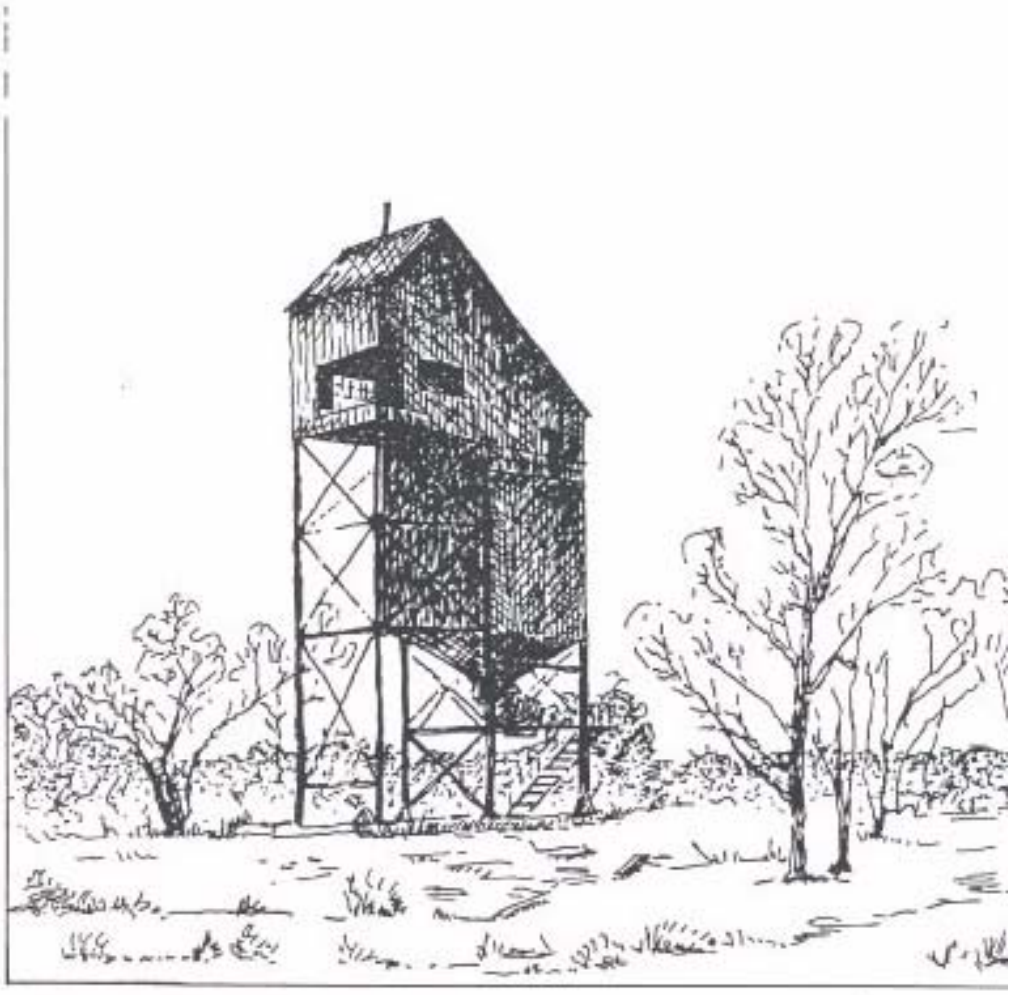
Chemical Analyses of Stream Sediment in the Tar Creek Basin of the Picher Mining Area, Northeast Oklahoma

Open-File Report 88–469



Ore loader in the Tar Creek area

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Chemical Analyses of Stream Sediment in the Tar Creek Basin of the Picher Mining Area, Northeast Oklahoma

By David L. Parkhurst, Michael Doughten, and Paul P. Hearn

Open-File Report 88–469

U.S. Department of the Interior
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Chemical Analyses of Stream Sediment in the Tar Creek Basin of the Picher Mining Area, Northeast Oklahoma

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Abstract

Chemical analyses are presented for 47 sediment samples from the Tar Creek drainage in the Picher mining area of northeast Oklahoma. The samples were taken in December 1983, June 1984, and June 1985. All of the samples were taken downstream from mine-water discharge points of abandoned lead and zinc mines. The 34 samples taken in December 1983 and June 1984 were analyzed semiquantitatively by emission spectrography for 64 elements and quantitatively for cadmium, copper, iron, manganese, nickel, lead, sulfur, zinc, and organic carbon. The 13 samples taken in June 1985 were analyzed quantitatively for aluminum, cadmium, cobalt, chromium, copper, iron, manganese, molybdenum, nickel, phosphorus, lead, sulfur, silicon, titanium, vanadium, zinc, and organic carbon.

Introduction

Lead and zinc were mined from the Picher field in northeast Oklahoma and southeast Kansas from about 1900 until the 1960s. The mines, which were from 100 to 500 feet below land surface, were dewatered by extensive pumpage during active mining. After mining ceased, mine dewatering was stopped and the mines subsequently filled with water. About 1980, mine water began discharging from a few mine shafts and air shafts into the Tar Creek basin. Mine water has discharged intermittently since that time. The stream sediments downstream from the mining area are characteristically red and yellow due to iron oxyhydroxide precipitates formed from the mine-water discharge.

Purpose and Scope

A study of the Picher mining area and Tar Creek was undertaken to determine the chemical evolution of mine water and the effects of mine-water discharge on the chemistry of surface water and surface-water sediments. The purpose of this report is to present chemical analyses of sediment samples collected during the study.

Description of Sampling Sites

Samples were taken from the sediment of Tar Creek and from three tributaries, which drain mine water to Tar Creek. Generally, the characteristic red-yellow iron precipitates were sampled. The precipitates had varied morphology, which ranged from a fine flocculated material to a hard crust which, in some stream reaches, covered the stream bottom. Some samples were taken from the sediment zone underlying the iron precipitates. Figures 1 and 2 show the sampling sites and table 1 lists the site locations by station number

(latitude and longitude) and by a modified legal description (attachment 1). The table also includes a description of the sample location and a short description of the sample.

Methods

Sediment samples were collected in plastic containers from a very small area, generally 100 to 1,000 square centimeters. The samples were allowed to air dry for about 4 weeks and then were sent for analysis to the laboratory of the Geologic Division of the U.S. Geological Survey in Reston, Virginia.

Semiquantitative emission spectrography was performed on weighed quantities of samples which had been ground.

For quantitative analyses, 0.5 grams of sample were weighed, placed in Teflon beakers, and digested overnight and concentrated acids, 5 mL (milliliters) nitric, 2 mL perchloric, and 15 mL hydrofluoric, at approximately 175 °C. The samples were evaporated to dryness and the residue was dissolved in 2N hydrochloric acid to a volume of 50 mL.

Cobalt, chromium, copper, lead, manganese, nickel, vanadium, and zinc were determined by flame atomic absorption or Graphite Furnace Atomic Absorption (GFAA) on the digested samples. For iron and aluminum, it was necessary to dilute the digested samples before analyzing them by Inductively Coupled Argon Plasma Atomic-Emission Spectroscopy (ICAP-AES). Cadmium and molybdenum were determined by using an ion exchange separation followed by GFAA analysis of cadmium and ICAP-AES analysis of molybdenum. Phosphorus, silica, and titanium were determined by fusing 0.2 grams of sample with a lithium metaborate-tetraborate mixture (Shapiro, 1975). The fusion pellets were dissolved in dilute nitric acid and analyzed by ICAP-AES. Sulfur was analyzed by LECO Sulfur Analyzer.

Description of Data Tables

Semiquantitative emission spectrographic data for samples taken in December 1983 and June 1984 are listed in table 2. Quantitative analyses for samples taken in December 1983 and June 1984 are listed in table 3. Quantitative analyses for samples taken in June 1985 are listed in table 4.

Reference Cited

Shapiro, L., 1975, Rapid analysis of silicate, carbonate, and phosphate rocks: U.S. Geological Survey Bulletin 1401 [revised edition], p. 43-46.

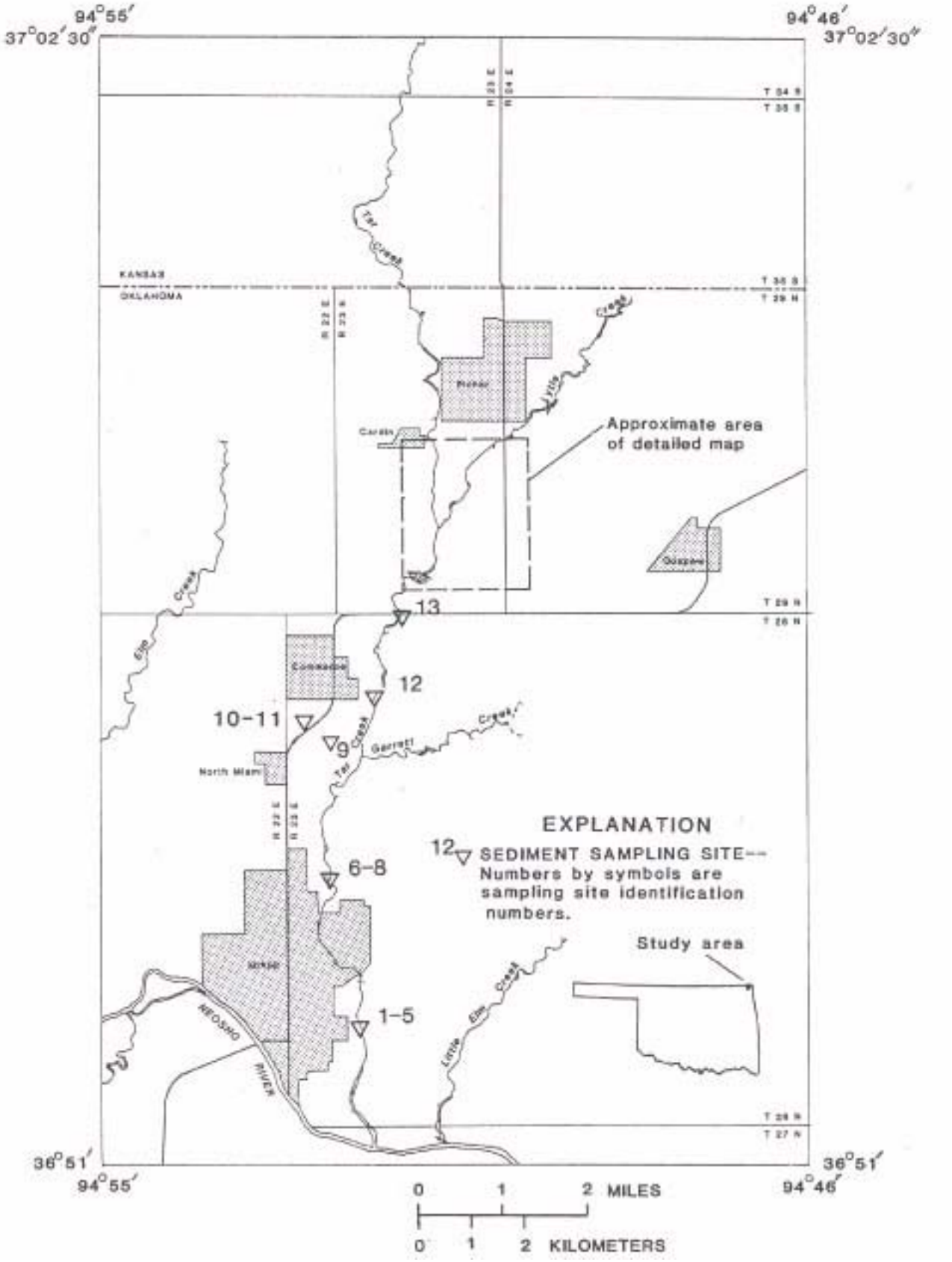

Figure 1. Locations of sampling sites. (Additional sites shown on detailed map.)

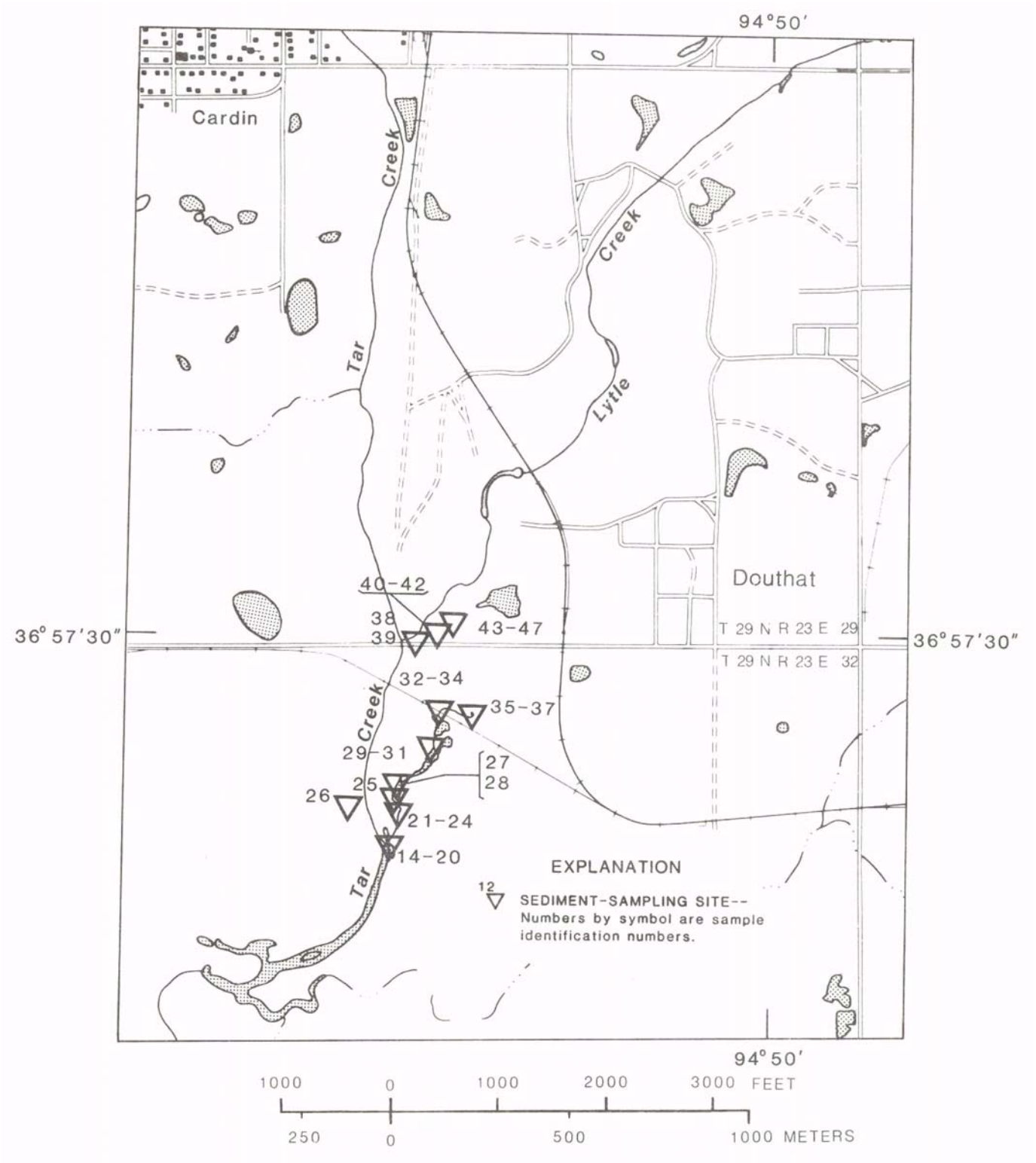

Figure 2. Detailed map showing locations of sampling sites.

Table 1. Sampling locations and sample descriptions.

[Station name: C, Creek; m, meters; nr, near; N, north; RR, railroad; trib, tributary. Sample description: µm, micrometers. Depth: cm, centimeters; surf., indicates sample from sediment surface.]

Sample number	Station	Date	Legal description	Station name	Sample description	Depth (cm)	Lab number
1	365230094514301	6/84	28N-23E-30 DBB 1	Tar C at Central Ave, Miami	iron precipitate on rocks	surf.	D20-47
2	365230094514301	6/84	28N-23E-30 DBB 1	Tar C at Central Ave, Miami	iron precipitate, organic matter	surf.	D20-48
3	365230094514301	6/84	28N-23E-30 DBB 1	Tar C at Central Ave, Miami	iron precipitate, organic matter	surf.	D20-49
4	365230094514301	6/84	28N-23E-30 DBB 1	Tar C at Central Ave, Miami	iron precipitate, black goo	0-5	D20-50
5	365230094514301	6/84	28N-23E-30 DBB 1	Tar C at Central Ave, Miami	iron precipitate	10-15	D20-52
6	365359094520401	6/84	28N-23E-19 ABB 1	Tar C at 22nd Ave, Miami	mud and sand	0-5	D16-43
7	365359094520401	6/84	28N-23E-19 ABB 1	Tar C at 22nd Ave, Miami	sand and silt	5-10	D16-44
8	365359094520401	6/84	28N-23E-19 ABB 1	Tar C at 22nd Ave, Miami	sand and silt	17-25	D16-46
9	365522094521301	6/84	28N-23E-07 CAA 1	Weir downstream from discharge	crusted iron precipitate	surf.	D14-38
10	365533094522801	12/83	28N-23E-07 BBD 1	10 m downstream Cactus Collapse	crusted iron precipitate	surf.	DP-1
11	365533094522801	12/83	28N-23E-07 BBD 1	10 m downstream Cactus Collapse	yellow powder below crust	2-5	DP-2
12	365544094513201	6/84	28N-23E-05 CCC 1	Tar C nr Commerce	layered iron precipitate, clay	surf.	D5-39
13	365637094511201	6/84	29N-23E-31 DCD 1	Tar C at Highway 66	layered iron precipitate	surf.	D10-36
14	365714094504401	12/83	29N-23E-32 BCA 1	Mine trib at Tar Creek	layered iron precipitate	surf.	DP-5
15	365714094504401	6/84	29N-23E-32 BCA 1	Mine trib at Tar Creek	iron precipitate	0-5	DRR-28
16	365714094504401	6/84	29N-23E-32 BCA 1	Mine trib at Tar Creek	silt below iron precipitate	5-10	DRR-29
17	365714094504401	6/84	29N-23E-32 BCA 1	Mine trib at Tar Creek	sand and silt below iron precipitate	10-15	DRR-30
18	365714094504401	6/84	29N-23E-32 BCA 1	Mine trib at Tar Creek	hard, iron precipitate, black coating	surf.	DRR-32
19	365714094504401	6/85	29N-23E-32 BCA 1	Mine trib at Tar Creek	iron precipitate	surf.	DRR-64
20	365714094504401	6/85	29N-23E-32 BCA 1	Mine trib at Tar Creek	clay below iron precipitate	2-5	DRR-65
21	365715094504302	6/84	29N-23E-32 BBD 3	Outflow from mine trib pond	iron precipitate and organic debris	surf.	DRR-25
22	365715094504302	6/84	29N-23E-32 BBD 3	Outflow from mine trib pond	iron precipitate and organic debris	surf.	DRR-27
23	365715094504302	6/85	29N-23E-32 BBD 3	Outflow from mine trib pond	iron precipitate	surf	DRR-62
24	365715094504302	6/85	29N-23E-32 BBD 3	Outflow from mine trib pond	clay below iron precipitate	2-5	DRR-63
25	365715094504301	6/85	29N-23E-32 BBD 2	Mine trib pond	iron precipitate	surf.	DRR-61

Table 1. Sampling locations and sample descriptions.

[Station name: C, Creek; m, meters; nr, near; N, north; RR, railroad; trib, tributary. Sample description: µm, micrometers. Depth: cm, centimeters; surf., indicates sample from sediment surface.]

Sample number	Station	Date	Legal description	Station name	Sample description	Depth (cm)	Lab number
26	365716094504601	6/85	29N-23E-32 BBD 1	Tailings discharge pond	<62 µm silt and clay fraction	surf.	DRR-66
27	365720094504001	6/85	29N-23E-32- BBD 4	Inflow to mine trib pond	iron precipitate	surf.	DRR-59
28	365720094504001	6/85	29N-23E-32- BBD 4	Inflow to mine trib pond	clay below iron precipitate	2-5	DRR-60
29	365720094503801	12/83	29N-23E-32 BAC 1	Mine trib south of RR culvert	iron precipitate	surf.	DP-4
30	365720094503801	6/85	29N-23E-32 BAC 1	Mine trib south of RR culvert	iron precipitate	surf.	DRR-57
31	365720094503801	6/85	29N-23E-32 BAC 1	Mine trib south of RR culvert	clay below iron precipitate	2-5	DRR-58
32	365723094503520	6/84	29N-23E-32 BAB 20	Mine trib N of RR culvert	floating iron precipitate	surf.	DRR-22
33	365723094503520	6/84	29N-23E-32 BAB 20	Mine trib N of RR culvert	iron precipitate and organic debris	surf.	DRR-23
34	365723094503520	6/85	29N-23E-32 BAB 20	Mine trib N of RR culvert	iron precipitate	surf.	DRR-56
35	365723094503501	12/83	29N-23E-32 BAB 1	Near RR borehole	iron precipitate	surf.	DP-3
36	365723094503502	6/85	29N-23E-32 BAB 2	5 m from RR borehole	iron precipitate	surf.	DRR-54
37	365723094503502	6/85	29N-23E-32 BAB 2	5 m from RR borehole	clay below iron precipitate	2-5	DRR-55
38	365730094504014	6/84	29N-23E-29 CDC 14	Mine discharge at Tar Creek	iron precipitate	surf.	D4-9
39	365730094504014	6/84	29N-23E-29 CDC 14	Mine discharge at Tar Creek	iron precipitate	surf.	D4-16
40	365730094504013	6/84	29N-23E-29 CDC 13	10 m downstream from weir	iron precipitate	surf.	D4-11
41	365730094504012	6/84	29N-23E-29 CDC 12	2 m downstream from weir	iron precipitate	surf.	D4-18
42	365730094504011	6/84	29N-23E-29 CDC 6	Near weir	efflorescence	surf.	D4-17
43	365730094504006	6/84	29N-23E-29 CDC 10	10 m from mine-discharge point	iron precipitate and organic debris	surf.	D4-20
44	365730094504006	6/84	29N-23E-29 CDC 10	10 m from mine-discharge point	soil zone below iron precipitate	8-12	D4-21
45	365730094504005	6/84	29N-23E-29 CDC 9	5 m from mine-discharge point	iron precipitate	surf.	D4-12
46	365730094504004	6/84	29N-23E-29 CDC 8	4 m from mine-discharge point	iron precipitate	surf.	D4-14
47	365730094504001	6/84	29N-23E-29 CDC 5	Near mine-discharge point	iron precipitate	surf.	D4-7

Table 2. Semiquantitative chemical analyses of sediment samples taken in December 1983 and June 1984.

[The relative standard deviation for each reported concentration is plus 50 percent and minus 33 percent. --, denotes the occurrence of an unresolved interference; >, indicates concentration is greater than the given value; <, indicates concentration is less than the given value. All samples had concentrations less than the detection limit for the following elements (concentrations in parts per million): Bi <10, In <10, Ir <15, Lu <15, Os <15, Pd <1, Pt <2.2, Re <10, Rh <2.2, Ru <2.2, Sb <68, Ta <320, Tb <32, Th <46, Tl <10, Tm <4.6, U <220, and W <15.]

Sample number	Lab number	Concentrations (in percent)									
		Aluminum	Calcium	Iron	Potassium	Magnesium	Manganese	Sodium	Phosphorous	Silicon	Titanium
1	D20-47	0.79	0.290	>24.0	0.350	0.044	0.00760	2.2000	<0.068	5.40	0.0280
2	D20-48	0.33	0.090	>24.0	<0.150	0.017	0.00720	0.8900	<0.068	1.00	0.0071
3	D20-49	2.20	0.340	17.0	0.360	0.220	0.01100	0.5400	<0.068	26.00	0.1300
4	D20-50	2.60	0.380	16.0	0.490	0.220	0.01600	2.0000	<0.068	25.00	0.1000
5	D20-52	1.80	0.540	16.0	0.290	0.140	0.01700	1.5000	<0.068	19.00	0.0620
6	D16-43	5.40	0.990	9.6	0.860	0.310	0.10000	0.5400	<0.068	>34.00	0.3100
7	D16-44	5.30	1.500	4.7	0.740	0.320	0.08400	0.2900	0.120	>34.00	0.3600
8	D16-46	5.50	0.350	7.1	0.810	0.310	0.19000	0.2600	0.150	>34.00	0.3900
9	D14-38	0.37	0.150	>24.0	<0.150	0.015	0.00630	<0.0022	<0.068	0.44	0.0063
10	DP-1	0.25	0.090	>24.0	0.390	0.026	0.00170	0.2400	<0.068	25.00	0.0320
11	DP-2	0.61	0.043	19.0	6.400	0.046	0.00360	0.3800	<0.068	13.00	0.0370
12	D5-39	2.90	0.270	21.0	0.440	0.200	0.01400	0.9400	<0.068	25.00	0.1200
13	D10-36	0.21	0.390	6.5	<0.068	0.018	0.00520	1.2000	<0.068	0.95	0.0041
14	DP-5	0.49	0.088	>24.0	0.210	0.043	0.00140	0.3600	<0.068	17.00	<0.0032
15	DRR-28	0.10	0.098	>24.0	<0.150	0.015	0.00059	<0.0022	<0.068	0.76	0.0058
16	DRR-29	1.50	2.000	6.7	0.570	0.180	0.00280	0.1500	<0.068	>34.00	0.0600
17	DRR-30	2.70	8.200	1.7	0.440	1.600	0.01600	1.1000	0.150	>34.00	0.0880
18	DRR-32	0.18	0.960	>24.0	<0.150	0.013	0.00190	0.8300	<0.068	3.40	<0.0032
21	DRR-25	3.90	0.230	17.0	0.790	0.220	0.01100	0.3400	<0.068	31.00	0.2400
22	DRR-27	0.16	0.091	>24.0	<0.150	0.017	0.00060	0.1600	<0.068	2.40	0.0100
29	DP-4	0.14	0.100	>24.0	<0.150	0.015	0.00051	<0.0022	<0.068	0.59	0.0067
32	DRR-22	0.31	0.180	>24.0	<0.150	0.017	0.00110	0.2400	<0.068	2.30	0.0058
33	DRR-23	0.26	0.250	>24.0	<0.150	0.023	0.00100	0.3200	<0.068	2.80	0.0460
35	DP-3	0.58	0.840	>24.0	<0.068	0.025	0.00180	0.4600	3.700	4.10	0.0200
38	D4-9	0.90	0.290	>24.0	<0.150	0.037	0.00180	1.3000	<0.068	2.90	0.0100

Table 2. Semiquantitative chemical analyses of sediment samples taken in December 1983 and June 1984.—Continued

[The relative standard deviation for each reported concentration is plus 50 percent and minus 33 percent. --, denotes the occurrence of an unresolved interference; >, indicates concentration is greater than the given value; <, indicates concentration is less than the given value. All samples had concentrations less than the detection limit for the following elements (concentrations in parts per million): Bi <10, In <10, Ir <15, Lu <15, Os <15, Pd <1, Pt <2.2, Re <10, Rh <2.2, Ru <2.2, Sb <68, Ta <320, Tb <32, Th <46, Tl <10, Tm <4.6, U <220, and W <15.]

Sample number	Lab number	Concentrations (in percent)									
		Aluminum	Calcium	Iron	Potassium	Magnesium	Manganese	Sodium	Phosphorous	Silicon	Titanium
39	D4-16	0.52	0.140	>24.0	<0.150	0.022	0.00088	0.5900	<0.068	2.30	0.0066
40	D4-11	0.86	0.780	>24.0	<0.150	0.045	0.00220	1.8000	<0.068	3.30	0.0082
41	D4-18	1.10	0.940	>24.0	<0.150	0.042	0.00330	2.8000	<0.068	0.73	0.0110
42	D4-17	0.22	13.000	4.1	0.150	0.300	0.00740	0.5300	0.170	2.70	0.0150
43	D4-20	0.98	0.790	>24.0	<0.150	0.033	0.00240	1.4000	<0.068	3.10	0.0074
44	D4-21	3.00	0.810	2.9	0.360	0.290	0.00580	0.5800	0.140	>34.00	0.0450
45	D4-12	1.90	0.530	>24.0	<0.150	0.051	0.00320	1.4000	3.200	7.70	0.0140
46	D4-14	1.70	0.760	>24.0	<0.150	0.039	0.00280	1.9000	1.400	2.40	0.0120
47	D4-7	0.83	0.360	>24.0	<0.150	0.019	0.002100	0.4800	>6.800	1.50	0.0110

Table 2. Semiquantitative chemical analyses of sediment samples taken in December 1983 and June 1984–Continued

[The relative standard deviation for each reported concentration is plus 50 percent and minus 33 percent. --, denotes the occurrence of an unresolved interference; >, indicates concentration is greater than the given value; <, indicates concentration is less than the given value. All samples had concentrations less than the detection limit for the following elements (concentrations in parts per million): Bi <10, In <10, Ir <15, Lu <15, Os <15, Pd <1, Pt <2.2, Re <10, Rh <2.2, Ru <2.2, Sb <68, Ta <320, Tb <32, Th <46, Tl <10, Tm <4.6, U <220, and W <15.]

Sample number	Lab number	Concentrations (in percent)												
		Silver	Arsenic	Gold	Boron	Barium	Beryllium	Cadmium	Cerium	Cobalt	Chromium	Copper	Dysprosium	Erbium
1	D20-47	0.58	160	<6.8	<6.8	89.0	2.5	<32	<200	6.8	10.0	4.2	<22	<4.6
2	D20-48	0.55	<100	<6.8	<6.8	4.0	1.0	<32	<200	3.6	<10.0	3.5	<22	<4.6
3	D20-49	1.20	<100	<6.8	20.0	200.0	1.3	<32	<63	3.1	70.0	56.0	<22	<4.6
4	D20-50	0.33	<100	<6.8	22.0	140.0	2.0	<32	<63	11.0	43.0	42.0	<22	<4.6
5	D20-52	0.40	<100	<6.8	16.0	170.0	1.8	<32	<63	7.9	27.0	65.0	<22	<4.6
6	D16-43	0.34	<100	<6.8	48.0	330.0	2.4	<32	<200	23.0	86.0	26.0	<22	<4.6
7	D16-44	0.33	<100	<6.8	52.0	320.0	1.6	<32	<200	15.0	57.0	16.0	<22	<4.6
8	D16-46	0.35	110	<6.8	64.0	280.0	1.8	<32	<200	19.0	77.0	19.0	<22	<4.6
9	D14-38	0.53	<100	<6.8	<6.8	3.1	7.9	<32	<200	19.0	11.0	1.5	<22	<4.6
10	DP-1	0.37	<100	<6.8	11.0	20.0	<1.0	<32	<200	<1.0	33.0	4.5	<22	<4.6
11	DP-2	0.49	<100	<6.8	22.0	38.0	<1.0	<32	<43	<1.0	63.0	79.0	<22	<4.6
12	D5-39	0.21	110	<6.8	19.0	170.0	2.0	<32	<200	3.6	34.0	29.0	<22	<4.6
13	D10-36	<0.10	<100	<6.8	<6.8	25.0	3.9	69	<43	3.2	<1.0	6.8	<22	<4.6
14	DP-5	0.44	<100	<6.8	<6.8	11.0	<1.0	<32	<200	1.8	40.0	7.4	<22	<4.6
15	DRR-28	0.26	<100	<6.8	<6.8	<1.5	<1.0	<32	<200	<1.0	<10.0	<1.0	<22	<4.6
16	DRR-29	0.24	<100	<6.8	18.0	43.0	<1.0	<32	<43	<1.0	45.0	35.0	<22	<4.6
17	DRR-30	0.17	<100	<6.8	25.0	52.0	2.7	<32	<43	3.6	59.0	180.0	<22	<4.6
18	DRR-32	<0.10	<100	<6.8	<6.8	<1.5	<1.0	<32	<200	3.1	<10.0	4.0	<22	<4.6
21	DRR-25	0.38	<100	<6.8	42.0	190.0	<1.0	<32	63	2.9	51.0	15.0	<22	<4.6
22	DRR-27	0.27	<100	<6.8	<6.8	3.0	<1.0	<32	<200	1.0	<10.0	<1.0	<22	<4.6
29	DP-4	0.45	120	<6.8	<6.8	<1.5	<1.0	<32	<200	1.1	32.0	1.5	<22	<4.6
32	DRR-22	0.31	<100	<6.8	<6.8	<1.5	<1.0	<32	<200	1.5	75.0	<1.0	<22	<4.6
33	DRR-23	0.38	140	<6.8	<6.8	<1.5	<1.0	<32	<200	<1.0	<10.0	<1.0	<22	<4.6
35	DP-3	0.39	230	<6.8	<6.8	14.0	3.7	<32	<200	2.2	50.0	1.6	<22	<4.6
38	D4-9	0.26	160	<6.8	<6.8	<1.5	13.0	<32	<200	4.2	5.2	4.6	58	33.0

Table 2. Semiquantitative chemical analyses of sediment samples taken in December 1983 and June 1984–Continued

[The relative standard deviation for each reported concentration is plus 50 percent and minus 33 percent. --, denotes the occurrence of an unresolved interference; >, indicates concentration is greater than the given value; <, indicates concentration is less than the given value. All samples had concentrations less than the detection limit for the following elements (concentrations in parts per million): Bi <10, In <10, Ir <15, Lu <15, Os <15, Pd <1, Pt <2.2, Re <10, Rh <2.2, Ru <2.2, Sb <68, Ta <320, Tb <32, Th <46, Tl <10, Tm <4.6, U <220, and W <15.]

Sample number	Lab number	Concentrations (in percent)												
		Silver	Arsenic	Gold	Boron	Barium	Beryllium	Cadmium	Cerium	Cobalt	Chromium	Copper	Dysprosium	Erbium
39	D4-16	0.22	150	<6.8	<6.8	1.6	5.0	<32	<200	1.7	3.9	3.2	51	28.0
40	D4-11	<0.10	190	<6.8	<6.8	<1.5	13.0	<32	<200	5.9	5.6	4.0	84	49.0
41	D4-18	0.50	290	<6.8	<6.8	<1.5	14.0	<32	<200	6.9	6.9	2.2	89	54.0
42	D4-17	<0.10	<100	<6.8	<3.2	15.0	2.9	<32	130	5.5	2.0	2.5	32	12.0
43	D4-20	0.24	140	<6.8	<6.8	3.0	21.0	43	<200	4.1	60.0	2.4	39	28.0
44	D4-21	0.17	<100	<6.8	22.0	38.0	2.7	<32	<43	2.3	43.0	51.0	28	5.3
45	D4-12	0.24	500	<6.8	<6.8	7.1	21.0	<32	250	3.4	46.0	30.0	99	53.0
46	D4-14	0.30	300	<6.8	<6.8	<1.5	21.0	<32	360	4.6	22.0	3.6	95	68.0
47	D4-7	0.39	130	<6.8	<6.8	21.0	16.0	<32	<200	1.2	<10.0	1.6	51	25.0

Table 2. Semiquantitative chemical analyses of sediment samples taken in December 1983 and June 1984.–Continued

[The relative standard deviation for each reported concentration is plus 50 percent and minus 33 percent. --, denotes the occurrence of an unresolved interference; >, indicates concentration is greater than the given value; <, indicates concentration is less than the given value. All samples had concentrations less than the detection limit for the following elements (concentrations in parts per million): Bi <10, In <10, Ir <15, Lu <15, Os <15, Pd <1, Pt <2.2, Re <10, Rh <2.2, Ru <2.2, Sb <68, Ta <320, Tb <32, Th <46, Tl <10, Tm <4.6, U <220, and W <15.]

Sample number	Lab number	Concentrations (in percent)											
		Europium	Gallium	Gadolinium	Germanium	Hafnium	Holmium	Lanthanum	Lithium	Manganese	Molybdenum	Niobium	Neodymium
1	D20-47	<2.2	--	64	12.0	<150	<6.8	48	--	76.0	--	9.9	56
2	D20-48	<2.2	--	69	9.6	<15	<6.8	<10	--	72.0	--	9.0	<32
3	D20-49	<2.2	<1.5	<32	<4.6	<15	<6.8	33	--	110.0	<1.0	<6.8	<32
4	D20-50	<2.2	<1.5	<32	<4.6	<15	<6.8	27	--	160.0	<1.0	8.5	<32
5	D20-52	<2.2	<1.5	<32	<4.6	<15	<6.8	30	--	170.0	<1.0	<6.8	<32
6	D16-43	<2.2	4.2	<32	<4.6	<150	<6.8	44	<68	1000.0	<1.0	14.0	51
7	D16-44	<2.2	4.3	<32	<4.6	<150	<6.8	37	--	840.0	<1.0	10.0	<32
8	D16-46	<2.2	5.2	<32	<4.6	<150	<6.8	41	--	1900.0	<1.0	18.0	36
9	D14-38	<2.2	--	<32	9.4	<15	<6.8	<10	--	63.0	--	<6.8	<32
10	DP-1	<2.2	<1.5	<32	5.2	<150	<6.8	16	--	17.0	--	7.5	55
11	DP-2	<2.2	6.7	<32	7.7	<15	<6.8	<10	--	36.0	2.7	8.1	<32
12	D5-39	<2.2	<1.5	57	7.4	<150	<6.8	44	--	140.0	<1.0	7.1	<32
13	D10-36	<2.2	<1.5	<32	<4.6	<15	<6.8	30	<68	52.0	8.6	<6.8	86
14	DP-5	<2.2	--	<32	6.1	<150	<6.8	<10	--	14.0	--	8.9	<32
15	DRR-28	<2.2	<1.5	<32	<4.6	<15	<6.8	<10	--	5.9	--	<6.8	<32
16	DRR-29	<2.2	<1.5	<32	<4.6	<150	<6.8	23	<68	28.0	<1.0	<6.8	<32
17	DRR-30	<2.2	4.8	<32	5.1	<15	<6.8	37	<68	160.0	2.4	8.0	<68
18	DRR-32	<2.2	--	<32	<4.6	<150	<6.8	17	--	19.0	--	6.9	<32
21	DRR-25	<2.2	2.1	<32	4.7	<15	<6.8	19	--	110.0	<1.0	13.0	<32
22	DRR-27	<2.2	<1.5	<32	<4.6	<15	<6.8	13	--	6.0	--	<6.8	59
29	DP-4	<2.2	--	<32	7.7	<150	<6.8	<10	--	5.1	--	<6.8	<32
32	DRR-22	<2.2	<1.5	<32	11.0	<15	<6.8	24	--	11.0	--	<6.8	<32
33	DRR-23	<2.2	--	<32	12.0	<15	16.0	<10	--	10.0	--	<6.8	<32
35	DP-3	<2.2	<1.5	<32	7.8	<150	<6.8	31	--	18.0	--	7.5	50
38	D4-9	8.2	<1.5	51	19.0	<15	<6.8	44	--	18.0	--	<6.8	220

Table 2. Semiquantitative chemical analyses of sediment samples taken in December 1983 and June 1984.–Continued

[The relative standard deviation for each reported concentration is plus 50 percent and minus 33 percent. --, denotes the occurrence of an unresolved interference; >, indicates concentration is greater than the given value; <, indicates concentration is less than the given value. All samples had concentrations less than the detection limit for the following elements (concentrations in parts per million): Bi <10, In <10, Ir <15, Lu <15, Os <15, Pd <1, Pt <2.2, Re <10, Rh <2.2, Ru <2.2, Sb <68, Ta <320, Tb <32, Th <46, Tl <10, Tm <4.6, U <220, and W <15.]

Sample number	Lab number	Concentrations (in percent)											
		Europium	Gallium	Gadolinium	Germanium	Hafnium	Holmium	Lanthanum	Lithium	Manganese	Molybdenum	Niobium	Neodymium
39	D4-16	5.1	<1.5	44	16.0	<15	<6.8	35	--	8.8	--	<6.8	180
40	D4-11	13.0	--	75	24.0	<15	<6.8	68	--	22.0	--	8.8	320
41	D4-18	16.0	--	94	30.0	<15	<6.8	78	--	33.0	--	12.0	360
42	D4-17	9.6	<1.5	<32	<4.6	<15	7.6	61	120	74.0	3.7	<6.8	180
43	D4-20	<2.2	<1.5	<32	25.0	<15	<6.8	33	--	24.0	--	<6.8	110
44	D4-21	4.0	4.8	<32	6.8	<15	<6.8	24	<68	58.0	<1.0	<6.8	49
45	D4-12	23.0	<1.5	110	27.0	<15	25.0	98	--	32.0	--	<6.8	440
46	D4-14	28.0	<1.5	140	39.0	<15	31.0	120	--	28.0	--	<6.8	510
47	D4-7	6.9	<1.5	<32	<4.6	<15	14.0	59	--	21.0	--	<6.8	170

Table 2. Semiquantitative chemical analyses of sediment samples taken in December 1983 and June 1984.–Continued

[The relative standard deviation for each reported concentration is plus 50 percent and minus 33 percent. --, denotes the occurrence of an unresolved interference; >, indicates concentration is greater than the given value; <, indicates concentration is less than the given value. All samples had concentrations less than the detection limit for the following elements (concentrations in parts per million): Bi <10, In <10, Ir <15, Lu <15, Os <15, Pd <1, Pt <2.2, Re <10, Rh <2.2, Ru <2.2, Sb <68, Ta <320, Tb <32, Th <46, Tl <10, Tm <4.6, U <220, and W <15.]

Sample number	Lab number	Concentrations (in percent)											
		Nickel	Lead	Praseodymium	Scandium	Samarium	Tin	Strontium	Vanadium	Yttrium	Ytterbium	Zinc	Zirconium
1	D20-47	140.0	47	<100	<1.0	<10	<4.6	7.2	11.0	69.0	3.70	>10000	140.0
2	D20-48	52.0	53	<100	1.6	<10	--	2.0	3.9	31.0	2.20	4600	<3.2
3	D20-49	48.0	350	130	2.1	<10	<4.6	16.0	23.0	25.0	2.10	3400	140.0
4	D20-50	110.0	330	<100	2.2	<10	<4.6	18.0	26.0	37.0	2.40	>10000	83.0
5	D20-52	74.0	330	<100	1.8	<10	<4.6	15.0	18.0	45.0	1.20	>10000	85.0
6	D16-43	72.0	250	<100	6.4	<10	<4.6	40.0	77.0	31.0	4.30	2600	240.0
7	D16-44	36.0	110	<100	5.4	<10	<4.6	47.0	61.0	21.0	3.70	870	250.0
8	D16-46	47.0	85	<100	6.0	<10	<4.6	46.0	69.0	23.0	4.10	590	320.0
9	D14-38	240.0	37	<100	2.3	<10	--	4.4	3.3	73.0	<6.80	>10000	<3.2
10	DP-1	2.6	330	<100	<1.0	<32	<4.6	12.0	7.0	9.7	2.00	930	99.0
11	DP-2	8.3	>1000	<100	1.7	<10	<4.6	240.0	19.0	<1.5	<0.15	450	33.0
12	D5-39	36.0	280	<100	2.4	<10	<4.6	18.0	30.0	52.0	1.80	5400	82.0
13	D10-36	28.0	84	<100	1.3	<10	<4.6	5.9	2.4	100.0	3.50	>10000	3.5
14	DP-5	9.2	140	<100	<1.0	<10	--	3.4	13.0	6.6	1.40	1700	22.0
15	DRR-28	4.3	41	<100	<1.0	<10	--	<1.0	5.1	2.6	1.40	530	7.3
16	DRR-29	11.0	350	<100	2.7	<10	<4.6	15.0	27.0	6.4	0.55	890	27.0
17	DRR-30	81.0	>1000	<100	5.1	<10	4.7	27.0	42.0	70.0	5.70	8800	50.0
18	DRR-32	30.0	79	<100	1.7	<10	--	1.7	8.0	13.0	1.60	4600	4.9
21	DRR-25	19.0	130	<100	3.5	<10	<4.6	32.0	35.0	16.0	2.60	1000	190.0
22	DRR-27	4.7	36	<100	1.4	<10	--	1.0	5.7	3.2	1.40	540	5.9
29	DP-4	4.8	84	<100	<1.0	<10	--	<1.0	8.1	9.1	1.30	630	<3.2
32	DRR-22	11.0	200	<100	1.8	<10	--	1.6	180.0	22.0	1.40	980	3.7
33	DRR-23	9.5	190	<100	<1.0	<10	--	<1.0	14.0	32.0	1.90	1200	<3.2
35	DP-3	20.0	>1000	<100	<1.0	<10	<4.6	3.8	190.0	62.0	2.30	3100	73.0
38	D4-9	65.0	590	<100	1.5	<10	--	3.4	50.0	170.0	6.60	>10000	3.5

Table 2. Semiquantitative chemical analyses of sediment samples taken in December 1983 and June 1984.–Continued

[The relative standard deviation for each reported concentration is plus 50 percent and minus 33 percent. --, denotes the occurrence of an unresolved interference; >, indicates concentration is greater than the given value; <, indicates concentration is less than the given value. All samples had concentrations less than the detection limit for the following elements (concentrations in parts per million): Bi <10, In <10, Ir <15, Lu <15, Os <15, Pd <1, Pt <2.2, Re <10, Rh <2.2, Ru <2.2, Sb <68, Ta <320, Tb <32, Th <46, Tl <10, Tm <4.6, U <220, and W <15.]

Sample number	Lab number	Concentrations (in percent)											
		Nickel	Lead	Praseodymium	Scandium	Samarium	Tin	Strontium	Vanadium	Yttrium	Ytterbium	Zinc	Zirconium
39	D4-16	20.0	520	<100	<1.0	<10	--	1.4	46.0	130.0	3.80	3600	3.2
40	D4-11	93.0	830	210	2.2	12	--	3.9	56.0	250.0	7.60	>10000	<3.2
41	D4-18	120.0	>1000	<100	1.8	<10	--	5.1	89.0	280.0	10.00	>10000	<3.2
42	D4-17	44.0	340	<100	1.4	<10	<4.6	390.0	33.0	98.0	3.90	3200	15.0
43	D4-20	69.0	670	<100	1.6	<10	--	3.1	120.0	130.0	3.70	>10000	4.1
44	D4-21	48.0	440	<100	2.9	<10	<4.6	18.0	30.0	47.0	3.90	4600	15.0
45	D4-12	54.0	>1000	140	2.8	12	<4.6	<15.0	180.0	270.0	11.00	>10000	16.0
46	D4-14	75.0	>1000	160	<1.0	15	--	3.4	160.0	530.0	14.00	>10000	<3.2
47	D4-7	7.1	>1000	<100	1.4	<10	<4.6	10.0	80.0	200.0	6.40	2800	<3.2

Table 3. Quantitative chemical analyses of sediment samples taken in December 1983 and June 1984.

[--, indicates no analysis for this constituent; <, indicates concentration is less than the given value; ppm, parts per million]

Sample number	Lab number	Cadmium (ppm)	Copper (ppm)	Iron (percent	Manganese (ppm)	Nickel (ppm)	Lead (ppm)	Sulfur (percent)	Zinc (ppm)	Organic carbon (percent)
1	D20-47	12.00	3.3	41.9	47	99.0	<40	1.50	12000	1.10
2	D20-48	2.90	2.5	46.7	53	28.0	<40	2.20	4900	0.95
3	D20-49	32.00	64.0	13.3	96	52.0	460	0.78	3400	6.80
4	D20-50	33.00	35.0	13.5	160	120.0	320	0.54	11000	3.50
5	D20-52	42.00	43.0	17.1	260	110.0	460	0.95	10000	7.00
6	D16-43	11.00	16.0	7.6	760	41.0	270	0.14	2700	0.78
7	D16-44	4.90	7.9	2.9	460	31.0	59	0.05	820	0.58
8	D16-46	2.70	10.0	5.2	770	28.0	41	0.02	490	0.73
9	D14-38	11.00	2.1	50.9	71	280.0	<40	0.43	35000	0.57
10	DP-1	6.30	6.1	26.7	<10	1.4	350	3.30	980	0.23
11	DP-2	1.50	72.0	25.1	22	11.0	2600	8.90	480	0.65
12	D5-39	7.90	19.0	17.7	110	22.0	280	0.81	3900	3.00
13	D10-36	130.00	15.0	16.6	110	46.0	200	0.93	14000	27.60
14	DP-5	9.20	10.0	33.5	16	7.2	220	2.50	2500	0.95
15	DRR-28	0.58	<2	42.8	10	5.6	<40	4.10	710	0.59
16	DRR-29	3.10	25.0	6.2	18	14.0	490	1.50	950	0.60
17	DRR-30	15.00	190.0	1.4	100	49.0	1400	1.90	6300	0.49
18	DRR-32	0.58	4.2	46.1	19	36.0	86	3.00	4400	0.68
21	DRR-25	4.70	10.0	15.4	56	21.0	120	1.40	980	2.80
22	DRR-27	0.26	<2	41.7	<10	4.8	<40	4.00	590	1.20
29	DP-4	0.68	2.7	45.4	<10	3.7	110	3.80	700	0.64
32	DRR-22	0.51	41.0	40.7	13	11.0	270	3.20	1200	0.97
33	DRR-23	0.51	41.0	43.6	<10	9.9	280	2.20	1300	1.20
35	DP-3	8.10	3.1	35.0	24	32.0	2700	1.70	2800	1.50
38	D4-9	9.60	6.1	45.1	26	65.0	1200	2.00	10000	0.49

Table 3. Quantitative chemical analyses of sediment samples taken in December 1983 and June 1984.—Continued

[--, indicates no analysis for this constituent; <, indicates concentration is less than the given value; ppm, parts per million]

Sample number	Lab number	Cadmium (ppm)	Copper (ppm)	Iron (percent	Manganese (ppm)	Nickel (ppm)	Lead (ppm)	Sulfur (percent)	Zinc (ppm)	Organic carbon (percent)
39	D4-16	2.90	7.0	43.4	14	43.0	1100	3.10	4400	0.67
40	D4-11	13.00	4.4	45.3	23	67.0	1300	2.00	11000	0.49
41	D4-18	32.00	3.1	44.9	29	85.0	1800	2.00	12000	1.60
42	D4-17	6.60	4.4	5.5	60	37.0	660	--	3200	2.50
43	D4-20	26.00	4.8	39.2	30	67.0	1500	1.80	11000	2.50
44	D4-21	9.00	64.0	3.1	33	35.0	590	0.52	2600	5.10
45	D4-12	15.00	31.0	27.4	36	48.0	8700	1.00	8800	0.91
46	D4-14	14.00	5.3	36.6	33	73.0	6000	1.80	11000	0.45
47	D4-7	14.00	24.0	24.6	24	17.0	6800	0.76	2600	3.50

Table 4. Quantitative chemical analyses of sediment samples taken in June 1985.

[<, indicates concentration is less than the given value; ppm, parts per million; Al, aluminum, Cd, cadmium; Co, cobalt; Cr, chromium; Cu, copper; Fe, iron; Mo, molybdenum; Ni, nickel; P, phosphorus; Pb, lead; S, sulfur; Si, silicon; Ti, titanium; V, vanadium; Zn, zinc]

Sample number	Lab number	Al (ppm)	Cd (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)	Fe (percent)	Mn (ppm)	Mo (ppm)	Ni (ppm)	P (percent)	Pb (ppm)	S (percent)	Si (percent)	Ti (ppm)	V (ppm)	Zn (ppm)	Organic carbon (percent)
19	DRR-64	4700	3.8	<1	14	9.4	42.50	39	<1	17	0.051	130	3.00	5.1	360	10	2200	1.10
20	DRR-65	18000	18.0	4.6	44	150.0	3.90	95	<1	84	0.089	1400	0.63	35.1	820	31	6600	1.00
23	DRR-62	7000	3.0	1.8	24	5.0	37.00	35	2.0	12	0.056	140	2.70	8.1	790	13	1700	1.70
24	DRR-63	26000	5.9	3.6	47	25.0	1.40	61	<1	26	0.031	170	0.19	38.6	3100	54	1600	2.40
25	DRR-61	7400	7.4	2.9	17	5.4	44.30	54	3.4	21	0.081	180	3.00	5.4	640	13	3000	1.40
26	DRR-66	5500	18.0	1.7	36	86.0	0.69	180	1.2	24	0.041	1200	0.30	32.7	450	22	3200	0.20
27	DRR-59	16000	2.0	4.9	39	7.5	27.30	220	1.0	20	0.064	100	1.80	18.4	2100	28	1100	0.89
28	DRR-60	30000	4.6	4.4	47	16.0	3.80	120	<1	24	0.042	160	0.52	36.4	3800	57	1100	1.30
30	DRR-57	5600	15.0	5.9	14	5.5	47.10	60	14.0	50	0.150	420	2.40	3.6	450	18	6400	1.30
31	DRR-58	21000	15.0	5.0	43	21.0	18.30	110	1.3	24	0.081	380	0.62	25.4	2900	45	3700	2.00
34	DRR-56	22000	11.0	4.4	51	13.0	23.20	83	17.0	32	0.230	430	1.20	19.2	2400	54	3100	1.90
36	DRR-54	27000	3.7	6.0	46	5.9	7.80	190	8.5	26	0.170	250	0.39	33.5	3300	51	1500	1.30
37	DRR-55	29000	5.7	5.1	52	11.0	8.20	170	7.6	29	0.160	260	0.35	32.6	3400	57	1800	1.50

Attachment 1

Explanation of the Site-Numbering System

The standard method for describing the location of a data-collection site by fractional section, section, township, and range, usually referred to as the legal description, is replaced in this report by a local number, illustrated in the diagram below. By the legal method, the location of the site indicated by the dot would be described as NE1/4SW1/4NW1/4, sec. 32, T. 29 N., R. 23 E. The method used in this report changes the order and indicates quarter subdivisions of the sections by letters. A sequence number is added to provide a unique local number for each site. By this method, the location of the site is given as 29N–23E–32 BCA 1.