1.8	0.04	1.3	0.13	0.14	0.04	0.71	0.48	0.25
V	ICPMS	mg/kg	1.3	39	1.1	21	4	11	1.7	86	29	<0.4
Y	ICPMS	mg/kg	<0.3	2.2	<0.3	0.96	0.46	0.54	3.1	3.6	1.1	2.6
Zn	ICPMS	mg/kg	1320	706	7690	3500	2390	4760	57000	1170	942	511

Chapter C. Chemical data for sediment samples

By Randolph A. Koski and Wayne C. Shanks, III

During studies of sulfide oxidation in coastal areas of Prince William Sound in 2003 and 2005, sediment samples were collected from the intertidal zones and in offshore locations near several abandoned mine sites (table 3). Intertidal sediment samples from the beach environment range from fine to coarse sand whereas offshore samples are mixtures of mud, silt, and fine sand. The offshore samples were collected by dredging and coring devices deployed from a small boat as well as by remotely operated vehicle. Twenty-six sediment samples from the Ellamar, Threeman, and Beatson sites were analyzed in laboratories of the U.S. Geological Survey in Denver, Colorado (table 4). Major and trace elements were determined by inductively coupled plasma-mass spectrometry following multi-acid (HCl-HNO_3-$HClO_4$-HF) digestion (Briggs and Meier, 2002) except for mercury, which was analyzed by cold-vapor atomic absorption spectroscopy (Brown et al., 2002). Additional details regarding sample preparation and detection limits are found in Taggert (2002). A discussion of metal concentrations in the sedimentary deposits is presented in Koski and others (2008).

Table 3. Locations and descriptions of sediment samples.

Sample Number	Mine site	Latitude	Longitude	Sample Location	Sample Description
03Ellamar-Pit 1	Ellamar	60°53.682'	-146°42.083'	intertidal zone near Ellamar pier, beach pit	sand with jarosite precipitate
03Ellamar-Pit 2	Ellamar	60°53.682'	-146°42.083'	intertidal zone near Ellamar pier, beach pit	sand with jarosite precipitate
03Ellamar-Pit 3	Ellamar	60°53.682'	-146°42.083'	intertidal zone near Ellamar pier, beach pit	sand with jarosite precipitate
03Ellamar-Pit 4	Ellamar	60°53.682'	-146°42.083'	intertidal zone near Ellamar pier, beach pit	sand with jarosite precipitate
03Ellamar-Pit 5	Ellamar	60°53.682'	-146°42.083'	intertidal zone near Ellamar pier, beach pit	sand with jarosite precipitate
PWS03-SELL-4	Ellamar	n.r.	n.r.	shallow offshore near end of Ellamar pier	sand
PWS03S-3	Ellamar	60°53.696'	-146°42.134'	offshore, bottom of Ellamar glory hole	silt
PWS030S-102	Ellamar	n.r.	n.r.	offshore	mud
05PWSE-002S	Ellamar	60°53.662'	-146°41.998'	upper intertidal zone	red beach sand
05PWSE-008S	Ellamar	60°53.637'	-146°42.156'	offshore, 6 m water depth	olive brown silt and sand
05PWSE-108S	Ellamar	60°53.701'	-146°42.239'	shallow offshore, near Ellamar glory hole	brownish-black sand
05PWSE-110R	Ellamar	60°53.653'	-146°42.093'	offshore, near low tide line	dark gray sand
05PWSE-111S	Ellamar	60°53.653'	-146°42.093'	offshore, near low tide line	black mud and silt
05PWSE-112S	Ellamar	60°53.582'	-146°42.355'	offshore, 5 m water depth	gray sand
05PWSE-207S	Ellamar	60°53.680'	-146°42.086'	intertidal zone near Ellamar pier, beach pit	brown sand
05PWSE-208S	Ellamar	60°53.680'	-146°42.086'	intertidal zone near Ellamar pier, beach pit	brown sand
05PWST-115S	Threeman	60°51.068'	-146°32.124'	offshore, 14 m water depth	olive-brown silt
05PWST-118S	Threeman	60°51.068'	-146°32.243'	lower intertidal zone	sand with Fe-oxyhydroxide precipitate
05PWST-120S	Threeman	60°51.150'	-146°32.247'	offshore, 3 m water depth	olive-brown silt
05PWST-304S-1	Threeman	60°51.206'	-146°32.228'	intertidal zone, beach pit	gray sand
05PWST-305SM-1	Threeman	60°51.180'	-146°32.260'	intertidal zone, beach pit	gray sand
05PWST-306SM-2	Threeman	60°51.182'	-146°32.261'	intertidal zone, beach pit	olive-brown sand
05PWST-308SM-1	Threeman	n.r.	n.r.	upper intertidal zone	beach sand near ore pile
05PWSB-010S	Beatson	60°03.287'	-147°54.344'	offshore, 33 m water depth	gray-brown mud and silt
05PWSB-101S	Beatson	60°03.209'	-147°54.201'	offshore, near low tide line	sand
05PWSB-104S	Beatson	60°03.213'	-147°54.272'	offshore, low tide line	sand

n.r. = not recorded

Table 4. Chemical data for sediment samples.

Sample numbers			03Ellamar-Pit 5	03Ellamar-Pit 4	03Ellamar-Pit 2	03Ellamar-Pit 1	03Ellamar-Pit 3	PWS03-SELL-4	PWS03S-3	PWS030S-102	05PWSE-002S	05PWSE-008S	05PWSE-108S	05PWSE-110R	05PWSE-111S
Mine site			Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar
Location			intertidal	intertidal	intertidal	intertidal	intertidal	offshore	glory hole	offshore	intertidal	offshore	offshore	offshore	offshore
Element	Method	Units													
Al	ICPMS	wt. %	2.99	0.65	3.65	4.19	5.37	5.84	7.06	6.12	4.75	6.56	4.39	7.24	6.58
Ca	ICPMS	wt. %	0.061	0.028	0.046	0.042	0.059	3.66	0.494	1.87	0.124	1.32	2.23	1.47	1.64
Fe	ICPMS	wt. %	18.8	40.6	24.5	18.6	19.3	5.86	9.95	4.65	19	3.4	4.5	4.5	5.1
K	ICPMS	wt. %	1.27	2.02	2.43	2.8	2.73	1.07	1.53	1.14	1.60	1.28	1.11	1.54	1.36
Mg	ICPMS	wt. %	0.281	0.0713	0.148	0.0888	0.512	1.61	1.24	1.64	0.64	1.42	1.64	1.61	1.47
Na	ICPMS	wt. %	0.624	0.206	0.695	1.8	0.786	3.05	1.87	3.48	0.746	1.65	4.32	1.73	1.64
P	ICPMS	wt. %	0.0514	0.0284	0.023	0.0177	0.0808	0.174	0.152	0.116	0.057	0.066	0.20	0.10	0.17
Ti	ICPMS	wt. %	0.219	0.0874	0.253	0.256	0.311	0.456	0.451	0.466	0.21	0.37	0.24	0.42	0.38
Ag	ICPMS	mg/kg	62	5.5	12	1.0	2.5	0.50	0.70	0.34	3.5	<3	<3	<3	<3
As	ICPMS	mg/kg	284	346	196	43	191	23	64	16	160	7.1	34	17	31
Au	ICPMS	mg/kg	9.9	1.8	0.60	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	n.a.	n.a.	n.a.	n.a.	n.a.
Ba	ICPMS	mg/kg	76	150	96	224	635	500	865	528	466	590	410	743	635
Be	ICPMS	mg/kg	0.76	0.12	0.72	0.64	1.0	0.88	1.3	0.9	0.86	1.1	0.81	1.3	1.2
Bi	ICPMS	mg/kg	15	3.0	5.1	2.6	2	0.3	1.1	0.23	1.8	0.090	0.34	0.20	0.36
Cd	ICPMS	mg/kg	1.4	0.38	3.4	0.031	0.06	<0.01	0.70	0.78	0.30	0.33	0.43	0.13	0.45
Ce	ICPMS	mg/kg	14	4.0	22	17	29	26	35	29	23	30	22	33	33
Co	ICPMS	mg/kg	50	68	14	11	7.5	14	22	11	32	8.0	8.9	12	13
Cr	ICPMS	mg/kg	38	9.8	35	38	66	81	91	80	70	94	68	102	99
Cs	ICPMS	mg/kg	2.1	0.26	1.6	2.4	3.2	2.2	4.0	2.5	1.8	1.9	1.9	2.2	2.4
Cu	ICPMS	mg/kg	4400	2240	2450	1440	1310	294	2020	374	3690	41	498	121	487
Dy	ICPMS	mg/kg	0.82	0.22	0.91	0.75	1.2	3.6	3.2	3.9	n.a.	n.a.	n.a.	n.a.	n.a.
Er	ICPMS	mg/kg	0.45	0.14	0.45	0.34	0.56	2.1	1.6	2.4	n.a.	n.a.	n.a.	n.a.	n.a.
Eu	ICPMS	mg/kg	0.42	0.066	0.38	0.29	0.49	0.93	1.1	1.0	n.a.	n.a.	n.a.	n.a.	n.a.
Ga	ICPMS	mg/kg	12	9.7	12	11	15	13	17	14	16	14	9.8	16	15
Gd	ICPMS	mg/kg	0.98	0.21	1.32	0.87	1.7	3.2	3.7	3.6	n.a.	n.a.	n.a.	n.a.	n.a.
Ge	ICPMS	mg/kg	23	2.2	4.0	1.4	1.9	0.75	1.7	0.67	n.a.	n.a.	n.a.	n.a.	n.a.
Hg	CVAA	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1.3	0.060	0.66	0.23	0.76
Ho	ICPMS	mg/kg	0.15	0.041	0.17	0.12	0.21	0.76	0.62	0.81	n.a.	n.a.	n.a.	n.a.	n.a.
In	ICPMS	mg/kg	0.35	0.12	0.15	0.13	0.18	< 0.01	0.33	0.10	n.a.	n.a.	n.a.	n.a.	n.a.
La	ICPMS	mg/kg	7.0	2.0	11	8.8	15	14	17	16	12	16	12	18	18
Li	ICPMS	mg/kg	20	5.3	14	16	31	33	73	34	43	51	31	55	50
Mn	ICPMS	mg/kg	106	64	34	8.5	161	554	375	543	230	502	359	589	523
Mo	ICPMS	mg/kg	88	26	13	11	18	9.3	12	20	31	4.4	5.3	3.4	5.7
Nb	ICPMS	mg/kg	3.1	1.5	3.8	3.5	4.7	5.5	7.8	6.0	6.3	9.0	6.6	11	10
Nd	ICPMS	mg/kg	6.1	1.7	9.3	6.9	12	14	17	15	n.a.	n.a.	n.a.	n.a.	n.a.

ICPMS = Inductively coupled plasma-mass spectrometry; CVAA = Cold vapor-atomic absorption spectrometry; n.a. = not analyzed

Table 4. (cont.)

Sample numbers			03Ellamar-Pit 5	03Ellamar-Pit 4	03Ellamar-Pit 2	03Ellamar-Pit 1	03Ellamar-Pit 3	PWS03-SELL-4	PWS03S-3	PWS030S-102	05PWSE-002S	05PWSE-008S	05PWSE-108S	05PWSE-110R	05PWSE-111S
Mine site			Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar	Ellamar
Location			intertidal	intertidal	intertidal	intertidal	intertidal	offshore	glory hole	offshore	intertidal	offshore	offshore	offshore	offshore
Element	Method	Units													
Ni	ICPMS	mg/kg	12	3.6	6.0	1.0	7.8	32	28	27	11	26	21	34	31
Pb	ICPMS	mg/kg	1480	297	581	33	139	149	202	44	128	13	56	28	66
Pr	ICPMS	mg/kg	1.6	0.44	2.5	1.9	3.3	3.3	4.0	3.8	n.a.	n.a.	n.a.	n.a.	n.a.
Rb	ICPMS	mg/kg	28	6.9	44	51	61	38	62	41	46	46	36	56	52
Re	ICPMS	mg/kg	0.052	0.012	< 0.01	< 0.01	< 0.01	0.01	< 0.01	0.011	n.a.	n.a.	n.a.	n.a.	n.a.
Sb	ICPMS	mg/kg	157	15	14	2.2	5.6	1.5	4.5	1.0	9.4	0.44	1.2	0.88	1.8
Sc	ICPMS	mg/kg	6.3	1.9	8.2	8.8	12	13	14	14	10	16	11	17	17
Se	ICPMS	mg/kg	58	30	32	26	21	2.4	7.2	2.0	n.a.	n.a.	n.a.	n.a.	n.a.
Sm	ICPMS	mg/kg	1.3	0.35	1.8	1.3	2.3	3.2	3.7	3.5	n.a.	n.a.	n.a.	n.a.	n.a.
Sn	ICPMS	mg/kg	182	10	8.4	4.0	4.6	364	25	25	n.a.	n.a.	n.a.	n.a.	n.a.
Sr	ICPMS	mg/kg	77	32	75	128	91	354	164	261	119	180	275	216	227
Tb	ICPMS	mg/kg	0.15	0.036	0.18	0.12	0.23	0.54	0.56	0.59	n.a.	n.a.	n.a.	n.a.	n.a.
Te	ICPMS	mg/kg	4.5	3.3	2.7	1.6	1.7	< 0.2	0.72	< 0.2	n.a.	n.a.	n.a.	n.a.	n.a.
Th	ICPMS	mg/kg	2.4	1.2	1.9	1.4	4.2	2.8	5.0	3.2	3.3	4.4	3.0	5.2	5.0
Tl	ICPMS	mg/kg	28	5.8	1.8	6.4	2.6	0.56	0.86	0.59	1.9	0.54	0.52	0.62	0.81
Tm	ICPMS	mg/kg	0.070	0.026	0.069	0.059	0.092	0.32	0.22	0.33	n.a.	n.a.	n.a.	n.a.	n.a.
U	ICPMS	mg/kg	2.0	0.83	0.91	0.64	1.4	3.2	3.1	6.8	4.5	2.8	2.2	2.3	3.3
V	ICPMS	mg/kg	95	43	77	91	150	154	172	146	136	134	144	161	164
W	ICPMS	mg/kg	4.2	0.66	0.81	0.55	0.81	0.98	1.4	0.92	n.a.	n.a.	n.a.	n.a.	n.a.
Y	ICPMS	mg/kg	2.8	0.91	3.2	2.5	4.1	18	13	19	5.2	14	14	16	17
Yb	ICPMS	mg/kg	0.41	0.16	0.43	0.34	0.54	1.7	1.3	1.8	n.a.	n.a.	n.a.	n.a.	n.a.
Zn	ICPMS	mg/kg	512	356	861	37	105	198	982	158	527	86	154	114	260

Table 4. (cont.)

Sample numbers			05PWSE-112S	05PWSE-207S	05PWSE-208S	05PWST-115S	05PWST-118S	05PWST-120S	05PWST-304S-1	05PWST-305SM-1	05PWST-306SM-2	05PWST-308SM-1	05PWSB-010S	05PWSB-101S	05PWSB-104S
Mine site			Ellamar	Ellamar	Ellamar	Threeman	Threeman	Threeman	Threeman	Threeman	Threeman	Threeman	Beatson	Beatson	Beatson
Location			offshore	intertidal	intertidal	offshore	intertidal	offshore	intertidal	intertidal	intertidal	intertidal	offshore	offshore	offshore
Element	Method	Units													
Al	ICPMS	wt. %	6.88	4.69	1.71	8.52	5.08	8.2	10.4	10	7.14	1.36	n.a.	n.a.	7.18
Ca	ICPMS	wt. %	1.25	0.085	0.030	1.44	3.45	1.55	1.11	3.44	1.24	0.246	2.1	0.437	0.371
Fe	ICPMS	wt. %	3.6	18	34	4.0	18	4.3	4.8	9.9	7.6	47	5.8	5.1	6.1
K	ICPMS	wt. %	1.66	1.48	0.538	1.54	0.597	1.57	1.94	0.71	0.284	0.0823	1.36	1.75	1.54
Mg	ICPMS	wt. %	1.51	0.538	0.197	1.78	2.01	2.06	2.15	4.66	3.50	0.654	2.84	1.8	2.26
Na	ICPMS	wt. %	1.50	0.658	0.249	2.93	0.987	3.10	2.33	1.43	1.98	0.130	1.24	1.49	1.12
P	ICPMS	wt. %	0.070	0.039	0.018	0.13	0.30	0.14	0.10	0.072	0.16	0.035	0.072	0.088	0.085
Ti	ICPMS	wt. %	0.43	0.20	0.081	0.060	0.28	0.50	0.50	0.55	0.32	0.049	0.25	0.28	0.22
Ag	ICPMS	mg/kg	<3	7.9	12	<3	<3	<3	<3	<3	<3	3.3	<3	<3	<3
As	ICPMS	mg/kg	11	170	380	9	67	11	9.1	7.9	9.7	21	38	24	50
Au	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Ba	ICPMS	mg/kg	801	183	223	660	274	643	909	299	93	21	760	923	838
Be	ICPMS	mg/kg	1.2	0.90	0.40	1.5	0.59	1.4	1.4	0.73	0.42	0.030	1.2	1.5	1.4
Bi	ICPMS	mg/kg	0.12	1.5	11	0.17	0.16	0.18	0.13	0.16	0.28	4.1	1.3	0.58	1.1
Cd	ICPMS	mg/kg	0.22	1.3	4.4	0.55	0.38	1.3	0.050	0.16	1.4	2.3	1.4	0.080	0.12
Ce	ICPMS	mg/kg	34	24	8.1	48	17	38	43	20	10	1.4	32	40	38
Co	ICPMS	mg/kg	7.9	38	187	10	12	13	14	27	28	204	19	11	16
Cr	ICPMS	mg/kg	103	57	24	89	98	94	105	280	192	43	94	105	92
Cs	ICPMS	mg/kg	2.1	2.0	0.73	3.2	1.2	3.3	2.9	0.99	0.49	0.080	2.7	3.5	3.2
Cu	ICPMS	mg/kg	60.5	2120	3090	88.6	1300	114	377	870	4690	25800	1590	1010	2580
Dy	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Er	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Eu	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Ga	ICPMS	mg/kg	16	14	7.1	15	8.9	15	17	16	9.2	2.7	18	17	18
Gd	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Ge	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Hg	CVAA	mg/kg	0.13	2.6	3.2	0.05	0.14	0.04	0.03	0.02	0.11	<0.02	0.19	0.12	0.16
Ho	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
In	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
La	ICPMS	mg/kg	19	12	4.3	23	8.5	18	21	9.1	4.6	0.60	18	22	21
Li	ICPMS	mg/kg	61	44	17	52	24	55	60	37	21	2.8	46	56	52
Mn	ICPMS	mg/kg	469	232	115	830	888	854	951	2010	1650	470	611	528	738
Mo	ICPMS	mg/kg	2.8	20	20	4.0	5.5	19	0.36	1.2	5.8	43	1.4	1.3	2.4
Nb	ICPMS	mg/kg	11	6.2	2.7	16	5.2	13	14	8.1	2.8	< 2	7.8	8.7	6.8
Nd	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Table 4. (cont.)

Sample numbers			05PWSE-112S	05PWSE-207S	05PWSE-208S	05PWST-115S	05PWST-118S	05PWST-120S	05PWST-304S-1	05PWST-305SM-1	05PWST-306SM-2	05PWST-308SM-1	05PWSB-010S	05PWSB-101S	05PWSB-104S
Mine site			Ellamar	Ellamar	Ellamar	Threeman	Threeman	Threeman	Threeman	Threeman	Threeman	Threeman	Beatson	Beatson	Beatson
Location			offshore	intertidal	intertidal	offshore	intertidal	offshore	intertidal	intertidal	intertidal	intertidal	offshore	offshore	offshore
Element	Method	Units													
Ni	ICPMS	mg/kg	27	16	7.9	29	25	35	31	65	40	36	26	29	25
Pb	ICPMS	mg/kg	16	143	116	15	30	17	24	22	7.8	15	63	59	98
Pr	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Rb	ICPMS	mg/kg	57	46	18	55	20	55	66	22	5.8	1.6	54	70	61
Re	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Sb	ICPMS	mg/kg	0.48	14	15	0.62	0.82	0.82	0.86	0.47	0.35	0.90	1.1	1.4	2.9
Sc	ICPMS	mg/kg	17	9.3	3.6	16	14	18	20	34	23	4.4	15	16	15
Se	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Sm	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Sn	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Sr	ICPMS	mg/kg	200	87	33	246	365	233	222	210	135	15	238	181	144
Tb	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Te	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Th	ICPMS	mg/kg	5.1	3.1	1.4	7.3	2.4	6.0	7.6	3.1	1.1	0.17	5.6	6.3	5.4
Tl	ICPMS	mg/kg	0.56	4.0	8.0	0.50	0.20	0.55	0.40	0.20	0.080	0.020	0.50	0.55	0.51
Tm	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
U	ICPMS	mg/kg	2.6	2.5	1.1	3.6	2.6	8.6	2.4	1.5	6.5	7.3	1.5	1.5	1.7
V	ICPMS	mg/kg	155	114	47	134	172	151	177	258	140	42	137	163	159
W	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Y	ICPMS	mg/kg	15	6.7	2.2	21	14	20	15	19	15	2.2	14	18	16
Yb	ICPMS	mg/kg	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Zn	ICPMS	mg/kg	87	854	820	113	260	132	139	289	938	1100	684	233	350

Chapter D. Chemical Data for Biological Samples

By LeeAnn Munk and Randolph A. Koski

Field investigations of sulfide oxidation at abandoned mine sites in coastal areas of Prince William Sound were conducted in 2003 and 2005. In 2005 marine organisms including mussels, barnacles, gastropods, clams, limpets, eelgrass, and algae were collected from intertidal zones at the Ellamar, Threeman, and Beatson sites (table 5). Biological samples were frozen shortly after collection, and were analyzed in laboratories of the U.S. Geological Survey in Denver, Colorado (table 6). Tissue from animal specimens was hand picked from shell material using tweezers and then freeze dried prior to grinding and analysis. Major and trace elements were determined by inductively coupled plasma-mass spectrometry following multi-acid (HCl-HNO_3-$HClO_4$-HF) digestion (Briggs and Meier, 2002) except for mercury, which was analyzed by cold-vapor atomic absorption spectroscopy (Brown et al., 2002). Details regarding sample preparation and detection limits are found in Taggert (2002). Base metal concentrations in mussels collected near the three mine sites are compared to similar data for mussels from other locations in Prince William Sound in Koski and others (2008).

Table 5. Types and locations of biological samples.

Sample number	Sample type	Mine site	Latitude	Longitude	Location description
05PWS-E201m	mussel	Ellamar	60°53.653'	-146°42.093'	old pier piling
05PWS-T2	mussel	Threeman	60°51.180'	-146°32.257'	rocks near mine debris
05PWS-T	mussel	Threeman	60°51.206'	-146°32.228'	rocks away from mine debris
05PWS-204B	mussel	Beatson	60°03.145'	-146°54.436'	rocky point west of mine debris
05PWS-204Bm	mussel	Beatson	60°03.145'	-146°54.436'	rocky point west of mine debris
05PWS-203Bm	mussel	Beatson	60°03.145'	-146°54.436'	rocky point west of mine debris
05PWS-T1b	barnacle	Threeman	60° 51.180'	-146°32.257'	rocks near mine debris
05PWS-204BA	barnacle	Beatson	60°03.145'	-146°54.436'	rocky point west of mine debris
05PWS-204BB	barnacle	Beatson	60°03.145'	-146°54.436'	rocky point west of mine debris
05PWS-T1g	gastropod	Threeman	60°51.180'	-146°32.257'	rocks near mine debris
05PWS-203Bs	gastropod	Beatson	60°03.145'	-146°54.436'	rocky point west of mine debris
05PWS-T201B	clam	Threeman	60°51.206'	-146°32.228'	beach sand near mine debris
05PWS-T1l	limpet	Threeman	60°51.180'	-146°32.257'	rocks near mine debris
05PWS-E201e	eelgrass	Ellamar	60°53.653'	-146°42.093'	shallow offshore near mine debris
05PWS-E201a	algae	Ellamar	60°53.653'	-146°42.093'	intertidal algal mat near mine debris

Table 6. Chemical data (dry weight) for biological samples.

Sample numbers			05PWS-E201m	05PWS-T2	05PWS-T	05PWS-204B	05PWS-204Bm	05PWS-203Bm	05PWS-T1b	05PWS-204BA	05PWS-204BB	05PWS-T1g	05PWS-203Bs	05PWS-T201B	05PWS-T1l	05PWS-E201e	05PWS-E201a
Organism			mussel	mussel	mussel	mussel	mussel	mussel	barnacle	barnacle	barnacle	gastropod	gastropod	clam	limpet	eelgrass	algae
Mine site			Ellamar	Threeman	Threeman	Beatson	Beatson	Beatson	Threeman	Beatson	Beatson	Threeman	Beatson	Threeman	Threeman	Ellamar	Ellamar
Element	Method	Units															
Al	ICPMS	wt. %	0.050	0.036	0.046	0.042	0.22	0.050	0.055	0.34	0.14	0.14	0.11	0.037	0.34	0.12	1.74
Ca	ICPMS	wt. %	1.20	0.86	1.05	0.59	1.05	0.80	3.56	2.86	10.5	0.55	0.64	1.12	2.46	1.46	1.61
Fe	ICPMS	wt. %	0.037	0.036	0.026	0.041	0.098	0.05	0.081	0.20	0.080	0.12	0.099	0.036	0.36	0.70	4.0
K	ICPMS	wt. %	0.71	0.68	0.89	0.63	0.95	0.57	0.31	0.76	0.53	0.93	0.76	0.93	0.68	0.55	0.45
Mg	ICPMS	wt. %	0.59	0.40	0.70	0.27	0.54	0.29	0.53	0.93	0.77	1.45	0.83	0.70	0.53	1.64	1.32
Na	ICPMS	wt. %	3.23	2.04	4.34	1.22	2.58	1.16	1.97	4.42	3.27	1.50	1.17	4.33	2.26	1.87	0.76
P	ICPMS	wt. %	1.3	0.92	1.2	1.3	2.0	1.2	0.61	1.2	0.80	1.0	0.86	1.1	1.0	0.32	0.19
Ti	ICPMS	wt. %	<0.004	<0.004	<0.004	<0.004	0.0051	<0.004	<0.004	0.011	<0.004	0.0069	0.0042	<0.004	0.016	0.0046	0.059
Ag	ICPMS	mg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
As	ICPMS	mg/kg	5.8	9.7	5.7	7.0	5.6	6.9	9.4	8.0	6.6	12	12	13	10	7.3	39
Ba	ICPMS	mg/kg	4.8	3.5	5.4	9.9	21	13	18	86	81	7.7	19	5.9	22	12	159
Be	ICPMS	mg/kg	0.008	0.007	0.004	0.005	0.03	0.02	0.01	0.04	0.003	0.01	0.04	0.007	0.05	0.01	0.18
Bi	ICPMS	mg/kg	<0.005	0.008	<0.005	0.005	0.010	0.009	0.030	0.020	0.030	0.020	0.020	<0.005	0.020	0.040	0.37
Cd	ICPMS	mg/kg	3.0	5.9	1.0	3.4	3.6	3.2	13	6.8	4.0	0.95	1.3	1.5	4.6	0.69	0.14
Ce	ICPMS	mg/kg	< 0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.97	18.7	0.5	0.78	<0.5	1.2	0.58	5.4
Co	ICPMS	mg/kg	0.79	1.1	1.3	0.68	0.86	0.81	2.0	1.5	0.89	2.9	3.7	1.1	2.8	1.3	3.6
Cr	ICPMS	mg/kg	2.0	2.6	1.8	2.9	3.3	2.7	8.8	4.9	12	3.8	3.6	2.2	8.2	3.2	30
Cs	ICPMS	mg/kg	0.02	0.02	0.02	0.04	0.08	0.04	0.03	0.11	0.04	0.04	0.08	0.02	0.10	0.04	0.44
Cu	ICPMS	mg/kg	45	74	68	86	67	58	564	451	239	1320	1020	227	304	157	1200
Ga	ICPMS	mg/kg	<0.006	0.10	<0.006	0.20	0.20	0.20	0.20	0.34	0.02	0.07	0.34	<0.006	0.37	<0.006	3.2
Hg	CVAA	mg/kg	0.07	0.07	0.03	0.04	0.08	0.08	n.a.	0.08	n.a.	0.11	0.07	0.03	0.07	0.04	0.67
La	ICPMS	mg/kg	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.50	1.9	0.32	0.48	<0.3	0.71	0.32	2.6
Li	ICPMS	mg/kg	1.6	1.8	1.0	1.8	2.4	1.8	4.2	3.4	2.4	0.80	1.8	0.30	1.6	0.90	9
Mn	ICPMS	mg/kg	9.7	8.3	17	8	14	11	13	26	27	50	49	13	50	49	58
Mo	ICPMS	mg/kg	0.27	0.41	0.53	0.26	0.26	0.30	0.60	0.59	0.77	0.46	0.47	0.46	0.38	12	7.2
Nb	ICPMS	mg/kg	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Ni	ICPMS	mg/kg	1.0	1.4	1.1	<1	1.2	1.2	5.4	2.4	5.3	6.3	8.1	2.2	11	2.0	3.9
Pb	ICPMS	mg/kg	0.95	0.92	0.30	2.4	3.0	2.9	1.5	3.4	3.9	1.9	3.5	<0.2	4.2	4.9	35
Rb	ICPMS	mg/kg	2.7	3.2	2.9	3.8	4.4	3.6	1.6	4.4	2.6	3.8	5.2	3.2	3.6	2.0	9.6
Sb	ICPMS	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	0.89	0.03	0.04	0.20	<0.02	0.04	<0.02	0.04	0.31	1.7
Sc	ICPMS	mg/kg	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.4	0.5	<0.3	<0.3	0.4	<0.3	0.6	<0.3	2.8
Sr	ICPMS	mg/kg	85	82	87	53	81	55	328	243	799	60	73	86	187	271	378
Th	ICPMS	mg/kg	<0.03	<0.03	<0.03	0.03	0.08	0.03	0.05	0.16	0.07	0.08	0.09	<0.03	0.20	0.08	0.85
Tl	ICPMS	mg/kg	0.01	0.01	0.007	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.009	0.02	0.03	0.3
U	ICPMS	mg/kg	0.15	0.2	0.23	0.1	0.12	0.16	0.90	0.59	0.65	0.40	0.37	0.31	0.62	0.99	1.8
V	ICPMS	mg/kg	1.5	1.3	1.6	2.4	4.2	2.5	2.0	7.0	3.1	3.8	4.5	1.6	6.7	15	48
Y	ICPMS	mg/kg	<0.3	<0.3	<0.3	<0.3	0.32	<0.3	0.39	0.73	0.71	0.47	0.49	0.30	1.1	0.66	2.5
Zn	ICPMS	mg/kg	117	117	157	177	174	304	890	990	610	135	117	91	150	100	209

ICPMS = Inductively coupled plasma-mass spectrometry; CVAA = Cold vapor-atomic absorption spectrometry; n.a. = not analyzed

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