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ANALYTICAL RESULTS FOR BULLION MINE AND CRYSTAL MINE WASTE SAMPLES AND BED SEDIMENTS FROM A SMALL TRIBUTARY TO JACK CREEK AND FROM UNCLE SAM GULCH, BOULDER RIVER WATERSHED, MONTANA

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Table of Contents

Figures

Tables

Appendix

ABSTRACT

Metal-mining related wastes in the Boulder River basin study area in northern Jefferson County, Montana affect water quality as a result of acid-generation and toxic-metal solubilization. Mine waste and tailings in the unnamed tributary to Jack Creek draining the Bullion mine area and in Uncle Sam Gulch below the Crystal mine are contributors to water quality degradation of Basin Creek and Cataract Creek, Montana. Basin Creek and Cataract Creek are two of three tributaries to the Boulder River in the study area. The bed sediment geochemistry in these two creeks has also been affected by the acidic drainage from these two mines. Geochemical analysis of 42 tailings cores and eleven bed-sediment samples was undertaken to determine the concentrations of Ag, As, Cd, Cu, Pb, and Zn present in these materials. These elements are environmentally significant, in that they can be toxic to fish and/or the invertebrate organisms in the aquatic food chain. Suites of one-inch cores of mine waste and tailings material were taken from two breached tailings impoundments near the site of the Bullion mine and from Uncle Sam Gulch below the Crystal mine. Forty-two core samples were taken and divided into 211 subsamples. The samples were analyzed by ICP-AES (inductively coupled plasma-atomic emission spectroscopy) using a mixed-acid (HCl-HNO_3-$HClO_4$-HF) digestion. Results of the core analyses show that some samples contain moderate to very high concentrations of arsenic (as much as 13,000 ppm), silver (as much as 130 ppm), cadmium (as much as 260 ppm), copper (as much as 9,000 ppm), lead (as much as 11,000 ppm), and zinc (as much as 18,000 ppm). Eleven bed-sediment samples were also subjected to the mixed-acid total digestion, and a warm (50°C) 2M HCl-1% H_2O_2 leach and analyzed by ICP-AES. Results indicate that bed sediments of the Jack Creek tributary are impacted by past mining at the Bullion and Crystal mines. The contaminating metals are mostly contained in the 2M HCl-1% H_2O_2 leachable phase, which are the hydrous amorphous iron- and manganese-hydroxide coatings on detrital sediment particles.

INTRODUCTION

Metal-mining related wastes in the Boulder River basin study area (fig. 1) in northern Jefferson County, Montana potentially affect water quality as a result of acid generation and toxic-metal solubilization during snow melt and storm water runoff events (Buxton and others, 1997). The bed sediments and waters of an unnamed tributary of Jack Creek have been impacted by contamination from mine waste and tailings from the Bullion mine and mill complex. This contamination also affects Jack Creek, which is a tributary to Basin Creek (Metesh and others, 1994). Similarly, waste material from the Crystal Mine, located on the east side of Jack Mountain from the Bullion mine, has been deposited in Uncle Sam Gulch. Uncle Sam Gulch is a tributary to Cataract Creek; both Basin Creek and Cataract Creek are major tributaries to the Boulder River in the study area (see fig. 1), and are contributors to water quality degradation of the Boulder River.

The Bullion Mine was worked periodically between 1897 and 1955; it was the largest and most productive of the inactive mines in the Basin Mining District. In 1929, a flotation mill was built at the mine site. The mined ore contained pyrite, tetrahedrite, galena, sphalerite, arsenopyrite, quartz, and siderite (Metesh and others, 1994). The mine and associated waste rock and development rock dumps, and the mill and its associated tailings are situated mostly on private land. However, there are two breached tailings impoundments below the mill on the Jack Creek tributary; most of the upper impoundment and the entire lower impoundment are located on Deerlodge National Forest land. These impoundments straddle the creek, and provide a continuous source of contamination to the creek. Tailings have been transported downstream to the confluence with Jack Creek.

The Crystal Mine was worked from 1908 through the 1960's and produced ore from veins of the same mineralized east-west shear zone as the Bullion Mine. Mineralized or ore-bearing veins of the Crystal Mine contain pyrite, arsenopyrite, galena, chalcopyrite, tetrahedrite, covellite, and chalcocite (Metesh and others, 1995). The Crystal Mine is also on private land, but waste material deposited in Uncle Sam Gulch is located on Deerlodge National Forest land.

Desborough and Fey (1997) studied waste material from nine mine sites in the Basin district and produced a qualitative scale for potential water-quality degradation resulting from these mine wastes. The scale was based on the combined weights of acid-generation potential, dissolved toxic metals from a passive leach, and estimated tonnage. At the Bullion Mine site, waste material from three mine dumps located on the hill above the mill and creek scored seven, eight, and nine on a scale of one (low) to nine (high). By comparison, material from the two breached tailings impoundments below the Bullion Mine complex scored a moderate four and five on the same scale. However, since this material lies directly in or next to the creek, these tailings have a more immediate effect on water quality. These two tailings impoundments on the Jack Creek tributary and a small reach of fluvially-deposited waste in Uncle Sam Gulch are the subject of this investigation. This report presents analytical results for total-digestion elemental content for 42 cores, nine bed sediments and bed-sediment leach residues, and leachable elemental content for the nine bed sediments as released by a warm (50^{o} C) 2M HCl-1 percent H_2O_2 digestion. Similar reports covered the fluvial tailings present in High Ore Creek below the Comet Mine (Fey and Church, 1998) and flotation tailings present in and near

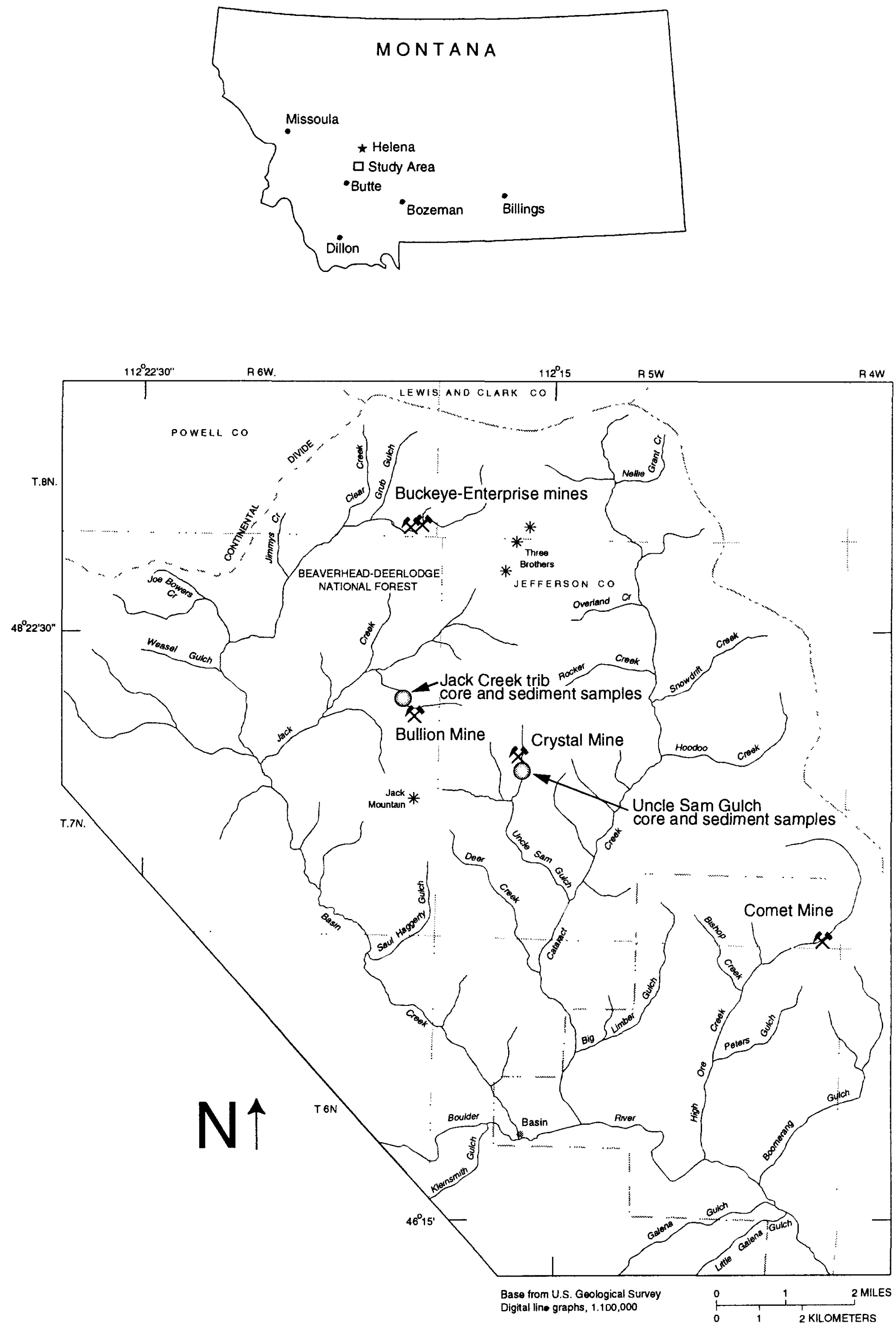

Figure 1. Index map of Montana showing Boulder River study area and sample localities for mill-tailings cores and bed sediments along tributary of Jack Creek below Bullion Mine, and sample localities for mine-waste cores and bed sediments along Uncle Sam Gulch below Crystal Mine.

the floodplain of Basin Creek at the Buckeye-Enterprise mines and mill complex (fig. 1) (Fey and others, 1999).

METHODS OF STUDY

Sample collection

Core and sediment samples were collected from a small, unnamed tributary of Jack Creek, which flows from the Bullion Mine area (T7N, R6W, Section 13) north to Jack Creek, and from Uncle Sam Gulch above and below the Crystal Mine area (T7N, R5W, Section 20). All sample sites are located on the Basin, Montana USGS 1:24,000 topographic map.

Bed sediments

In October 1996, we collected 47 bed-sediment samples in the Boulder River basin, including one from the unnamed Jack Creek tributary and one from Jack Creek just below its confluence with that tributary. In July 1997, we collected four additional bed-sediment samples from the same tributary, from above the mine development area down to near the confluence with Jack Creek, and a second sample from Jack Creek below the tributary. In July 1998, we collected a third sample at that same site. In October 1996, we collected two bed-sediment samples from Uncle Sam Gulch, both below the Crystal mine site. In July 1997, we collected two additional sediments from Uncle Sam Gulch, one above the Crystal mine and one below. See figure 2 for the localities of the bed-sediment samples.

Analyses of bed-sediment samples represent the geochemistry of material eroded upstream of the sample site and from colloidal material coating the detrital grains. An integrated bed-sediment sample was collected at each site by compositing 10 to 20 individual subsites within 15 m (50 ft) of the plotted sample locality, collecting material from the active channel alluvium. In the field, each composited sample was sieved through a 2 mm (10-mesh) stainless-steel screen, and the minus-2 mm fraction retained; the larger size fractions were discarded.

Tailings Cores

In July 1997, we collected a suite of 23 one-inch diameter cores from the upper tailings impoundment area (not the active stream channel) downstream from the Bullion Mine. This sample suite is identified as 97-BMF-102. Farther downstream at the lower tailings impoundment area, we collected a suite of 15 cores; this suite is identified as 97-BMF-103. Along Uncle Sam Gulch below the Crystal mine, we collected four one-inch diameter cores of fluvially deposited mine waste; these samples are identified as 97-BMF-109. See figure 2 for the site localities of the core-sample suites.

All samples were collected in plastic core tubes using a stainless-steel soil probe/sampler. Most cores were driven to depths up to 65 cm, the maximum penetration of a single probe. However, at favorable sites, a probe extension was used to collect a second core from below the depth of the first core, with a maximum penetration of 130 cm. Core penetration depth and actual core length were recorded on-site to determine the amount of compression.

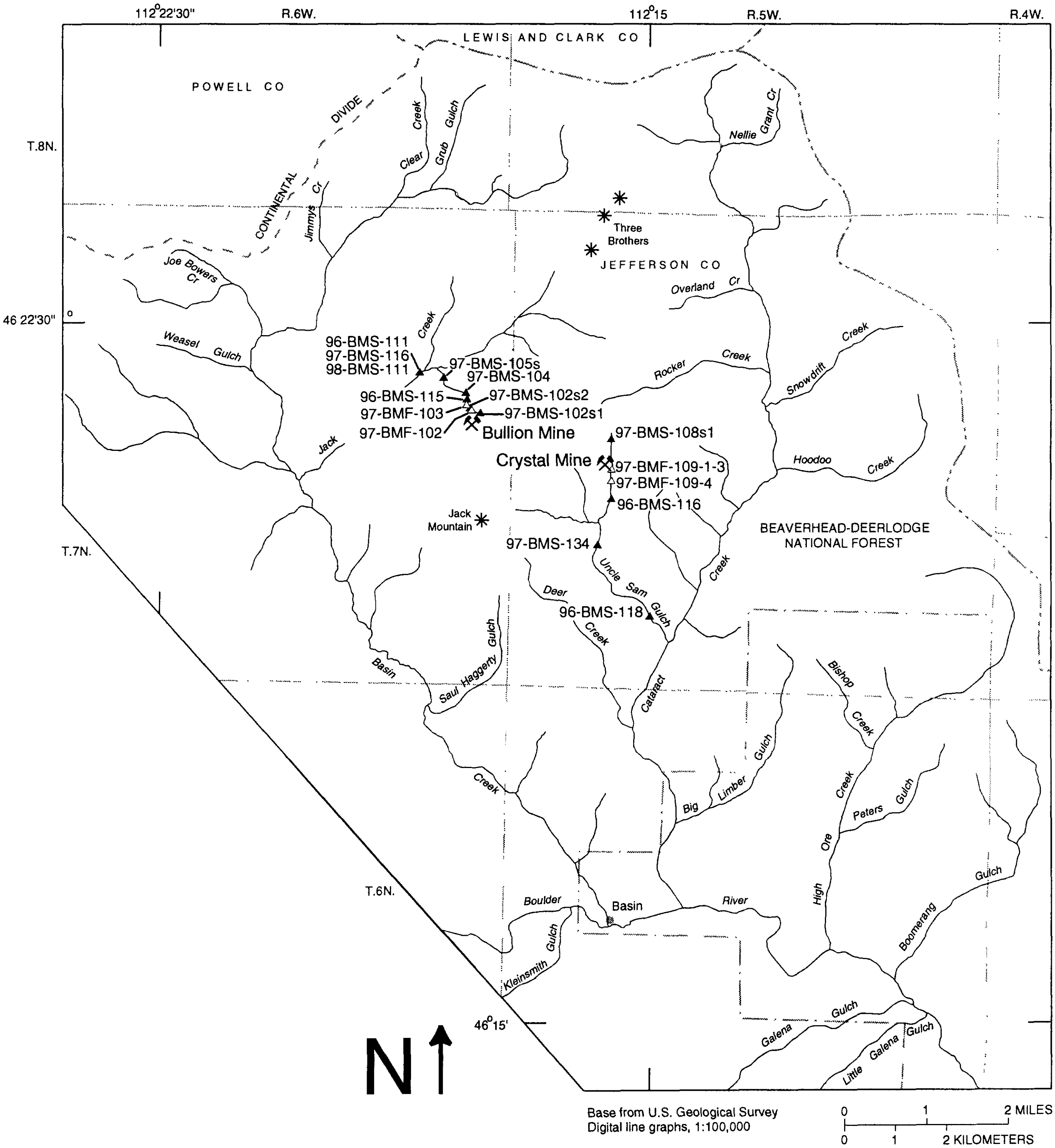

Figure 2. Sample locality map for bed sediments (▲) and mine-waste core samples (△) from the Bullion and Crystal Mine areas.

Sample Preparation

Bed-sediment Samples

Bed-sediment samples were dried at ambient room temperature (25°C) and sieved to minus-80-mesh (<0.18 mm) prior to laboratory analyses.

Tailings Cores

Core samples were subdivided in the laboratory into subsamples (by depth) according to visual identification of differences in color, mineralogy, organic content, and presence of iron oxide coloring. A core compression factor was calculated and used to determine the actual depth of the subsamples; the assigned depth for each is defined as the midpoint of that subsample. The cores were divided into two to thirteen subsamples, typically about five or six. These subsamples were then placed in a random order and ground using a vertical pulverizer with ceramic plates to minus 100-mesh (<0.15 mm). The 23 cores from the upper impoundment (97-BMF-102) were subdivided into 124 subsamples, and the 15 cores from the lower impoundment (97-BMF-103) were subdivided into 74 subsamples. The four cores from Uncle Sam Gulch were subdivided into 13 subsamples.

Sample Analysis

Total-digestion Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES) analysis for 33 elements

The ten bed-sediment samples, leach residues from partial extractions (described below) of the ten sediment samples, and 211 core subsamples were digested with a mixed-acid procedure consisting of HCl, HNO_3, $HClO_4$, and HF, and analyzed for 33 elements by ICP-AES (Crock and others, 1983; Briggs, 1996). This procedure dissolves most minerals, including silicates, oxides and sulfides; resistant or refractory minerals such as zircon, chromite, and some tin oxides are only partially dissolved. Previous investigations using a variety of geologic materials confirm the completeness of the digestion (Church and others, 1987; Wilson and others, 1994).

The core sample analyses were performed by a contract laboratory using the prescribed procedure. The values for total-digestion analyses for the core samples are given in tables 7 and 8 (Bullion mine-tailings impoundments), and table 9 (Uncle Sam Gulch below Crystal Mine). The analyses of the stream sediments and their leach residues were performed at the USGS laboratories in Denver, using the same chemical digestion procedure. The concentrations for total-digestion analyses of the bed sediments are given in table 10, and the concentrations for the total-digestion analyses of the bed-sediment leach residues are given in table 12. Limits of determination for the total digestion method are given in table A7 in the Appendix. Comparisons of values observed for three National Institute of Standards and Technology (NIST) standard reference materials (SRM-2704, SRM-2709 and SRM-2711) with certified values (NIST, 1993a, 1993b, and 1993c) are given in tables A1 through A3 (contract laboratory) and A4 through A6 (USGS laboratory) in the Appendix.

Warm 2M HCl-1percent H_2O_2 leach extraction

The use of a partial-digestion extraction enables one to determine concentrations of trace elements bound within different phases, whereas a total digestion releases all trace elements in a sample (Chao, 1984). The ten bed sediments from the Jack Creek tributary and Uncle Sam Gulch were subjected to a partial-digestion extraction consisting of warm (50^0 C) 2M HCl-1 percent H_2O_2 for three hours with continuous agitation in USGS laboratories; the leachates were subsequently analyzed by ICP-AES for 29 elements. This partial extraction releases trace elements associated with hydrous amorphous iron- and manganese-oxide mineral coatings and colloidal particles (Appendix III of Church and others, 1993; Church and others, 1997). Mineral coatings such as those observed in Jack Creek can contain a significant portion of the trace elements in a sample (Church and others, 1997). The residues from this extraction were then dried, weighed, and subjected to the total digestion described above to determine trace element concentrations bound in the oxide, silicate, and more-resistant sulfide phases. The data obtained from the 2M HCl-1percent H_2O_2 extraction are presented in table 11. Analytical limits of determination for the partial-digestion leach method are given in table A7 in the Appendix.

Site descriptions

Bullion Mine area bed sediments

Four bed-sediment samples were taken from the unnamed tributary that flows from above the Bullion Mine to its confluence with Jack Creek. The uppermost one (97-BMS-102S1) was collected above any influence from the mine waste, tailings, or draining water (fig.2). The next sediment sample (97-BMS-102S2) was collected about 200 m (650 ft) downstream from 97-BMS-102S1, and about 120 m (400 ft) below the upper of two breached tailings impoundment dams. The next sample, 96-BM-115, was collected about 150 m (500 ft) downstream of 97-BMS-102S2; it is about 60 m (200 ft) below the lower of the two breached tailings impoundments. The lowest bed-sediment sample from the tributary, 97-BMS-105S, was collected about 700 m (2,300 ft) below 96-BM-115. This sample is about 270 m (900 ft) above the confluence of this tributary with Jack Creek. About 300 m (1,000 ft) below this confluence is a former beaver dam that impounded tailings on Jack Creek; this beaver dam has also been breached. We took a bed-sediment sample from Jack Creek at a site just below the beaver dam in 1996, 1997, and 1998. These samples are labeled 96-BM-111, 97-BMS-116, and 98-BMS-111. The purpose of taking replicate sediment samples from the same site was to assess the annual variation in trace element content. Sample sites were plotted in the field on the USGS 1:24,000 Basin topographic map; table 1 gives the localities of the bed-sediments for samples from the Bullion mine area.

Crystal Mine area bed sediments

Three bed-sediment samples from Uncle Sam Gulch are included in this report. The uppermost sample, 97-BMS-108S1, was taken about 0.8 km (0.5 mi.) upstream from the Crystal Mine (fig. 2), above the influence from mine waste, tailings, or drainage. The second sample, 96-BM-116, was taken about 0.5 km (0.3 MI) downstream from the Crystal mine. The third sample, 97-BMS-134, was taken about 1.5 km (0.9 MI.) downstream from the mine. The fourth bed-sediment sample (96-BM-118) on Uncle Sam Gulch was taken about 0.7 km (0.4 mi.) upstream from the confluence with Cataract Creek. Table 1 gives the localities of the bed sediments from Uncle Sam Gulch.

Table 1. Localities of bed-sediment sites from the Bullion mine and Crystal mine areas.

	Sample Site	Latitude (DMS)	Longitude (DMS)
	97-BMS-102s1	46° 21' 26.2"	112° 17' 40.8"
	97-BMS-102s2	46° 21' 29.5"	112° 17' 47.8"
Bullion area	96-BMS-115	46° 21' 33.8"	112° 17' 48.6"
bed sediments	97-BMS-105S	46° 21' 47.1"	112° 18' 11.7"
(Jack Creek and trib)	97-BMS-116	46° 21' 52.4"	112° 18' 32.4"
	96-BMS-111	46° 21' 52.4"	112° 18' 32.4"
	98-BMS-111	46° 21' 52.4"	112° 18' 32.4"
Crystal area	97-BMS-108s1	46° 21' 16.9"	112° 15' 36.7"
bed sediments	96-BMS-116	46° 20' 37.7"	112° 15' 37.3"
(Uncle Sam Gulch)	97-BMS-134	46° 20' 02.8"	112° 15' 47.9"
	96-BMS-118	46° 19' 21.0"	112° 15' 00.0"

Bullion Mine area tailings cores

Upper tailings impoundment

One-inch diameter core suites were collected from two breached tailings impoundments located on the Jack Creek tributary. Below the former millsite at the main mine development area, a moderately steep, logged slope extends down to the creek and towards the upper impoundment dam. The dam, built about 1930 (Rossilon and Haynes, 1999), was constructed of tailings material; subsequently, the dam was breached, and tailings were transported down the creek. The dam is about 40 m (130 ft) wide, 5 m (16 ft) thick at the base, and 2.5 m (8 ft) tall. There are still tailings present on both banks of the creek, and the active channel continues to cut through the tailings, eroding and transporting tailings material downstream We ran a traverse line from the southern half of the tailings impoundment about 60 m (200 ft) southeast up the slope, roughly parallel to the creek and about 10 to 15 m (30 to 45 ft) southwest of it. The bearing of the traverse line was S 52^0 E. We collected core samples along the traverse labeled 97-BMF-102 (fig 3). Core samples were taken from sites 1, 4, 5, 6, 7, and 8 (97-BMF-102-4, -5, -6, -7, and -8) at regular 5 m spacing. No core was taken at either site 2 or 3 (fig. 3), because the material was loose, unconsolidated sand and peat, and would not stay in the collection tube. Sample 97-BMF-102-9 was collected 7 m (23 ft) from 97-BMF-102-8, and sample 97-BMF-102-10 was collected 8 m (27 ft) down from -102-9. Sample 97-BMF-102-10 was taken from an isolated lens of tailings material that was formerly contiguous with the southern half of the impoundment. Samples above this site (southeast) were of material that was a mixture of mine waste, soil, peat, and wood. The last core sample of the main traverse, 97-BMF-102-11, was collected from southeast side of the impoundment dam.

We collected core samples from two additional traverses, one across the top of the impoundment dam, perpendicular to the main traverse, and one along the north half of the

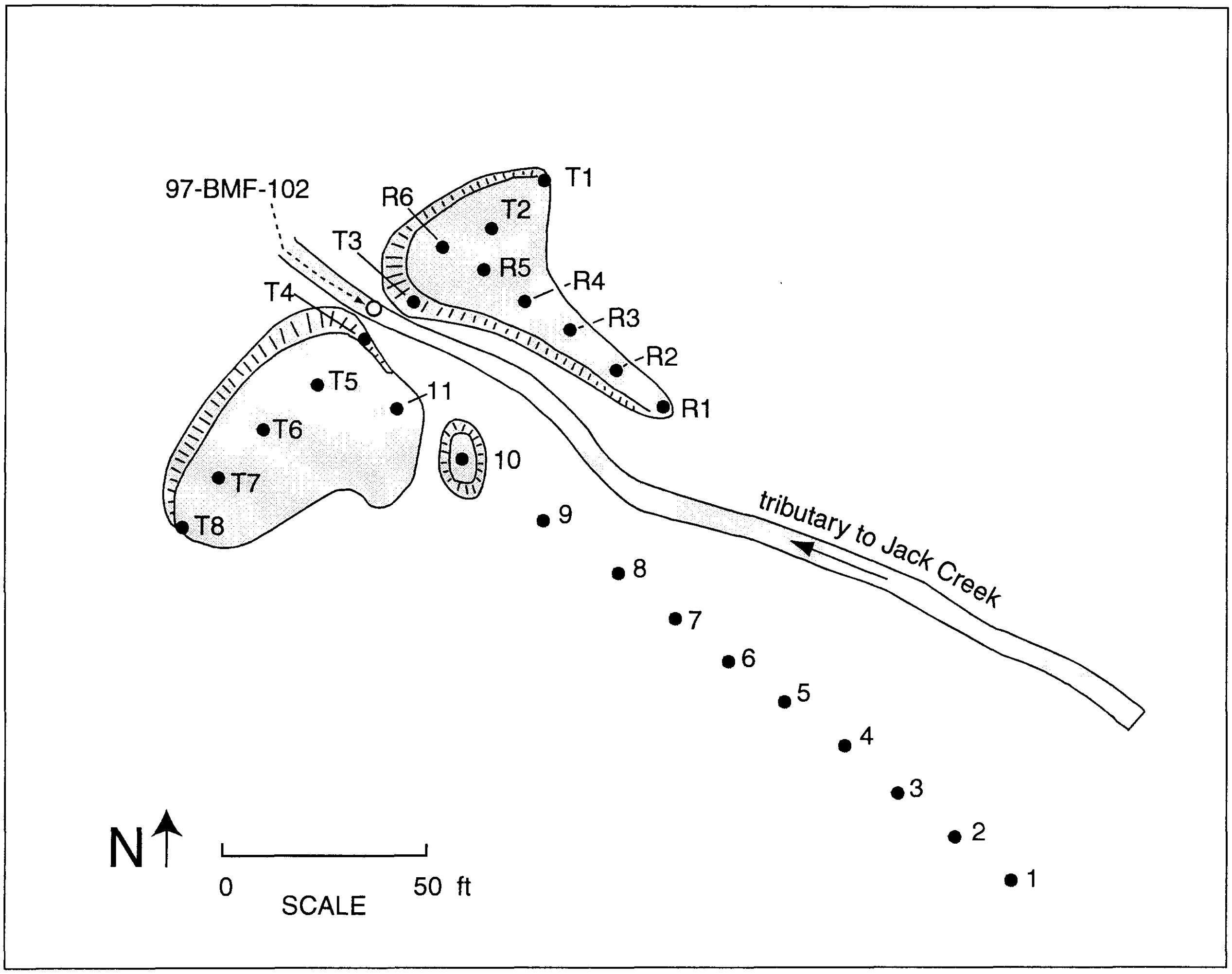

Figure 3. Sample configuration map for tailings cores taken at 97-BMF-102, upper tailings impoundment at Bullion Mine

dissected impoundment, parallel to the main traverse (fig. 3). The end traverse (samples labeled 97-BMF-102-T1 through T8) was started at the northeast corner of the impoundment dam, where the forest soil began, and ran southwest, on a bearing of S 48^0 W, across the creek and to the other side, ending at the edge of the southwest corner of the dam. The sites were unevenly spaced because of the interruption caused by the breach, the stream, and debris close to the stream. The unnamed tributary runs between sample sites 97-BMF-102-T3 and -T4. The localities of the core sites are not presented in the tables because the relative positions were determined by compass and tape, and are best presented in the figures 3 and 4. However, the locality of the point where the tributary passes through the breached dam can accurately be determined from aerial photographs. Table 2 gives the localities of the points where the tributary passes through the two breached dams. Finally, we collected cores from a traverse along the north half of the tailings impoundment. This traverse started about 30 m (100 ft) southeast of the face of the impoundment dam, and ran above and along the bank of the creek. Six core samples were taken from this tailings bank at regular spacing intervals of 5 m. These are labeled 97-BMF-102-R1 through -R6 (fig. 3).

Table 2. Localities of points where Jack Creek tributary passes through breached dams

	Sample Site	Latitude (DMS)	Longitude (DMS)
upper impoundment	97-BMF-102	46° 21' 28.0"	112° 17' 46.0"
lower impoundment	97-BMF-103	46° 21' 30.5"	112° 17' 48.5"

Lower tailings impoundment

About 100 m (330 ft) downstream from the first breached impoundment dam is a second tailings impoundment dam, which is also breached. This lower dam is about 1.5 m (5 ft) tall, 5 m (16 ft) thick at the base, and 75 m (250 ft) wide, and was constructed of rock and dirt fill; the dam itself contained no tailings. We collected core samples from this impoundment from three separate traverses. The main traverse samples are labeled 97-BMF-103-T1 through -103-T9 (fig. 4). The sample line had a bearing of N 60^O E and was located parallel to the dam top and about 5 m (16 ft) upstream. Core sample 97-BMF-103-T1 was taken from the southwest end of the traverse, and subsequent samples were taken at 10 m spacing (33 ft) for samples -103-T2 through -103-T6. Sample number 97-BMF-103-T7 was located 57 m (190 ft) northeast of 97-BMF-103-T1; sample number 97-BMF-103-T8 was 67 m (220 ft), and 97-BMF-103-T9 was 73 m (240 ft) from 97-BMF-103-T1. The unnamed tributary runs between samples -103-T6 and -103-T7; Table 2 gives the locality of where the tributary passes through the breached dam.

We collected core samples from two longitudinal traverses, the first starting at sample site 97-BMF-103-T4 and running perpendicular to the dam and up through the tailings material. This line produced three samples. The first, 97-BMF-103-L1, was located 5 m (16 ft) up (southeast) of the main traverse line. Samples 97-BMF-103-L2 and -L3 were located 10 and 15 m up from the main line, respectively. Along this longitudinal traverse, at a distance of 18 m (60 ft) up from the main traverse line, only a thin veneer of tailings is present, and at 20 m (65 ft) there are no tailings.

The second longitudinal traverse was started from the main traverse line between samples 97-BMF-103-T5 and -T6 (fig 4.) The first sample, 97-BMF-103-R1, was collected from where the main traverse and second traverse intersect. The second sample, -103-R2, was collected 5 m

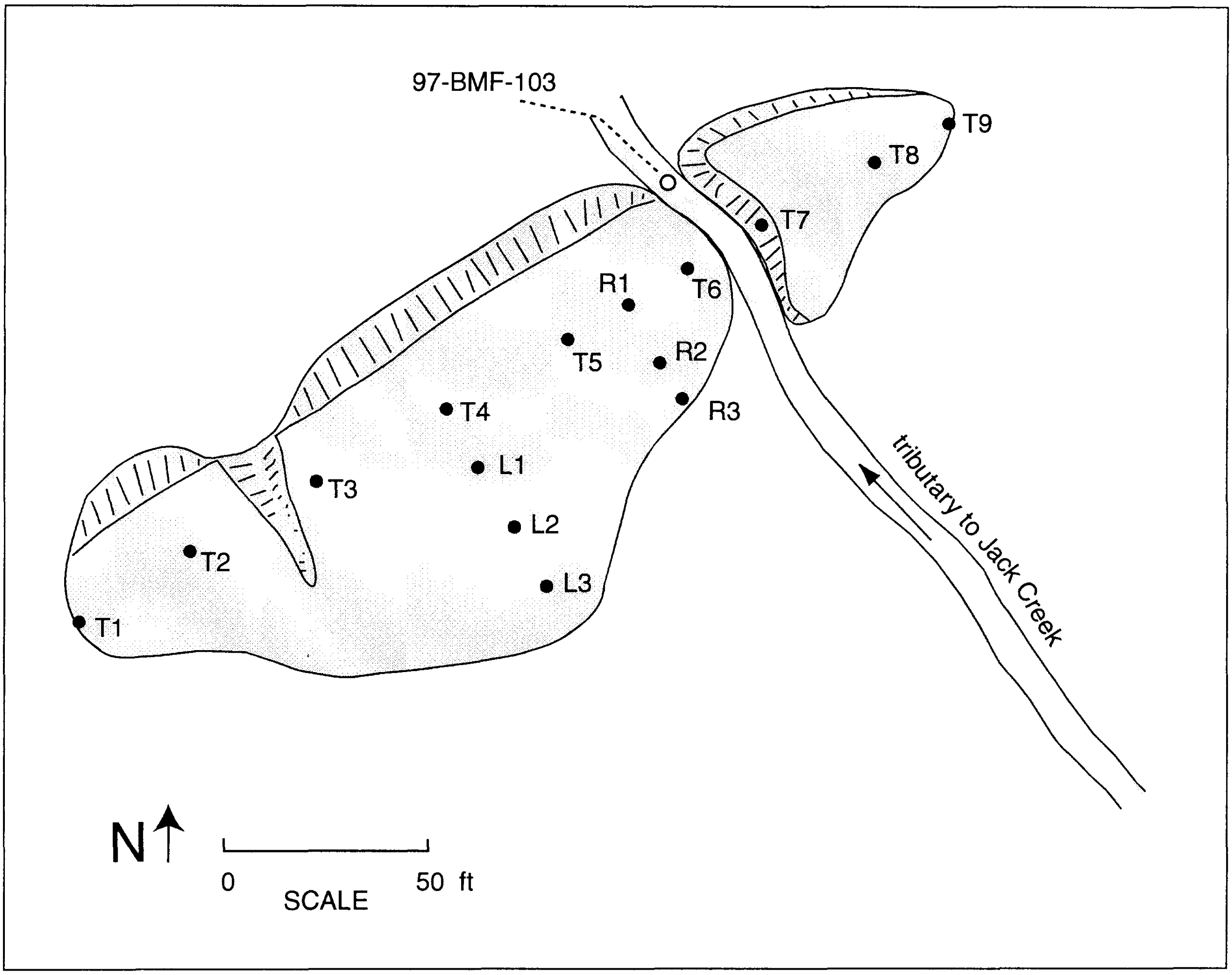

Figure 3. Sample configuration map for tailings cores taken at 97-BMF-103, lower tailings impoundment at Bullion Mine.

(16 ft) up (southeast) from the first, and the last sample, -103-R3 was taken 8 m (26 ft) up from the first. At 10 m (33 ft) along the second traverse line, there are no tailings present.

Crystal Mine area fluvial tailings cores

Mine waste and tailings from the Crystal Mine have been eroded into the creek in Uncle Sam Gulch. This material is then incorporated into the bed sediments and transported downstream. We took four different one-inch cores from Uncle Sam Gulch downstream of the Crystal Mine. Uncle Sam Gulch in this area is steep and narrow, with an active channel of about 3 to 4 m (10 to 13 ft). There are numerous downed logs in the creek channel which create pockets where sediment has accumulated. The first three cores, 97-BMF-109-1 through -109-3, were collected from the creek about 100 m downstream from the mine (fig 2.). Sample -109-2 is 7 m (23 ft) downstream from -109-1, and -109-3 is 10 m (33 ft) downstream from -109-1. Below the third sample, the sediment deposits are discontinuous. The fourth sample, 97-BMF-109-4, was taken from an isolated sediment deposit about 230 m (750 ft) downstream from 97-BMF-109-3. Table 3 gives the localities of the fluvial tailings cores from Uncle Sam Gulch.

Table 3. Localities of four fluvial tailings cores from Uncle Sam Gulch below Crystal mine

	Sample Site	Latitude (DMS)	Longitude (DMS)
Uncle Sam Gulch fluvial tailings cores	97-BMF-109-1	46° 20' 49.5"	112° 15' 36.5"
	97-BMF-109-2	46° 20' 49.3"	112° 15' 36.5"
	97-BMF-109-3	46° 20' 49.2"	112° 15' 36.5"
	97-BMF-109-4	46° 20' 42.0"	112° 15' 36.5"

Discussion of Results

Mine-waste cores

Bullion mine upper impoundment

Examination of the analytical data (table 7) indicates that the majority of core samples contain contamination from the environmentally important elements Ag, As, Cd, Cu, Pb, and Zn. Along the main traverse (97-BMF-102-1 through -11), the maximum concentrations for the elements listed above are: 110 ppm silver, 6,600 ppm arsenic, 250 ppm cadmium, 9,000 ppm copper, 6,500 ppm lead, and 18,000 ppm zinc (1.8%). Along traverse R, the maximum concentrations for the elements listed above are: 76 ppm silver, 6,800 ppm arsenic, 34 ppm cadmium, 930 ppm copper, 7,800 ppm lead, and 500 ppm zinc. Along traverse T, the maximum concentrations for the elements listed above are: 120 ppm silver, 11,000 ppm arsenic (1.1%), 56 ppm cadmium, 2,300 ppm copper, 6,500 ppm lead, and 770 ppm zinc. In a report on the mill tailings present at Buckeye Meadow, Fey and others (1999) used operationally defined cutoff values for five elements (Ag, Cd, Cu, Pb, and Zn) to determine the depths at which cores penetrated through mine waste and associated deeper contamination related to downward metal migration. These values are shown in table 4. However, application of these cutoff values to cores from the Bullion mine area was not possible, because the cores typically were not deep enough to penetrate through to uncontaminated material; analytical results from the cores did not show contaminant-element concentrations approach the cutoff values with depth. The depths of penetration for the cores along the main traverse of the upper impoundment did not exceed 60 cm (2 ft), and thus the analytical results indicate that the total depths of contamination were greater than 60 cm along the entire line of cores. Four cores from the upper impoundment exceeded 60 cm in depth: 97- BMF-102-R5, -R6, -T7, and -T8; their penetrations were 77, 76, 126, and 97 cm, respectively. None of these cores penetrated to below the contaminated material. Only one core, 97-BMF-102-R1, penetrated below contamination; this core was taken from the southeast end of the north half of the impoundment, where the tailings grade into forest soil.

Table 4. Element concentrations used for determining depth of contamination at Buckeye Meadow, upper Basin Creek (from Fey and others, 1999)

Element	Cutoff (ppm)
Silver	5
Cadmium	5
Copper	300
Lead	100
Zinc	500

The data do show a difference in metal content between the material on the slope southeast of the upper impoundment (cores 97-BMF-102-1 through -10) and the actual tailings of the impoundment. The concentrations of zinc from cores along the main traverse before the impoundment tailings are higher (maximum concentraion of 18,000 ppm) and more variable than from the tailings themselves (maximum concentration of 770 ppm). The same is true for copper (maximum concentration of 9,000 ppm from slope above tailings; maximum concentration of 2,300 ppm from tailings themselves). The opposite is true for lead: concentrations in the impoundment tailings are much higher (maximum concentration of 7,800 ppm) and more variable than concentrations along the main traverse line (maximum concentration of 3,800 ppm). The silver concentrations are higher and more variable in the impoundment tailings than from the slope above the tailings. Arsenic values are high and variable for all cores. Average cadmium concentrations show no great distinction between the cores from the slope and the cores from the impoundment tailings.

Bullion Mine lower impoundment

The analytical data from the lower impoundment cores (table 8) also show high concentrations of Ag, As, Cd, Cu, Pb, and Zn. Along the transverse traverse (97-BMF-103-T1 through -T9), the maximum concentrations for the elements listed above are: 90 ppm silver, 7,300 ppm arsenic, 39 ppm cadmium, 2,500 ppm copper, 6,500 ppm lead, and 640 ppm zinc. Along traverse R, the maximum concentrations for the elements listed above are: 130 ppm silver, 123,000 ppm arsenic (1.2%), 68 ppm cadmium, 1,000 ppm copper, 7,700 ppm lead, and 310 ppm zinc. Along traverse L, the maximum concentrations for the elements listed above are: 110 ppm silver, 13,000 ppm arsenic (1.3%), 31 ppm cadmium, 520 ppm copper, 16,000 ppm lead (1.6%), and 280 ppm zinc. Only two cores from the lower impoundment penetrated below the tailings. One was core 97-BMF-103-R3, taken from within two meters of the edge of the tailings upstream from the dam, and the other was 97-BMF-103-T5.

Uncle Sam Gulch cores

The data for the cores taken below the Crystal Mine along Uncle Sam Gulch are shown in table 9. These cores are also contaminated with the elements discussed above. The maximum concentrations from the four cores are: 26 ppm silver, 11,000 ppm arsenic (1.1%), 110 ppm cadmium, 1,600 ppm copper, 2,300 ppm lead, and 8,000 ppm zinc. These cores are from small, discontinuous lenses of sediment in Uncle Sam Gulch.

Bed sediments

The contrast in trace-element content between bed-sediment samples from above and below the two mines is shown by the total-digest data in table 10. Regional background values, determined from our unpublished work in the Boulder study area, are: silver, less than 2 ppm; cadmium, less than 2 ppm: copper, 30 ppm; lead 55 ppm; and zinc, 170 ppm. Both bed-sediment samples taken from above the respective mines (97-BMS-102S1 above the Bullion Mine and 97-BMS-108S1 above the Crystal Mine) have concentrations similar to these regional background values. The concentrations increase markedly below the two mine sites. For example, at the Bullion Mine tributary to Jack Creek, arsenic concentrations in bed sediments increase from 45 ppm (upstream) to 2,300 ppm (first sediment sample downstream). Copper increases from 47 ppm to 320 ppm, lead increases from 59 ppm to 870 ppm, and zinc increases from 240 ppm to 690 ppm. Along Uncle Sam Gulch, similar increases occur below the Crystal Mine. Arsenic concentrations increase from 39 ppm (upstream) to 3,600 ppm (first sediment sample downstream), copper increases from 36 ppm to 560 ppm, lead increases from 34 ppm to 1,900 ppm, and zinc increases from 160 ppm to 920 ppm

Analyses of trace elements from the warm 2M HCl -1% H_2O_2 leach (table 11) show that much of the trace-element content in the bed sediments is in the leachable phase. This partial extraction releases metals associated with hydrous amorphous iron- and manganese-oxide coatings and colloidal particles incorporated into the bed sediments (Church and others, 1997). The extraction solution only weakly attacks primary sulfide grains with the exception of galena (PbS), which is readily soluble in warm 2M HCl. The proportions of leachable to total concentrations for the metals reveal information about the mineral phases containing and transporting the different metals in the bed sediments.

Examination of the individual elements from the six bed sediments reveals the following:

1. Silver in the leachable phase from the Jack Creek tributary (Bullion Mine) and from Uncle Sam Gulch (Crystal Mine) comprises 70 percent to 100 percent of the total.
2. Arsenic in the leachable phase from the Jack Creek tributary (Bullion Mine) and from Uncle Sam Gulch (Crystal mine) comprises 70 percent to 100 percent of the total.
3. Cadmium in the leachable phase from the Jack Creek tributary comprises 40 percent to 100 percent of the total and from Uncle Sam Gulch comprises 80 percent to 100 percent of the total.
4. Copper in the leachable phase from the Jack Creek tributary comprises 60 percent to 100 percent of the total and from Uncle Sam Gulch comprises 45 percent to 100 percent of the total.
5. Lead in the leachable phase from the Jack Creek tributary (Bullion Mine) and from Uncle Sam Gulch (Crystal Mine) comprises 80 percent to 100 percent of the total (although since the

leach solution solubilizes primary galena, one cannot differentiate between primary-mineral lead and sorbed lead.

6. Zinc in the leachable phase from the Jack Creek tributary comprises 40 percent to 100 percent of the total and from Uncle Sam Gulch comprises 7 percent to 100 percent of the total zinc.

The leach data of the bed sediments reflect the process of element sorption onto colloids and iron- and manganese-hydroxides, and subsequent settling and incorporation into bed sediments. This process helps describe element transport in bed sediments downstream, as discussed in Church and others (1997). A striking example of this is the case of copper and zinc in sample 96-BMS-118. This sample is the farthest downstream from the Crystal Mine on Uncle Sam Gulch, and yet the copper and zinc concentrations are greater than samples collected proximal to the mine. The copper and zinc are sorbed onto colloids and/or iron- and manganese-hydroxides, which are carried in suspension in the water column until they settle out in stream reaches with lower gradients. At the site of 96-BMS-118, the gradient of Uncle Sam Gulch is lower than above, and so the suspended material has accumulated in the bed sediments. The leach data show that 100 percent of the copper and 97 percent of the zinc in this sample are contained in the leachable phase.

Summary and Conclusions

Analytical results for 23 cores collected from above the upper tailings impoundment below the Bullion Mine, 15 cores from the lower tailings impoundment, and four cores from Uncle Sam Gulch below the Crystal Mine reveal that six environmentally important trace elements (Ag, As, Cd, Cu, Pb and Zn) are present at high concentrations. Analyses of eleven bed sediments from the Jack Creek tributary and from Uncle Sam Gulch show significant influence from mine waste and tailings. Partial extractions of the bed sediments reveal that a significant fraction (40 percent to 100 percent) of these named trace elements are present in phases dissolved by a warm 2M HCl–1percent H_2O_2 leach. These leachable phases include settled colloids and hydrous amorphous iron- and manganese-hydroxide coatings of bed-sediment particles.

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Table 5. Field numbers, depths to midpoints of intervals, and interval sample descriptions for cores from Bullion Mine tailings impoundments

Field No	DEPTH (cm)	sample description
97BMF-102-1-a	5	brown silt, micas, abundant wood bits and fibers
97BMF-102-1-b	17	medium-brown silt, micaceous, some rootlet fibers, some iron oxidation coloring
97BMF-102-1-c	29	brown-orange silt, micas, root fibers
97BMF-102-1-d	40	orange-brown coarse-to-fine sand, wood bits and fibers
97BMF-102-1-e	55	dark brown peaty silt, some fine pebbles, some mica, abundant wood fiber
97BMF-102-4-a	4	tan-gray well sorted fine sand and silt, little iron oxidation, wood fibers
97BMF-102-4-b	14	gray medium-to-fine sand, sparse charcoal, micas, moderately-strong iron oxidation, wood plug at bottom of section
97BMF-102-4-c	22	dark gray silt, very fine fresh mafics, micas, root fibers
97BMF-102-4-d	28	medium brown peaty silt, very fibrous, wood fibers
97BMF-102-4-e	36	medium gray-brown blocky silt, little clay, wood fibers
97BMF-102-4-f	45	gray-brown fine sand and silt, little clay, wood fibers, sparse charcoal
97BMF-102-4-g	58	gray-brown medium to fine sand and clay, micas, moderate charcoal, wood fibers
97BMF-102-5-a	3	medium brown well sorted fine sand, little iron oxidation, some wood fibers
97BMF-102-5-b	12	dark gray silt, clay, root fibers
97BMF-102-5-c	27	gray silt and clay, some micas, iron oxidation, root fibers
97BMF-102-6-a	3	brown fine sand, fresh mafics, pyrite and biotite, no organic debris observed
97BMF-102-6-b	10	brown organic material with a wood fiber plug
97BMF-102-6-c	17	brown medium-to-fine sand, mica, some root fibers
97BMF-102-6-d	22	dark brown peaty organic clay, some mica, root fibers
97BMF-102-6-e	29	dark brown very fibrous wood section
97BMF-102-6-f	34	brown medium-to-fine sand, fresh mafics, no organic debris observed
97BMF-102-6-g	37	brown organic clay, moist, wood fibers
97BMF-102-6-h	54	dark black moist organic clay, micaceous, wood fibers
97BMF-102-7-a	3	light tan fine sand, some iron oxidation, no organic debris observed
97BMF-102-7-b	9	dark brown silt, peaty fibrous plug, root fibers, moderate iron oxidation
97BMF-102-7-c	14	dark brown medium-to-fine sand, minor iron oxidation, slightly organic, fibers
97BMF-102-7-d	20	dark brown medium-to-fine sand, minor iron oxidation, slightly organic, fibers
97BMF-102-7-e	27	dark brown organic clay plug, root fibers
97BMF-102-7-f	36	medium brown medium-to-fine moist sand, mica, few fibers, few organics
97BMF-102-7-g	45	brown fine sand, silt and clay, fine micas, some organics, some fiber

Table 5. Field numbers, depths to midpoints of intervals, and interval sample descriptions for cores from Bullion Mine tailings impoundments (cont.)

Field No	DEPTH (cm)	sample description
97BMF-102-8-a	5	brown well sorted fine sand, micaceous, a few fine pebbles, some fresh mafics, slight orange cast, no organic debris observed
97BMF-102-8-b	13	dark brown silt, minor iron oxidation coloring, root wood plug, very fibrous wood
97BMF-102-8-c	27	dark brown medium-to-fine moist sand, micaceous, fibrous organics
97BMF-102-9-a	4	medium brown fine sand, micas, no organic debris observed
97BMF-102-9-b	10	light brown fine sand, a few fresh mafics, minor iron oxidation, no organic debris observed
97BMF-102-9-c	16	brown silt, fibrous peaty material, some organics
97BMF-102-9-d	22	medium brown medium-to-fine sand, slight iron oxidation, sparse root fibers
97BMF-102-10-a	8	buff fine sand, well sorted, no organic debris observed
97BMF-102-10-b	23	homogenous buff and yellow fine sand and silt, moist, sulfurous odor, no organic debris observed
97BMF-102-10-c	36	homogenous buff and yellow fine sand and silt, clay, moist, slight sulfur odor, few plant fibers
97BMF-102-10-d	48	gray clay and silt, some grass fibers
97BMF-102-10-e	54	gray fine sand, some fresh mafics, fresh biotite, few wood bits
97BMF-102-11-a	10	buff-orange leached fine homogeneous sand, no mafics, no organic debris observed
97BMF-102-11-b	24	buff-white and orange well sorted silt, some clay, no organic debris observed
97BMF-102-11-c	38	buff-white well sorted silt, some clay, no organic debris observed
97BMF-102-11-d	54	buff-white well sorted silt, clay, no organic debris observed
97BMF-102-R1-a	4	tan-brown medium-to fine-sand, a few mafics, pine needles, slight orange coloring
97BMF-102-R1-b	13	tan-brown medium to fine sand, a few mafics, pine needles, slight orange coloring
97BMF-102-R1-c	21	tan-brown medium to fine sand, a few mafics, pine needles, slight orange coloring
97BMF-102-R1-d	28	buff fine sand, minor iron oxidation, little wood fibers
97BMF-102-R1-e	42	medium brown medium-to-fine sand, micaceous, a few fresh mafics, no organic debris observed
97BMF-102-R1-f	59	brown and orange medium-to-fine sand, oxidized mica, iron oxidation color, no organic debris observed
97BMF-102-R2-a	4	orange-brown fine sand, fresh biotite, iron oxidation, few pine needles
97BMF-102-R2-b	17	tan and orange loosely consolidated fine sand, fresh mafics, some sticks and twigs
97BMF-102-R2-c	38	buff fine sand, oxidized mica, fresh mafics, little or no iron oxidation, no organic debris observed
97BMF-102-R2-d	59	buff fine sand, oxidized mica, fresh mafics, little or no iron oxidation, no organic debris observed

Table 5. Field numbers, depths to midpoints of intervals, and interval sample descriptions for cores from Bullion Mine tailings impoundments (cont.)

Field No	DEPTH (cm)	sample description
97BMF-102-R3-a	4	tan-buff fine sand, mica, iron oxidation, pine needles
97BMF-102-R3-b	15	tan fine sand, mostly quartz, sparse micas, bleached, minor iron oxidation, no organic debris observed
97BMF-102-R3-c	25	bleached silt and clay plug, slightly yellow, no organic debris observed
97BMF-102-R3-d	30	brown medium-to-fine sand, a few fine pebbles, mica, charcoal, twigs
97BMF-102-R4-a	4	buff silt, some clay, a few wood fibers
97BMF-102-R4-b	11	buff silt, some clay, no organic debris observed
97BMF-102-R4-c	17	buff silt, some clay, no organic debris observed
97BMF-102-R5-a	11	buff fine sand, quartz, fresh mica, homogenous, no organic debris observed
97BMF-102-R5-b	28	buff fine sand, quartz, fresh mica, homogenous, no organic debris observed
97BMF-102-R5-c	50	buff fine sand, quartz, fresh mica, homogenous, no organic debris observed
97BMF-102-R5-d	69	buff fine sand, quartz, fresh mica, homogenous, no organic debris observed
97BMF-102-R5-e	77	buff fine sand and clay, fresh mica, homogenous, no organic debris observed
97BMF-102-R6-a	7	light tan-brown fine sand, micas, sparse fresh mafics, pine needles
97BMF-102-R6-b	21	buff and yellow fine sand, mica, sparse fresh mafics, sparse pine needles
97BMF-102-R6-c	29	tan silt and clay plug, leached, minor iron oxidation, no organic debris observed
97BMF-102-R6-d	32	buff and yellow fine sand, sparse fine fresh mafics, micas, no organic debris observed
97BMF-102-R6-e	38	buff and yellow fine sand, loosely consolidated, no organic debris observed
97BMF-102-R6-f	48	buff and yellow fine sand, loosely consolidated, no organic debris observed
97BMF-102-R6-g	60	buff and yellow fine sand, loosely consolidated, no organic debris observed
97BMF-102-R6-h	69	buff and yellow fine sand, loosely consolidated, few pine needles
97BMF-102-R6-I	76	buff and yellow fine sand, loosely consolidated, two pine needles

Table 5. Field numbers, depths to midpoints of intervals, and interval sample descriptions for cores from Bullion Mine tailings impoundments (cont.)

Field No	DEPTH (cm)	sample description
97BMF-102-T1-a	6	buff and yellow fine sand, fresh mafics, some pine needles
97BMF-102-T1-b	17	buff and yellow fine sand, fresh mafics, no organic debris observed
97BMF-102-T1-c	25	buff and yellow silt and clay plug, no organic debris observed
97BMF-102-T1-d	29	buff and yellow fine sand, fresh mafics, no organic debris observed
97BMF-102-T1-e	34	buff and yellow silt and clay plug, no organic debris observed
97BMF-102-T1-f	39	yellow and orange fine sand and silt, very fine fresh mafics, no organic debris observed
97BMF-102-T1-g	40	buff and yellow silt and clay plug, no organic debris observed
97BMF-102-T1-h	47	yellow and orange fine sand and silt, very fine fresh mafics, no organic debris observed
97BMF-102-T1-l	53	yellow and orange silt and clay plug
97BMF-102-T1-j	60	dark brown silt and clay, coarse-to-fine sand, medium pebbles, sparse charcoal, some wood fiber
97BMF-102-T2-a	4	buff-yellow fine sand, micas, fresh mafics, some wood fibers
97BMF-102-T2-b	23	buff-yellow fine sand, micas, fresh mafics, no organic debris observed
97BMF-102-T2-c	42	buff-yellow and brown fine sand, micas, fresh mafics, no organic debris observed
97BMF-102-T2-d	49	buff-yellow and brown fine sand, micas, fresh mafics, wood chips
97BMF-102-T2-e	58	buff and yellow fine sand, micas, fresh mafics, no organic debris observed
97BMF-102-T3-a	4	buff and yellow fine sand and silt, some wood fibers, fresh mafics, no organic debris observed
97BMF-102-T3-b	15	buff and yellow silt and clay, very fine fresh mafics, micas, no organic debris observed
97BMF-102-T3-c	26	buff and yellow silt and clay, some coarse sand, very fine mafics, micas, wood fibers
97BMF-102-T4-a	6	dark yellow silt and clay, no organic debris observed
97BMF-102-T4-b	13	brown medium-to-fine sand, fresh biotite, some coarse pebbles, no organic debris observed
97BMF-102-T5-a	9	yellow silt and clay, no organic debris observed
97BMF-102-T5-b	25	medium brown silt, coarse-to-medium sand, coarse pebbles, wood fiber, fresh mafics, no organic debris observed
97BMF-102-T5-c	44	brown silt, coarse-to-fine sand, root fibers, oxidized micas and fresh mafics

Table 5. Field numbers, depths to midpoints of intervals, and interval sample descriptions for cores from Bullion Mine tailings impoundments (cont.)

Field No	DEPTH (cm)	sample description
97BMF-102-T6-a	4	buff-yellow silt and clay, moist, no organic debris observed
97BMF-102-T6-b	13	gray silt and clay, no organic debris observed
97BMF-102-T6-c	23	buff-yellow silt and clay, moist, no organic debris observed
97BMF-102-T6-d	31	brown silt, fine sand, strong iron oxidation, no organic debris observed
97BMF-102-T6-e	36	buff-yellow silt and clay, moist, no organic debris observed
97BMF-102-T6-f	41	gray silt and clay, no organic debris observed
97BMF-102-T6-g	45	buff-yellow silt and clay, moist, no organic debris observed
97BMF-102-T6-h	47	gray silt and clay, no organic debris observed
97BMF-102-T6-I	55	buff and yellow medium-to-fine sand, fine fresh mafics, micas, sparse wood fiber
97BMF-102-T7-a	19	buff-yellow fine sand, fine fresh mafics, micas, no organic debris observed
97BMF-102-T7-b	51	buff-yellow fine sand and clay, fine fresh mafics, micas, no organic debris observed
97BMF-102-T7-c	65	buff-yellow fine sand and clay, fine fresh mafics, micas, no organic debris observed
97BMF-102-T7-d	70	buff-yellow fine sand and clay, fine fresh mafics, micas, no organic debris observed
97BMF-102-T7-e	95	gray clay and silt, fine sand, moist, no organic debris observed
97BMF-102-T7-f	106	gray and yellow consolidated clay and silt, fine sand, sulfur odor, moist, no organic debris observed
97BMF-102-T7-g	115	gray and yellow consolidated clay and silt, fine sand, sulfur odor, moist, no organic debris observed
97BMF-102-T7-h	126	gray and yellow consolidated clay and silt, fine sand, sulfur odor, moist, no organic debris observed
97BMF-102-T8-a	13	buff-yellow medium-to-fine sand, very fine fresh mafics, micas, no organic debris observed
97BMF-102-T8-b	36	buff-yellow and orange medium-to-fine sand, very fine fresh mafics, micas, no organic debris observed
97BMF-102-T8-c	54	buff-yellow and orange medium-to-fine sand, very fine fresh mafics, micas, no organic debris observed
97BMF-102-T8-d	66	buff-yellow and orange medium-to-fine sand, very fine fresh mafics, micas, no organic debris observed
97BMF-102-T8-e	72	buff-yellow and orange consolidated medium-to-fine sand, very fine fresh mafics, micas, no organic debris observed
97BMF-102-T8-f	88	buff-yellow and orange consolidated medium-to-fine sand, very fine fresh mafics, micas, no organic debris observed
97BMF-102-T8-g	97	buff-yellow clay, moist, no organic debris observed
97BMF-103-L1-a	6	brown and yellow silt, clay, fine fresh mafics, pine needles
97BMF-103-L1-b	15	buff-yellow silt and clay, no organic debris observed
97BMF-103-L1-c	27	buff-yellow silt and clay, no organic debris observed
97BMF-103-L1-d	38	light brown silt and clay, moderate wood fibers
97BMF-103-L1-e	49	medium brown sand and silt, fine pebbles, no organic debris observed

Table 5. Field numbers, depths to midpoints of intervals, and interval sample descriptions for cores from Bullion Mine tailings impoundments (cont.)

Field No	DEPTH (cm)	sample description
97BMF-103-L2-a	5	buff and tan fine sand, fine fresh mafics, no organic debris observed
97BMF-103-L2-b	14	yellow wood and clay plug
97BMF-103-L2-c	22	brown-tan and buff fine sand, oxidized mica, fine fresh mafics, sparse fine pebbles, no organic debris observed
97BMF-103-L2-d	30	buff-yellow fine sand, fine fresh mafics, no organic debris observed
97BMF-103-L2-e	38	buff-yellow silt and clay, mixed with wood and twigs
97BMF-103-L2-f	45	dark brown medium-to-fine sand, micas, medium pebbles, some wood fiber
97BMF-103-L3-a	9	buff-yellow fine sand, fine fresh mafics, no organic debris observed
97BMF-103-L3-b	21	yellow fine sand and silt, fresh mafics, wood plug
97BMF-103-L3-c	29	yellow-orange silt, mixed with wood plug
97BMF-103-L3-d	42	brown medium-to-fine sand, coarse pebbles, micas, some root fibers
97BMF-103-R1-a	6	brown and burnt orange medium sand, some wood
97BMF-103-R1-b	27	brown coarse-to-fine sand, fresh mafics, strong iron oxidation, some wood
97BMF-103-R1-c	44	orange-brown coarse-to-fine sand, fresh mafics, strong iron oxidation, wood bits
97BMF-103-R1-d	50	white clay, a little organic fiber
97BMF-103-R2-a	7	light yellow silt and clay, slight sulfur odor, no organic debris observed
97BMF-103-R2-b	16	buff-yellow fine sand, very fine fresh mafics, no organic debris observed
97BMF-103-R2-c	22	buff-sage silt and clay, no organic debris observed
97BMF-103-R2-d	31	medium brown coarse-to-medium sand, fine fresh mafics, some wood
97BMF-103-R3-a	2	buff clay, some twigs
97BMF-103-R3-b	8	buff clay, wood, charcoal
97BMF-103-R3-c	26	brown silt and clay, fine sand, little wood, oxidized micas
97BMF-103-T1-a	2	brown and yellow fine sand, pine needles, fresh mafics
97BMF-103-T1-b	10	buff-yellow fine sand, fresh mafics, micas, no organic debris observed
97BMF-103-T1-c	21	buff-yellow fine sand, fresh mafics, micas, iron oxidation, no organic debris observed
97BMF-103-T1-d	30	buff-yellow fine sand, fresh mafics, micas, iron oxidation, no organic debris observed
97BMF-103-T2-a	4	buff-yellow fine sand, fine fresh mafics, no organic debris observed
97BMF-103-T2-b	15	buff-yellow fine sand, fine fresh mafics, no organic debris observed
97BMF-103-T2-c	29	buff-yellow coarse-to-fine sand, fine fresh mafics, no organic debris observed
97BMF-103-T2-d	41	buff-yellow coarse-to-fine sand, fine fresh mafics, iron oxidation, no organic debris observed
97BMF-103-T2-e	53	buff-yellow coarse-to-fine sand, fine fresh mafics, iron oxidation, no organic debris observed

Table 5. Field numbers, depths to midpoints of intervals, and interval sample descriptions for cores from Bullion Mine tailings impoundments (cont.)

Field No	DEPTH (cm)	sample description
97BMF-103-T3-a	6	buff fine sand and silt, a few wood fibers
97BMF-103-T3-b	14	buff fine sand and silt, iron oxidation plug, few wood fibers
97BMF-103-T3-c	25	light gray fine sand and silt, little clay, no organic debris observed
97BMF-103-T3-d	36	yellow fine sand and silt, no organic debris observed
97BMF-103-T3-e	40	yellow clay, fine sand and silt, no organic debris observed
97BMF-103-T3-f	45	buff silt, a little clay, iron oxidation, no organic debris observed
97BMF-103-T3-g	51	buff fine sand and silt, iron oxidation, sparse fine fresh mafics, no organic debris observed
97BMF-103-T3-h	60	buff clay, fine sand and silt, fine fresh mafics, iron oxidation, sparse wood bits
97BMF-103-T3-I	69	buff silt and clay, iron oxidation, few fine fresh mafics, no organic debris observed
97BMF-103-T3-j	75	mixed zone of dark silt and clay, no organic debris observed
97BMF-103-T3-k	82	brown fine sand, some coarse pebbles, wood fiber
97BMF-103-T3-l	93	dark brown rootlet fibers, fine micas
97BMF-103-T3-m	103	dark brown rootlet fibers, fine micas
97BMF-103-T4-a	4	medium brown fine sand and silt, fine fresh mafics, pine needles, wood bits
97BMF-103-T4-b	9	mix of brown-orange-yellow medium-to-fine sand, wood bits
97BMF-103-T4-c	13	buff-brown silt and clay, sparse wood matter, fresh mafics
97BMF-103-T4-d	18	medium brown silt, organics, wood fibers
97BMF-103-T7-a	7	buff-yellow silt and clay, fresh mafics, sparse wood fibers
97BMF-103-T7-b	22	brown medium-to-fine sand, fresh mafics, micas, few twigs
97BMF-103-T7-c	40	buff-yellow silt and clay, sparse very coarse pebbles
97BMF-103-T8-a	15	buff-yellow fine sand and silt, loosely consolidated, fine fresh mafics, oxidized mica, no organic debris observed
97BMF-103-T8-b	40	buff-yellow clay, fine sand and silt, loosely consolidated, fine fresh mafics, oxidized mica, no organic debris observed
97BMF-103-T8-c	58	buff-yellow fine sand and silt, some clay, fine fresh mafics, no organic debris observed
97BMF-103-T9-a	3	buff-yellow fine silt, some wood twigs
97BMF-103-T9-b	13	buff-yellow silt, fine fresh mafics, some clay, no organic debris observed
97BMF-103-T9-c	27	buff-yellow silt, fine fresh mafics, some clay, no organic debris observed
97BMF-103-T9-d	42	brown fine sand, abundant fresh mafics, and oxidized micas
97BMF-103-T9-e	54	buff clay, abundant wood fibers
97BMF-103-T9-f	63	dark brown and orange medium-to-fine sand, some root fibers, iron oxidation, sparse root fibers

Table 5. Field numbers, depths to midpoints of intervals, and interval sample descriptions for cores from Bullion Mine tailings impoundments (cont.)

Field No	DEPTH (cm)	sample description
97BMF-103-T5-a	9	buff and yellow fine sand, mica, fine fresh mafics, few pine needles
97BMF-103-T5-b	26	yellow-white silt and clay, leached, no organic debris observed
97BMF-103-T5-c	38	brown-gray silt and clay, some organic rootlets
97BMF-103-T5-d	46	brown-orange silt and clay, mica, some organic fiber
97BMF-103-T5-e	55	brown-orange silt and clay, mica, iron oxidation, some organic fiber
97BMF-103-T5-f	63	brown silt and clay, some fine to medium pebbles, oxidized micas, no organic debris observed
97BMF-103-T6-a	6	brown and orange coarse to fine sand, fresh mafics, micas, biotite, no organic debris observed
97BMF-103-T6-b	16	gray, slightly yellow silt and clay, iron oxidation, no organic debris observed
97BMF-103-T6-c	28	dark brown very fibrous organic silt, root fibers, some leached clay
97BMF-103-T6-d	43	dark brown very fibrous organic silt, root fibers, some leached clay

Table 6 Field numbers, depths to midpoints of intervals, and interval sample descriptions for cores from Uncle Sam Gulch below Crystal Mine

Field No	DEPTH (cm)	sample description
97BMF-109-1-a	15	tan-brown medium sand, weak iron oxide staining, abundant fresh mafics, loose biotite
97BMF-109-1-b	38	tan-brown coarse-to-medium sand, weak iron oxide staining, fresh mafics, loose biotite
97BMF-109-1-c	56	tan-brown coarse-to-medium sand with some fine pebbles, weak iron oxide staining
97BMF-109-2-a	15	light brown coarse and fine sand with fine pebbles, abundant fresh mafics and loose biotite
97BMF-109-2-b	38	medium sand with silt and clay, some wood, weak iron oxide staining
97BMF-109-2-c	51	silt and clay, some wood and charcoal, moderate iron oxide staining, some oxidized micas
97BMF-109-3-a	2	mostly wood, some tan-gray silt with loose oxidized micas
97BMF-109-3-b	8	coarse and medium sand, charcoal, some fresh mafics
97BMF-109-3-c	18	brown-orange medium and fine sand, loose oxidized micas, some charcoal and wood pieces
97BMF-109-3-d	29	medium brown medium and fine sand, some fine pebbles, charcoal pieces, oxidized micas
97BMF-109-4-a	10	brown-tan medium and fine sand, abundant fresh and oxidized micas, some small twigs
97BMF-109-4-b	32	orange-brown fine sand and silt, loose biotite and oxidized micas, some pine needles
97BMF-109-4-c	53	coarse and fine sand, some wood pieces, abundant iron oxide crusts with fine-to-coarse pebble-size sulfides

Table 7. Major and trace-element data from core samples analyzed by ICP-AES, upper tailings impoundment below Bullion Mine, Montana

Field Number	DEPTH, (cm)	Al %	Ca %	Fe %	K %	Mg %	Na %	P %	Ti %	Mn ppm	Ag ppm
97BMF-102-1-a	5	5.7	0.86	4.6	2.1	0.57	0.93	0.07	0.28	360	21
97BMF-102-1-b	17	6.4	0.99	7.3	1.8	0.80	0.96	0.03	0.37	680	6
97BMF-102-1-c	29	6.8	1.2	5.6	2.5	0.75	1.2	0.04	0.34	1300	3
97BMF-102-1-d	40	6.6	1.2	4.2	3.1	0.57	1.3	0.03	0.25	690	< 2
97BMF-102-1-e	55	6.1	1.7	2.0	2.1	0.62	1.0	0.06	0.32	320	2
97BMF-102-4-a	4	7.1	1.5	5.0	2.7	0.89	1.7	0.08	0.49	640	< 2
97BMF-102-4-b	14	6.7	1.4	3.5	3.1	0.62	1.7	0.05	0.30	400	< 2
97BMF-102-4-c	22	7.8	1.0	3.1	1.6	1.0	1.0	0.08	0.50	390	3
97BMF-102-4-d	28	6.0	0.60	2.0	0.82	0.44	0.42	0.08	0.23	330	< 2
97BMF-102-4-e	36	7.4	1.2	3.4	1.9	0.86	1.1	0.08	0.41	760	< 2
97BMF-102-4-f	45	7.2	1.5	3.3	2.4	1.0	1.5	0.05	0.45	570	< 2
97BMF-102-4-g	58	7.2	1.5	2.7	2.7	0.87	1.5	0.05	0.40	440	< 2
97BMF-102-5-a	3	6.3	1.1	2.7	2.3	0.6	1.2	0.06	0.30	450	7
97BMF-102-5-b	12	6.5	0.89	2.8	1.5	0.7	0.89	0.10	0.39	410	3
97BMF-102-5-c	27	8.0	1.1	4.5	1.9	0.90	1.1	0.03	0.48	530	< 2
97BMF-102-6-a	3	3.4	0.55	6.9	1.8	0.24	0.68	0.02	0.16	260	110
97BMF-102-6-b	10	4.7	0.55	3.8	1.3	0.39	0.52	0.10	0.19	540	29
97BMF-102-6-c	17	7.1	1.2	3.3	2.5	0.76	1.3	0.05	0.36	410	< 2
97BMF-102-6-d	22	6.1	0.74	1.6	1.2	0.45	0.68	0.09	0.27	290	< 2
97BMF-102-6-e	29	3.2	0.72	2.0	0.52	0.21	0.23	0.10	0.10	410	2
97BMF-102-6-f	34	6.3	1.2	0.98	3.6	0.42	1.7	0.03	0.19	240	< 2
97BMF-102-6-g	37	6.2	1.2	1.9	1.2	0.62	0.57	0.10	0.31	780	3
97BMF-102-6-h	54	4.7	1.4	1.8	0.92	0.52	0.59	0.06	0.27	650	2
97BMF-102-7-a	3	4.9	0.67	4.3	1.9	0.54	0.72	0.06	0.24	310	24
97BMF-102-7-b	9	3.0	0.51	6.5	0.61	0.25	0.34	0.13	0.13	590	23
97BMF-102-7-c	14	6.7	1.2	2.3	2.9	0.59	1.5	0.05	0.27	290	3
97BMF-102-7-d	20	6.8	1.1	3.2	2.6	0.62	1.5	0.04	0.31	300	< 2
97BMF-102-7-e	27	6.3	1.1	2.5	1.6	0.65	0.84	0.08	0.36	480	2
97BMF-102-7-f	36	7.2	1.4	1.6	3.3	0.60	1.5	0.03	0.31	360	< 2
97BMF-102-7-g	45	5.9	1.3	1.9	1.5	0.71	0.86	0.05	0.31	490	2

Table 7. Major and trace-element data from core samples analyzed by ICP-AES, upper tailings impoundment below Bullion Mine, Montana (cont.)

Field Number	As ppm	Ba ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cu ppm	Ga ppm	La ppm	Li ppm	Mo ppm
97BMF-102-1-a	3300	510	5	59	5	7	1000	8	43	36	7
97BMF-102-1-b	960	590	8	68	8	28	1100	14	43	43	< 2
97BMF-102-1-c	640	670	6	82	13	26	730	14	51	37	3
97BMF-102-1-d	300	740	4	57	7	9	290	11	34	26	< 2
97BMF-102-1-e	170	510	< 2	60	10	3	50	10	40	42	2
97BMF-102-4-a	680	630	< 2	99	9	21	340	11	64	30	3
97BMF-102-4-b	580	720	< 2	62	5	10	230	6	40	23	3
97BMF-102-4-c	260	520	7	98	8	7	780	19	63	55	2
97BMF-102-4-d	460	300	1300	130	8	7	9000	11	110	38	15
97BMF-102-4-e	180	560	51	62	16	9	160	12	36	60	4
97BMF-102-4-f	100	620	< 2	67	11	19	50	11	40	51	< 2
97BMF-102-4-g	130	640	< 2	72	11	16	43	15	44	42	2
97BMF-102-5-a	550	570	< 2	68	5	3	400	9	42	27	3
97BMF-102-5-b	210	420	8	180	7	7	1600	16	120	42	4
97BMF-102-5-c	340	590	10	91	9	31	1100	15	54	53	9
97BMF-102-6-a	6600	83	150	35	38	5	1300	< 4	29	20	8
97BMF-102-6-b	1400	490	27	200	8	8	2700	14	120	24	13
97BMF-102-6-c	250	630	8	85	6	19	430	14	52	35	4
97BMF-102-6-d	150	430	260	100	5	2	3600	14	90	33	7
97BMF-102-6-e	420	200	140	64	8	7	140	6	45	17	17
97BMF-102-6-f	59	800	< 2	30	5	2	16	11	20	20	< 2
97BMF-102-6-g	120	330	< 2	74	19	7	79	14	49	57	6
97BMF-102-6-h	310	330	11	82	29	5	110	11	40	39	26
97BMF-102-7-a	4100	460	3	58	4	4	310	8	35	30	7
97BMF-102-7-b	3300	360	12	200	5	12	2500	6	140	14	14
97BMF-102-7-c	250	650	5	67	5	3	430	12	44	26	2
97BMF-102-7-d	350	690	13	74	5	20	880	9	58	33	5
97BMF-102-7-e	240	520	52	70	10	8	630	11	47	43	4
97BMF-102-7-f	27	740	< 2	53	6	7	21	11	29	27	< 2
97BMF-102-7-g	150	470	< 2	68	13	13	56	13	42	45	5

Table 7. Major and trace-element data from core samples analyzed by ICP-AES, upper tailings impoundment below Bullion Mine, Montana (cont.)

Field Number	Nb ppm	Nd ppm	Ni ppm	Pb ppm	Sc ppm	Sr ppm	Th ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm
97BMF-102-1-a	11	36	10	3800	17	160	29	< 100	86	23	3	930
97BMF-102-1-b	17	39	14	190	19	170	39	< 100	110	32	4	960
97BMF-102-1-c	11	42	12	190	15	220	31	< 100	120	31	4	750
97BMF-102-1-d	10	26	9	110	8	260	14	< 100	100	17	2	670
97BMF-102-1-e	11	32	13	130	9	200	17	< 100	69	24	2	1500
97BMF-102-4-a	16	54	12	270	11	290	29	< 100	180	29	4	510
97BMF-102-4-b	11	35	7	200	8	300	17	< 100	100	20	3	350
97BMF-102-4-c	15	73	16	270	15	170	33	120	100	51	7	930
97BMF-102-4-d	11	71	19	380	9	86	24	< 100	170	130	8	5900
97BMF-102-4-e	12	30	24	130	11	190	24	< 100	110	20	3	440
97BMF-102-4-f	13	31	13	170	11	250	24	< 100	110	20	2	700
97BMF-102-4-g	13	32	12	150	10	250	20	< 100	96	20	2	320
97BMF-102-5-a	11	41	9	300	10	220	17	< 100	74	23	3	440
97BMF-102-5-b	13	170	13	280	15	150	30	290	91	100	16	1000
97BMF-102-5-c	19	42	15	140	13	200	29	< 100	160	54	5	930
97BMF-102-6-a	< 4	19	9	11000	4	170	7	< 100	89	8	1	18000
97BMF-102-6-b	< 4	210	11	1900	18	110	22	450	77	100	20	1900
97BMF-102-6-c	13	49	15	240	10	230	20	< 100	90	30	4	660
97BMF-102-6-d	11	62	14	180	10	130	24	< 100	65	100	7	3000
97BMF-102-6-e	6	36	27	120	5	66	15	< 100	58	43	4	9500
97BMF-102-6-f	8	13	6	65	5	300	15	< 100	31	7	1	990
97BMF-102-6-g	12	45	30	120	12	120	29	< 100	76	38	4	7400
97BMF-102-6-h	9	35	37	97	8	130	16	< 100	110	32	3	8200
97BMF-102-7-a	8	30	8	1400	11	120	19	< 100	78	16	2	620
97BMF-102-7-b	< 4	200	10	610	24	79	22	370	70	120	18	1200
97BMF-102-7-c	10	48	8	250	8	250	16	< 100	64	30	5	530
97BMF-102-7-d	12	58	10	170	8	240	18	< 100	78	47	6	840
97BMF-102-7-e	11	35	22	82	11	160	24	< 100	78	37	4	4200
97BMF-102-7-f	13	23	9	60	8	290	14	< 100	66	14	2	1400
97BMF-102-7-g	9	35	13	120	10	160	22	< 100	72	28	3	2000

Table 7. Major and trace-element data from core samples analyzed by ICP-AES, upper tailings impoundment below Bullion Mine, Montana (cont.)

Field Number	DEPTH, (cm)	Al %	Ca %	Fe %	K %	Mg %	Na %	P %	Ti %	Mn ppm	Ag ppm
97BMF-102-8-a	5	6.1	1.1	3.3	2.8	0.60	1.1	0.04	0.27	430	9
97BMF-102-8-b	13	1.3	0.39	1.0	0.24	0.09	0.12	0.06	0.05	220	12
97BMF-102-8-c	27	6.7	1.1	2.7	2.7	0.63	1.4	0.06	0.31	500	< 2
97BMF-102-9-a	4	6.3	1.0	3.3	2.8	0.64	1.1	0.04	0.29	450	12
97BMF-102-9-b	10	3.4	0.08	1.1	1.6	0.14	0.08	0.02	0.12	80	17
97BMF-102-9-c	16	7.2	1.1	4.4	2.5	0.75	1.3	0.08	0.36	700	10
97BMF-102-9-d	22	7.3	1.2	4.3	2.7	0.73	1.3	0.03	0.37	1600	< 2
97BMF-102-10-a	8	5.2	0.05	2.2	2.3	0.18	0.06	0.04	0.17	130	59
97BMF-102-10-b	23	6.4	0.08	2.6	2.8	0.23	0.04	0.03	0.18	730	64
97BMF-102-10-c	36	7.4	0.09	2.8	3.1	0.27	0.04	0.05	0.18	330	79
97BMF-102-10-d	48	7.9	0.09	2.4	3.3	0.28	0.04	0.08	0.19	320	73
97BMF-102-10-e	54	3.0	0.06	0.86	1.3	0.12	0.03	0.03	0.16	70	40
97BMF-102-11-a	10	3.9	0.05	1.7	1.8	0.13	0.04	0.03	0.16	70	30
97BMF-102-11-b	24	6.6	0.02	2.1	2.8	0.22	0.04	0.06	0.19	80	54
97BMF-102-11-c	38	6.9	0.02	2.7	3.0	0.23	0.04	0.07	0.19	89	58
97BMF-102-11-d	54	7.2	0.04	2.9	3.1	0.24	0.04	0.07	0.19	96	58
97BMF-102-R1-a	4	2.6	0.06	1.7	1.3	0.09	0.02	0.03	0.13	100	27
97BMF-102-R1-b	13	2.9	0.03	1.6	1.4	0.10	0.04	0.02	0.12	89	21
97BMF-102-R1-c	21	2.8	0.04	1.4	1.3	0.09	0.05	0.02	0.12	78	19
97BMF-102-R1-d	28	3.4	0.08	1.3	1.6	0.12	0.03	0.04	0.14	72	23
97BMF-102-R1-e	42	7.2	1.5	3.8	2.6	0.79	1.4	0.009	0.40	580	< 2
97BMF-102-R1-f	59	6.6	1.3	2.8	3.3	0.62	1.5	0.01	0.33	550	< 2
97BMF-102-R2-a	4	2.5	0.06	1.5	1.3	0.09	0.03	0.03	0.12	120	21
97BMF-102-R2-b	17	3.1	0.04	1.5	1.4	0.10	0.04	0.02	0.12	120	21
97BMF-102-R2-c	38	3.2	0.02	0.97	1.5	0.11	0.05	0.02	0.14	65	20
97BMF-102-R2-d	59	3.1	0.02	0.76	1.5	0.10	0.04	0.02	0.13	62	20
97BMF-102-R3-a	4	3.2	0.07	1.5	1.5	0.12	0.03	0.03	0.12	110	19
97BMF-102-R3-b	15	3.4	0.04	1.1	1.6	0.11	0.05	0.02	0.15	67	16
97BMF-102-R3-c	25	8.5	0.01	3.0	3.5	0.27	0.03	0.07	0.20	97	74
97BMF-102-R3-d	30	4.8	0.85	3.3	2.7	0.39	1.0	0.03	0.28	270	9

Table 7. Major and trace-element data from core samples analyzed by ICP-AES, upper tailings impoundment below Bullion Mine, Montana (cont.)

Field Number	As ppm	Ba ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cu ppm	Ga ppm	La ppm	Li ppm	Mo ppm
97BMF-102-8-a	2200	680	10	72	5	8	220	13	39	23	4
97BMF-102-8-b	230	100	19	160	3	5	2400	5	110	3	3
97BMF-102-8-c	180	670	< 2	65	6	9	460	10	48	31	3
97BMF-102-9-a	2000	640	10	63	6	11	250	11	33	25	4
97BMF-102-9-b	1900	150	9	26	< 2	< 2	110	8	14	28	9
97BMF-102-9-c	530	620	< 2	67	8	5	860	13	41	37	6
97BMF-102-9-d	360	670	< 2	59	15	18	230	15	31	35	6
97BMF-102-10-a	3600	350	18	38	< 2	3	250	10	22	31	16
97BMF-102-10-b	2600	330	19	40	4	3	580	12	22	30	18
97BMF-102-10-c	3700	250	24	43	4	5	670	17	25	27	19
97BMF-102-10-d	2700	230	17	44	5	3	580	19	25	27	17
97BMF-102-10-e	3300	270	11	35	6	< 2	290	5	23	28	16
97BMF-102-11-a	3500	320	17	33	< 2	< 2	160	7	18	27	12
97BMF-102-11-b	5700	290	27	39	< 2	3	270	14	23	27	15
97BMF-102-11-c	4700	270	23	43	< 2	2	280	15	24	26	17
97BMF-102-11-d	4100	250	20	44	< 2	3	310	15	25	28	18
97BMF-102-R1-a	3200	360	4	26	< 2	3	160	< 4	17	30	10
97BMF-102-R1-b	2200	290	10	31	< 2	< 2	140	4	16	28	10
97BMF-102-R1-c	2300	200	11	26	< 2	2	140	5	14	28	10
97BMF-102-R1-d	2600	290	< 2	29	< 2	< 2	250	< 4	18	28	11
97BMF-102-R1-e	240	630	< 2	78	9	18	830	14	47	35	3
97BMF-102-R1-f	34	710	< 2	60	7	20	280	14	38	25	< 2
97BMF-102-R2-a	2800	210	3	23	< 2	< 2	140	< 4	14	31	9
97BMF-102-R2-b	2300	250	11	27	< 2	< 2	120	5	14	27	13
97BMF-102-R2-c	1900	240	10	25	< 2	< 2	88	6	13	25	8
97BMF-102-R2-d	1300	210	6	27	< 2	< 2	66	5	15	26	10
97BMF-102-R3-a	2200	230	< 2	25	< 2	2	120	< 4	15	23	10
97BMF-102-R3-b	2000	220	10	26	< 2	< 2	93	6	14	26	10
97BMF-102-R3-c	6300	270	30	40	< 2	4	330	16	25	25	21
97BMF-102-R3-d	1200	580	< 2	38	3	7	140	7	21	16	2

Table 7. Major and trace-element data from core samples analyzed by ICP-AES, upper tailings impoundment below Bullion Mine, Montana (cont.)

Field Number	Nb ppm	Nd ppm	Ni ppm	Pb ppm	Sc ppm	Sr ppm	Th ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm
97BMF-102-8-a	12	28	8	1600	8	200	20	< 100	82	17	2	330
97BMF-102-8-b	< 4	130	8	340	12	32	16	310	10	130	16	1500
97BMF-102-8-c	9	40	9	200	8	240	17	< 100	67	41	5	500
97BMF-102-9-a	13	27	8	1300	9	200	22	< 100	83	15	2	380
97BMF-102-9-b	4	10	< 2	1900	5	29	8	< 100	53	4	< 1	150
97BMF-102-9-c	12	30	12	410	10	220	18	< 100	100	30	3	1100
97BMF-102-9-d	14	25	10	210	9	250	19	< 100	120	22	2	450
97BMF-102-10-a	5	17	< 2	4700	8	34	12	< 100	84	5	< 1	270
97BMF-102-10-b	8	17	3	5500	9	34	16	< 100	99	7	1	1200
97BMF-102-10-c	13	20	4	6700	11	44	24	110	120	9	1	1500
97BMF-102-10-d	10	21	4	7500	12	45	29	120	120	10	1	1600
97BMF-102-10-e	< 4	16	< 2	3700	5	22	7	< 100	50	4	< 1	3800
97BMF-102-11-a	5	14	< 2	2900	6	30	9	< 100	65	4	< 1	120
97BMF-102-11-b	10	17	< 2	6000	12	36	20	< 100	100	6	< 1	210
97BMF-102-11-c	12	19	< 2	6500	10	41	22	< 100	120	7	< 1	220
97BMF-102-11-d	10	20	< 2	6500	10	40	23	< 100	120	8	1	280
97BMF-102-R1-a	< 4	11	< 2	2500	3	21	< 4	< 100	43	3	< 1	500
97BMF-102-R1-b	< 4	12	< 2	2200	4	22	7	< 100	48	3	< 1	150
97BMF-102-R1-c	5	10	< 2	1900	3	24	7	< 100	44	3	< 1	190
97BMF-102-R1-d	< 4	13	< 2	2400	5	32	7	< 100	52	4	< 1	170
97BMF-102-R1-e	16	34	11	100	10	270	17	< 100	130	22	2	260
97BMF-102-R1-f	15	28	12	39	8	280	13	< 100	92	17	2	190
97BMF-102-R2-a	< 4	10	< 2	2000	3	22	< 4	< 100	41	3	< 1	370
97BMF-102-R2-b	< 4	11	< 2	2000	4	24	7	< 100	48	3	< 1	140
97BMF-102-R2-c	< 4	10	< 2	1900	4	31	7	< 100	48	3	< 1	160
97BMF-102-R2-d	4	11	< 2	1700	4	31	< 4	< 100	45	3	< 1	120
97BMF-102-R3-a	< 4	11	< 2	2300	4	23	8	< 100	52	3	< 1	160
97BMF-102-R3-b	< 4	12	< 2	1800	4	29	< 4	< 100	51	3	< 1	130
97BMF-102-R3-c	11	20	< 2	7800	12	36	28	< 100	130	6	< 1	160
97BMF-102-R3-d	10	17	6	430	7	180	10	< 100	110	9	2	140

Table 7. Major and trace-element data from core samples analyzed by ICP-AES, upper tailings impoundment below Bullion Mine, Montana (cont.)

Field Number	DEPTH, (cm)	Al %	Ca %	Fe %	K %	Mg %	Na %	P %	Ti %	Mn ppm	Ag ppm
97BMF-102-R4-a	4	6.9	0.03	3.2	3.0	0.24	0.04	0.05	0.18	98	76
97BMF-102-R4-b	11	5.9	0.03	3.2	2.6	0.19	0.04	0.05	0.16	85	65
97BMF-102-R4-c	17	6.9	0.02	2.8	2.9	0.23	0.04	0.06	0.19	87	62
97BMF-102-R5-a	11	3.1	0.04	1.1	1.5	0.11	0.05	0.03	0.14	68	19
97BMF-102-R5-b	28	2.9	0.02	0.88	1.3	0.09	0.04	0.03	0.11	61	16
97BMF-102-R5-c	50	3.3	0.02	1.1	1.5	0.11	0.04	0.03	0.14	64	23
97BMF-102-R5-d	69	3.1	0.02	0.95	1.4	0.11	0.04	0.03	0.14	64	19
97BMF-102-R5-e	77	3.3	0.02	1.0	1.5	0.11	0.04	0.03	0.14	62	25
97BMF-102-R6-a	7	3.1	0.05	1.1	1.4	0.11	0.05	0.03	0.15	75	21
97BMF-102-R6-b	21	3.2	0.03	1.1	1.4	0.11	0.04	0.03	0.14	64	21
97BMF-102-R6-c	29	3.5	0.02	1.3	1.5	0.13	0.03	0.04	0.17	61	27
97BMF-102-R6-d	32	3.0	0.01	0.89	1.4	0.10	0.04	0.02	0.13	58	25
97BMF-102-R6-e	38	3.0	0.01	0.97	1.4	0.10	0.04	0.02	0.13	57	24
97BMF-102-R6-f	48	3.4	0.02	1.1	1.6	0.11	0.06	0.02	0.16	61	39
97BMF-102-R6-g	60	3.0	0.01	0.78	1.4	0.10	0.04	0.01	0.14	59	37
97BMF-102-R6-h	69	3.0	0.01	0.84	1.4	0.10	0.04	0.02	0.14	64	26
97BMF-102-R6-i	76	2.5	0.01	0.54	1.2	0.08	0.04	0.01	0.11	51	25
97BMF-102-T1-a	6	3.2	0.04	1.2	1.5	0.11	0.06	0.03	0.14	77	23
97BMF-102-T1-b	17	3.4	0.04	1.2	1.6	0.13	0.05	0.03	0.17	78	23
97BMF-102-T1-c	25	5.1	0.04	2.2	2.2	0.18	0.05	0.04	0.18	79	37
97BMF-102-T1-d	29	3.8	0.04	1.2	1.8	0.13	0.05	0.02	0.16	74	23
97BMF-102-T1-e	34	4.5	0.03	1.6	1.9	0.15	0.04	0.04	0.16	73	26
97BMF-102-T1-f	39	3.6	0.03	1.4	1.6	0.12	0.04	0.03	0.16	66	20
97BMF-102-T1-g	40	5.1	0.01	1.8	2.2	0.17	0.03	0.06	0.16	73	38
97BMF-102-T1-h	47	3.1	0.03	1.1	1.4	0.11	0.03	0.03	0.11	59	28
97BMF-102-T1-i	53	6.4	0.02	2.3	2.7	0.21	0.03	0.08	0.16	81	52
97BMF-102-T1-j	60	6.7	1.0	4.3	3.1	0.60	1.2	0.05	0.35	410	4

Table 7. Major and trace-element data from core samples analyzed by ICP-AES, upper tailings impoundment below Bullion Mine, Montana (cont.)

Field Number	As ppm	Ba ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cu ppm	Ga ppm	La ppm	Li ppm	Mo ppm
97BMF-102-R4-a	5600	290	27	40	< 2	7	300	17	24	25	18
97BMF-102-R4-b	6800	300	34	38	< 2	5	260	12	22	25	17
97BMF-102-R4-c	5600	250	27	37	< 2	4	310	13	22	24	15
97BMF-102-R5-a	2000	290	9	28	< 2	< 2	87	6	15	25	9
97BMF-102-R5-b	1700	180	8	30	< 2	< 2	76	5	16	23	8
97BMF-102-R5-c	2100	290	10	30	< 2	< 2	91	7	16	26	13
97BMF-102-R5-d	1700	200	9	30	< 2	< 2	75	6	16	27	8
97BMF-102-R5-e	2100	240	11	29	< 2	< 2	85	6	17	29	12
97BMF-102-R6-a	2100	290	11	36	< 2	< 2	100	6	20	24	9
97BMF-102-R6-b	2100	250	10	27	< 2	< 2	90	7	15	27	10
97BMF-102-R6-c	2500	320	12	38	< 2	< 2	140	5	21	29	15
97BMF-102-R6-d	1700	270	8	25	< 2	< 2	85	< 4	14	29	11
97BMF-102-R6-e	1800	220	9	26	< 2	< 2	88	4	14	25	11
97BMF-102-R6-f	1900	290	11	28	< 2	< 2	120	5	16	27	11
97BMF-102-R6-g	900	230	6	25	< 2	< 2	92	5	14	26	10
97BMF-102-R6-h	1200	250	6	28	< 2	< 2	92	< 4	15	26	9
97BMF-102-R6-i	840	190	5	23	< 2	< 2	54	< 4	12	27	7
97BMF-102-T1-a	2600	340	13	33	< 2	2	110	< 4	19	25	9
97BMF-102-T1-b	2200	240	11	30	< 2	< 2	100	6	15	28	10
97BMF-102-T1-c	4800	280	23	34	< 2	< 2	180	9	20	26	14
97BMF-102-T1-d	2100	200	10	27	< 2	< 2	100	6	15	29	10
97BMF-102-T1-e	3000	230	15	33	< 2	< 2	140	9	19	26	12
97BMF-102-T1-f	2100	180	10	30	< 2	< 2	94	6	17	25	9
97BMF-102-T1-g	3000	200	15	32	< 2	2	180	9	19	25	13
97BMF-102-T1-h	2300	160	11	26	< 2	< 2	90	5	14	24	10
97BMF-102-T1-i	4500	220	22	40	< 2	4	220	12	23	25	16
97BMF-102-T1-j	320	700	< 2	47	5	27	79	13	25	20	< 2

Table 7. Major and trace-element data from core samples analyzed by ICP-AES, upper tailings impoundment below Bullion Mine, Montana (cont.)

Field Number	Nb ppm	Nd ppm	Ni ppm	Pb ppm	Sc ppm	Sr ppm	Th ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm
97BMF-102-R4-a	12	18	< 2	6400	10	35	22	< 100	110	6	< 1	170
97BMF-102-R4-b	11	17	< 2	5100	9	32	18	< 100	100	5	< 1	160
97BMF-102-R4-c	12	18	< 2	5800	10	35	21	< 100	110	6	< 1	170
97BMF-102-R5-a	< 4	12	< 2	2000	4	26	7	< 100	51	3	< 1	100
97BMF-102-R5-b	< 4	12	< 2	1800	4	23	6	< 100	44	3	< 1	100
97BMF-102-R5-c	5	12	< 2	2700	5	25	8	< 100	55	3	< 1	160
97BMF-102-R5-d	< 4	12	3	2300	4	25	7	< 100	51	3	< 1	130
97BMF-102-R5-e	< 4	12	< 2	2500	4	28	7	< 100	54	3	< 1	170
97BMF-102-R6-a	5	14	< 2	2200	4	28	7	< 100	52	4	< 1	160
97BMF-102-R6-b	< 4	12	7	2100	4	26	7	< 100	51	3	< 1	160
97BMF-102-R6-c	< 4	16	< 2	4400	5	31	10	< 100	62	4	< 1	130
97BMF-102-R6-d	< 4	11	< 2	2600	4	24	7	< 100	50	3	< 1	130
97BMF-102-R6-e	< 4	11	< 2	2600	4	25	6	< 100	49	3	< 1	150
97BMF-102-R6-f	5	11	< 2	3400	5	32	7	< 100	55	3	< 1	300
97BMF-102-R6-g	< 4	10	< 2	2600	4	28	< 4	< 100	46	3	< 1	360
97BMF-102-R6-h	< 4	10	< 2	2300	4	27	6	< 100	48	3	< 1	190
97BMF-102-R6-i	< 4	9	< 2	1600	3	21	< 4	< 100	37	2	< 1	170
97BMF-102-T1-a	4	14	< 2	2800	4	28	9	< 100	49	3	< 1	130
97BMF-102-T1-b	5	12	3	2300	5	29	9	< 100	56	4	< 1	320
97BMF-102-T1-c	8	15	< 2	3700	7	33	12	< 100	84	4	< 1	150
97BMF-102-T1-d	5	11	< 2	1700	5	29	9	< 100	59	4	< 1	120
97BMF-102-T1-e	6	14	< 2	3200	6	31	11	< 100	72	4	< 1	160
97BMF-102-T1-f	5	13	< 2	2300	5	29	9	< 100	59	4	< 1	110
97BMF-102-T1-g	6	14	< 2	4700	7	30	15	< 100	81	5	< 1	120
97BMF-102-T1-h	< 4	11	< 2	2600	4	22	10	< 100	48	3	< 1	120
97BMF-102-T1-i	9	18	< 2	6300	9	38	21	< 100	100	6	< 1	150
97BMF-102-T1-j	14	20	10	280	9	240	17	< 100	150	11	2	86

Table 7. Major and trace-element data from core samples analyzed by ICP-AES, upper tailings impoundment below Bullion Mine, Montana (cont.)

Field Number	DEPTH, (cm)	Al %	Ca %	Fe %	K %	Mg %	Na %	P %	Ti %	Mn ppm	Ag ppm
97BMF-102-T2-a	4	3.5	0.05	1.2	1.6	0.12	0.06	0.03	0.16	82	18
97BMF-102-T2-b	23	3.1	0.03	1.2	1.4	0.11	0.04	0.02	0.16	65	26
97BMF-102-T2-c	42	2.6	0.02	0.77	1.2	0.09	0.03	0.03	0.09	73	20
97BMF-102-T2-d	49	2.8	0.04	0.96	1.3	0.10	0.01	0.03	0.14	67	23
97BMF-102-T2-e	58	2.8	0.02	0.91	1.3	0.09	0.03	0.02	0.13	62	28
97BMF-102-T3-a	4	3.2	0.03	1.1	1.4	0.11	0.05	0.03	0.13	62	21
97BMF-102-T3-b	15	4.4	0.04	1.6	1.9	0.15	0.07	0.04	0.15	76	44
97BMF-102-T3-c	26	4.5	0.47	1.8	2.2	0.25	0.50	0.03	0.18	170	20
97BMF-102-T4-a	6	5.4	0.03	2.3	2.3	0.18	0.05	0.04	0.16	86	55
97BMF-102-T4-b	13	6.0	0.04	2.5	2.6	0.20	0.05	0.05	0.18	86	64
97BMF-102-T5-a	9	5.3	0.72	2.6	2.6	0.31	0.79	0.03	0.20	270	23
97BMF-102-T5-b	25	6.7	1.1	3.0	2.6	0.57	1.2	0.03	0.34	340	5
97BMF-102-T5-c	44	7.7	1.4	2.8	2.7	0.77	1.5	0.04	0.35	420	< 2
97BMF-102-T6-a	4	7.0	0.03	2.6	3.0	0.22	0.05	0.04	0.19	84	76
97BMF-102-T6-b	13	7.1	0.01	2.2	3.0	0.22	0.04	0.02	0.18	80	70
97BMF-102-T6-c	23	6.7	0.01	2.5	2.8	0.21	0.03	0.06	0.16	76	60
97BMF-102-T6-d	31	4.3	0.03	3.3	1.9	0.14	0.04	0.03	0.13	69	46
97BMF-102-T6-e	36	5.8	0.02	2.2	2.4	0.19	0.04	0.04	0.17	72	43
97BMF-102-T6-f	41	7.2	0.01	1.7	3.0	0.23	0.04	< 0.005	0.18	75	95
97BMF-102-T6-g	45	3.9	0.03	2.1	1.7	0.13	0.04	0.03	0.15	58	24
97BMF-102-T6-h	47	6.8	0.02	1.7	2.8	0.22	0.03	0.03	0.19	74	120
97BMF-102-T6-i	55	3.2	0.12	0.79	1.6	0.11	0.20	0.02	0.13	70	21
97BMF-102-T7-a	19	3.2	0.02	0.90	1.5	0.10	0.05	0.02	0.14	66	24
97BMF-102-T7-b	51	3.4	0.01	1.0	1.6	0.11	0.04	0.02	0.14	57	28
97BMF-102-T7-c	65	4.2	0.01	1.6	1.9	0.14	0.04	0.03	0.16	64	35
97BMF-102-T7-d	70	3.9	0.02	1.6	1.8	0.13	0.04	0.05	0.15	59	42
97BMF-102-T7-e	95	5.6	0.02	1.9	2.4	0.17	0.04	0.03	0.17	66	55
97BMF-102-T7-f	106	6.0	0.02	2.1	2.6	0.19	0.04	0.02	0.17	75	66
97BMF-102-T7-g	115	7.4	0.04	2.6	3.1	0.24	0.04	0.02	0.19	82	74
97BMF-102-T7-h	126	6.5	0.05	2.2	2.7	0.21	0.04	< 0.005	0.17	78	66

Table 7. Major and trace-element data from core samples analyzed by ICP-AES, upper tailings impoundment below Bullion Mine, Montana (cont.)

Field Number	As ppm	Ba ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cu ppm	Ga ppm	La ppm	Li ppm	Mo ppm
97BMF-102-T2-a	2500	240	13	34	< 2	3	110	5	18	30	10
97BMF-102-T2-b	2400	300	12	26	< 2	< 2	97	5	14	26	10
97BMF-102-T2-c	1800	150	9	24	< 2	< 2	61	5	13	25	9
97BMF-102-T2-d	2400	160	< 2	22	< 2	< 2	77	< 4	13	29	11
97BMF-102-T2-e	2100	250	12	25	< 2	< 2	87	< 4	14	26	12
97BMF-102-T3-a	2100	420	11	33	< 2	< 2	90	< 4	18	25	10
97BMF-102-T3-b	3700	290	19	30	< 2	< 2	120	10	17	26	15
97BMF-102-T3-c	2400	460	11	42	< 2	3	84	7	24	26	9
97BMF-102-T4-a	4100	270	22	35	< 2	3	240	10	21	26	16
97BMF-102-T4-b	4900	300	24	39	< 2	4	240	12	23	27	16
97BMF-102-T5-a	1900	550	9	63	2	4	83	9	36	21	26
97BMF-102-T5-b	820	640	3	56	5	13	160	14	30	33	2
97BMF-102-T5-c	1400	720	6	68	6	9	110	16	35	39	2
97BMF-102-T6-a	5400	300	29	38	< 2	3	480	11	23	26	17
97BMF-102-T6-b	4700	270	26	38	2	3	1200	16	23	26	18
97BMF-102-T6-c	5400	270	26	36	< 2	4	280	14	21	25	18
97BMF-102-T6-d	3000	220	15	30	< 2	6	170	7	17	25	12
97BMF-102-T6-e	4600	240	23	33	< 2	3	240	10	19	27	16
97BMF-102-T6-f	2000	260	13	39	5	10	2300	14	23	27	20
97BMF-102-T6-g	5600	260	29	30	< 2	< 2	330	7	17	27	14
97BMF-102-T6-h	2200	300	14	40	3	2	860	13	24	25	20
97BMF-102-T6-i	1500	250	7	27	< 2	< 2	53	6	16	27	9
97BMF-102-T7-a	1400	220	8	27	< 2	< 2	76	5	15	25	8
97BMF-102-T7-b	1600	240	9	27	< 2	< 2	97	4	15	26	12
97BMF-102-T7-c	3200	340	16	35	< 2	2	140	7	19	29	16
97BMF-102-T7-d	5000	330	25	30	< 2	< 2	130	6	17	26	17
97BMF-102-T7-e	6600	330	33	34	< 2	3	780	11	20	28	17
97BMF-102-T7-f	6000	310	33	38	< 2	3	1000	13	22	27	17
97BMF-102-T7-g	5500	290	29	45	2	3	1400	13	25	26	19
97BMF-102-T7-h	4400	310	29	39	3	4	1900	15	22	27	18

Table 7. Major and trace-element data from core samples analyzed by ICP-AES, upper tailings impoundment below Bullion Mine, Montana (cont.)

Field Number	Nb ppm	Nd ppm	Ni ppm	Pb ppm	Sc ppm	Sr ppm	Th ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm
97BMF-102-T2-a	4	13	< 2	2500	6	30	8	< 100	56	4	< 1	180
97BMF-102-T2-b	< 4	11	< 2	2300	4	26	7	< 100	52	3	< 1	180
97BMF-102-T2-c	< 4	10	< 2	2000	4	20	7	< 100	41	3	< 1	86
97BMF-102-T2-d	< 4	9	< 2	1900	4	20	< 4	< 100	45	3	< 1	160
97BMF-102-T2-e	< 4	10	< 2	2600	4	22	7	< 100	47	3	< 1	170
97BMF-102-T3-a	< 4	13	< 2	2300	4	28	9	< 100	52	3	< 1	140
97BMF-102-T3-b	7	13	< 2	3900	6	31	11	< 100	72	4	< 1	120
97BMF-102-T3-c	6	15	4	1900	6	110	13	< 100	68	5	< 1	110
97BMF-102-T4-a	7	16	< 2	4800	7	35	14	< 100	89	4	< 1	190
97BMF-102-T4-b	9	18	< 2	5200	8	38	16	< 100	96	5	< 1	210
97BMF-102-T5-a	10	22	4	1900	6	160	15	< 100	98	8	1	200
97BMF-102-T5-b	14	26	8	580	8	230	14	< 100	110	16	2	420
97BMF-102-T5-c	14	30	11	320	10	280	20	< 100	93	19	2	770
97BMF-102-T6-a	11	18	< 2	5600	10	38	18	< 100	110	5	< 1	210
97BMF-102-T6-b	5	18	< 2	5660	11	35	22	240	110	5	< 1	310
97BMF-102-T6-c	10	17	< 2	6100	10	34	21	< 100	110	5	< 1	200
97BMF-102-T6-d	7	13	< 2	3400	6	35	9	< 100	88	4	< 1	140
97BMF-102-T6-e	10	15	< 2	4900	8	32	14	< 100	92	4	< 1	180
97BMF-102-T6-f	11	18	< 2	5800	12	37	22	< 100	110	6	< 1	520
97BMF-102-T6-g	4	13	< 2	5000	6	32	11	< 100	69	4	< 1	180
97BMF-102-T6-h	11	19	< 2	6500	10	39	21	< 100	100	6	< 1	430
97BMF-102-T6-i	7	11	< 2	2100	4	51	6	< 100	44	3	< 1	110
97BMF-102-T7-a	< 4	12	< 2	1900	4	26	< 4	< 100	51	3	< 1	140
97BMF-102-T7-b	5	11	< 2	2000	5	27	< 4	< 100	54	3	< 1	200
97BMF-102-T7-c	6	15	< 2	2700	6	31	10	< 100	68	3	< 1	120
97BMF-102-T7-d	5	13	< 2	2800	5	30	12	< 100	63	3	< 1	150
97BMF-102-T7-e	10	16	< 2	4600	7	31	14	< 100	84	4	< 1	270
97BMF-102-T7-f	9	17	< 2	5400	8	34	19	< 100	92	5	< 1	380
97BMF-102-T7-g	11	22	< 2	6200	16	39	26	130	120	8	1	320
97BMF-102-T7-h	6	18	< 2	5800	10	36	21	230	100	6	< 1	460

Table 7. Major and trace-element data from core samples analyzed by ICP-AES, upper tailings impoundment below Bullion Mine, Montana (cont.)

Field Number	DEPTH, (cm)	Al %	Ca %	Fe %	K %	Mg %	Na %	P %	Ti %	Mn ppm	Ag ppm
97BMF-102-T8-a	13	3.3	0.01	1.0	1.5	0.11	0.04	0.02	0.17	65	31
97BMF-102-T8-b	36	3.5	0.02	1.3	1.7	0.11	0.04	0.03	0.15	64	26
97BMF-102-T8-c	54	3.0	0.01	0.97	1.4	0.09	0.04	0.02	0.10	64	18
97BMF-102-T8-d	66	3.1	0.02	0.95	1.5	0.10	0.04	0.02	0.13	65	15
97BMF-102-T8-e	72	3.1	0.02	1.0	1.5	0.10	0.04	0.02	0.13	63	17
97BMF-102-T8-f	88	3.6	0.03	1.3	1.7	0.12	0.05	0.02	0.15	63	20
97BMF-102-T8-g	97	5.9	0.02	3.4	2.6	0.19	0.04	0.05	0.15	86	58

Field Number	As ppm	Ba ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cu ppm	Ga ppm	La ppm	Li ppm	Mo ppm
97BMF-102-T8-a	1700	260	10	26	< 2	< 2	120	6	15	25	10
97BMF-102-T8-b	2600	330	14	29	< 2	< 2	110	5	17	26	13
97BMF-102-T8-c	1400	230	8	31	< 2	< 2	69	5	17	26	9
97BMF-102-T8-d	1400	200	8	22	< 2	< 2	60	5	12	28	8
97BMF-102-T8-e	1700	210	9	24	< 2	< 2	74	5	13	27	9
97BMF-102-T8-f	2500	240	13	27	< 2	< 2	88	< 4	15	30	11
97BMF-102-T8-g	11000	330	56	33	< 2	5	270	10	20	27	23

Field Number	Nb ppm	Nd ppm	Ni ppm	Pb ppm	Sc ppm	Sr ppm	Th ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm
97BMF-102-T8-a	4	12	< 2	2400	5	25	< 4	< 100	54	3	< 1	250
97BMF-102-T8-b	< 4	12	< 2	2600	5	29	7	< 100	57	3	< 1	270
97BMF-102-T8-c	< 4	11	< 2	1700	4	24	< 4	< 100	47	3	< 1	230
97BMF-102-T8-d	< 4	< 4	< 2	1300	4	26	< 4	< 100	48	3	< 1	150
97BMF-102-T8-e	< 4	10	< 2	1500	4	28	< 4	< 100	48	3	< 1	190
97BMF-102-T8-f	6	11	< 2	1600	4	31	< 4	< 100	57	3	< 1	120
97BMF-102-T8-g	11	15	< 2	5300	8	30	18	< 100	95	4	< 1	210

Table 8. Major and trace-element data from core samples analyzed by ICP-AES, lower tailings impoundment below Bullion Mine, Montana

FieldNo	DEPTH	Al %	Ca %	Fe %	K %	Mg %	Na %	P %	Ti %	Mn ppm	Ag ppm
97BMF-103-T1-a	2	3.2	0.07	1.3	1.6	0.12	0.04	0.03	0.16	74	20
97BMF-103-T1-b	10	3.2	0.03	1.0	1.5	0.10	0.04	0.02	0.15	68	19
97BMF-103-T1-c	21	3.2	0.03	1.0	1.5	0.10	0.04	0.02	0.14	67	23
97BMF-103-T1-d	30	2.8	0.03	0.95	1.3	0.09	0.04	0.01	0.12	65	21
97BMF-103-T2-a	4	3.2	0.02	1.5	1.5	0.11	0.04	0.02	0.14	68	32
97BMF-103-T2-b	15	2.7	0.02	1.2	1.3	0.09	0.03	0.01	0.12	75	23
97BMF-103-T2-c	29	3.0	0.04	1.2	1.4	0.10	0.05	0.01	0.12	69	24
97BMF-103-T2-d	41	3.0	0.04	1.3	1.4	0.10	0.05	0.01	0.13	79	27
97BMF-103-T2-e	53	2.6	0.03	0.73	1.3	0.09	0.06	0.01	0.10	54	20
97BMF-103-T3-a	6	4.9	0.008	0.93	2.0	0.15	0.03	0.05	0.12	56	72
97BMF-103-T3-b	14	4.7	0.005	2.1	2.0	0.14	0.03	0.04	0.13	57	32
97BMF-103-T3-c	25	3.0	0.009	0.64	1.2	0.09	0.02	0.03	0.11	44	27
97BMF-103-T3-d	36	5.0	0.01	1.9	2.0	0.15	0.03	0.05	0.14	60	39
97BMF-103-T3-e	40	5.9	0.02	2.0	2.4	0.18	0.03	0.05	0.14	72	50
97BMF-103-T3-f	45	2.8	< 0.005	1.4	1.1	0.09	0.02	0.03	0.10	45	29
97BMF-103-T3-g	51	2.5	0.009	0.68	1.0	0.08	0.02	0.03	0.09	42	23
97BMF-103-T3-h	60	3.2	0.02	1.2	1.4	0.11	0.03	0.03	0.13	58	35
97BMF-103-T3-i	69	3.5	0.006	0.88	1.5	0.10	0.02	0.03	0.11	47	46
97BMF-103-T3-j	75	5.6	0.007	2.1	2.3	0.16	0.03	0.03	0.11	62	61
97BMF-103-T3-k	82	5.6	0.84	4.9	2.4	0.41	1.0	0.06	0.22	210	21
97BMF-103-T3-l	93	9.7	1.2	4.2	2.5	0.81	1.4	0.11	0.45	410	4
97BMF-103-T3-m	103	7.5	1.0	3.5	2.0	0.77	1.1	0.07	0.38	480	3
97BMF-103-T4-a	4	3.6	0.07	1.9	1.7	0.15	0.06	0.04	0.14	85	33
97BMF-103-T4-b	9	4.2	0.45	3.4	2.2	0.20	0.60	0.04	0.16	150	32
97BMF-103-T4-c	13	4.0	0.04	3.0	1.8	0.15	0.02	0.06	0.13	67	49
97BMF-103-T4-d	18	5.7	0.99	3.7	2.4	0.54	1.3	0.05	0.35	280	16

Table 8. Major and trace-element data from core samples analyzed by ICP-AES, lower tailings impoundment below Bullion Mine, Montana (cont.)

FieldNo	As ppm	Ba ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cu ppm	Ga ppm	La ppm	Li ppm	Mo ppm
97BMF-103-T1-a	2200	280	< 2	27	< 2	< 2	120	5	16	27	11
97BMF-103-T1-b	1700	290	10	30	< 2	< 2	100	4	17	27	9
97BMF-103-T1-c	1700	260	10	30	< 2	< 2	90	< 4	17	23	10
97BMF-103-T1-d	1700	240	10	26	< 2	< 2	92	4	14	25	11
97BMF-103-T2-a	2200	490	13	32	< 2	< 2	130	5	19	24	11
97BMF-103-T2-b	2200	370	12	36	< 2	< 2	95	< 4	20	23	10
97BMF-103-T2-c	2100	270	12	25	< 2	< 2	100	< 4	14	25	10
97BMF-103-T2-d	2100	270	13	25	< 2	< 2	130	< 4	14	24	11
97BMF-103-T2-e	1200	220	7	17	< 2	< 2	74	< 4	9	22	8
97BMF-103-T3-a	2400	120	13	28	< 2	< 2	44	8	16	25	19
97BMF-103-T3-b	6700	150	36	26	< 2	3	120	8	16	24	19
97BMF-103-T3-c	1500	110	9	23	< 2	< 2	73	< 4	12	24	13
97BMF-103-T3-d	7100	170	39	31	< 2	< 2	200	9	18	24	20
97BMF-103-T3-e	6400	150	33	33	< 2	< 2	130	11	19	23	19
97BMF-103-T3-f	2500	72	14	20	< 2	< 2	55	< 4	12	25	11
97BMF-103-T3-g	1200	70	7	22	< 2	< 2	48	4	13	23	8
97BMF-103-T3-h	2600	160	14	26	< 2	< 2	110	6	14	26	12
97BMF-103-T3-i	1900	110	11	23	< 2	< 2	110	4	13	24	14
97BMF-103-T3-j	5100	110	29	29	16	4	520	13	17	25	24
97BMF-103-T3-k	7300	160	4	48	4	5	410	6	29	20	10
97BMF-103-T3-l	810	680	< 2	170	8	6	2500	24	170	55	11
97BMF-103-T3-m	170	660	< 2	74	7	6	1400	12	99	51	9
97BMF-103-T4-a	4000	220	3	27	< 2	5	190	< 4	18	27	13
97BMF-103-T4-b	7100	480	4	37	< 2	6	150	< 4	24	23	12
97BMF-103-T4-c	6600	170	3	23	< 2	5	270	6	16	25	20
97BMF-103-T4-d	3100	520	< 2	49	4	9	220	8	32	21	4

Table 8. Major and trace-element data from core samples analyzed by ICP-AES, lower tailings impoundment below Bullion Mine, Montana (cont.)

FieldNo	Nb ppm	Nd ppm	Ni ppm	Pb ppm	Sc ppm	Sr ppm	Th ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm
97BMF-103-T1-a	< 4	11	< 2	2300	4	28	< 4	< 100	51	3	< 1	210
97BMF-103-T1-b	4	12	< 2	1700	4	28	< 4	< 100	52	3	< 1	180
97BMF-103-T1-c	4	12	< 2	1700	4	27	< 4	< 100	50	3	< 1	190
97BMF-103-T1-d	< 4	11	< 2	1700	4	24	< 4	< 100	45	3	< 1	170
97BMF-103-T2-a	< 4	13	< 2	3100	4	27	7	< 100	57	3	< 1	220
97BMF-103-T2-b	< 4	15	< 2	2200	4	22	6	< 100	47	3	< 1	160
97BMF-103-T2-c	< 4	11	< 2	2000	4	29	< 4	< 100	49	3	< 1	170
97BMF-103-T2-d	< 4	11	< 2	2400	4	29	< 4	< 100	52	3	< 1	270
97BMF-103-T2-e	< 4	< 4	< 2	1400	3	31	< 4	< 100	40	2	< 1	160
97BMF-103-T3-a	7	13	< 2	5200	7	34	17	< 100	77	5	< 1	120
97BMF-103-T3-b	8	12	< 2	3900	7	34	14	< 100	79	4	< 1	92
97BMF-103-T3-c	< 4	10	< 2	2500	5	23	8	< 100	47	3	< 1	100
97BMF-103-T3-d	8	15	< 2	4500	8	30	25	< 100	81	4	< 1	96
97BMF-103-T3-e	9	15	< 2	4600	9	36	22	< 100	95	5	< 1	110
97BMF-103-T3-f	< 4	9	< 2	2400	4	23	7	< 100	54	3	< 1	61
97BMF-103-T3-g	< 4	9	< 2	2300	4	21	< 4	< 100	43	3	< 1	70
97BMF-103-T3-h	5	11	< 2	2800	5	25	7	< 100	55	3	< 1	110
97BMF-103-T3-i	< 4	10	4	3200	5	26	11	< 100	55	3	< 1	120
97BMF-103-T3-j	8	14	5	5300	9	32	22	< 100	96	7	< 1	270
97BMF-103-T3-k	7	29	7	3100	12	200	26	< 100	79	15	3	340
97BMF-103-T3-l	13	140	15	690	18	240	33	410	110	160	15	430
97BMF-103-T3-m	13	78	13	170	13	190	22	< 100	93	88	7	370
97BMF-103-T4-a	< 4	12	< 2	3200	5	30	9	< 100	61	4	< 1	150
97BMF-103-T4-b	< 4	15	< 2	3000	5	130	10	< 100	67	5	< 1	190
97BMF-103-T4-c	< 4	13	< 2	6500	6	31	14	< 100	73	5	< 1	110
97BMF-103-T4-d	12	20	8	780	7	210	15	< 100	84	11	2	150

Table 8. Major and trace-element data from core samples analyzed by ICP-AES, lower tailings impoundment below Bullion Mine, Montana (cont.)

FieldNo	DEPTH	Al %	Ca %	Fe %	K %	Mg %	Na %	P %	Ti %	Mn ppm	Ag ppm
97BMF-103-T5-a	9	3.5	0.25	2.8	1.4	0.23	0.26	0.03	0.16	130	30
97BMF-103-T5-b	26	5.6	0.01	1.6	2.2	0.16	0.03	0.05	0.14	65	38
97BMF-103-T5-c	38	6.1	1.0	3.4	2.5	0.53	1.6	0.08	0.37	270	< 2
97BMF-103-T5-d	46	7.5	1.1	3.4	2.7	0.59	1.4	0.04	0.37	270	< 2
97BMF-103-T5-e	55	8.4	1.1	3.5	2.9	0.53	1.5	0.03	0.35	410	< 2
97BMF-103-T5-f	63	7.4	1.2	3.9	2.7	0.86	1.3	0.03	0.40	700	< 2
97BMF-103-T6-a	6	6.1	1.2	4.2	3.4	0.41	1.4	0.02	0.33	530	4
97BMF-103-T6-b	16	3.1	0.01	1.1	1.3	0.10	0.03	0.03	0.11	55	23
97BMF-103-T6-c	28	7.0	0.01	2.1	2.8	0.21	0.03	0.03	0.17	92	81
97BMF-103-T6-d	43	5.6	0.71	2.8	1.7	0.48	0.71	0.05	0.31	210	15
97BMF-103-T7-a	7	3.8	0.05	1.7	1.7	0.14	0.07	0.03	0.15	77	34
97BMF-103-T7-b	22	5.2	0.74	4.4	2.5	0.43	0.84	0.04	0.23	450	15
97BMF-103-T7-c	40	5.3	0.08	1.9	2.2	0.19	0.09	0.04	0.17	100	50
97BMF-103-T8-a	15	3.4	0.03	1.4	1.5	0.11	0.04	0.02	0.13	75	31
97BMF-103-T8-b	40	5.1	0.04	2.3	2.3	0.17	0.01	0.04	0.15	88	49
97BMF-103-T8-c	58	4.2	0.02	1.6	1.8	0.14	0.05	0.03	0.14	67	55
97BMF-103-T9-a	3	4.8	0.06	2.0	2.3	0.16	0.02	0.05	0.16	80	40
97BMF-103-T9-b	13	4.1	0.03	1.6	2.0	0.13	0.04	0.03	0.16	73	34
97BMF-103-T9-c	27	3.4	0.04	1.1	1.7	0.11	0.04	0.02	0.13	69	21
97BMF-103-T9-d	42	4.1	0.40	1.9	1.9	0.29	0.38	0.03	0.19	170	14
97BMF-103-T9-e	54	5.5	0.06	2.6	2.4	0.20	0.05	0.05	0.16	86	90
97BMF-103-T9-f	63	6.4	1.1	4.0	2.6	0.58	1.3	0.07	0.37	510	8
97BMF-103-L1-a	6	3.4	0.04	1.2	1.7	0.12	0.03	0.03	0.15	73	23
97BMF-103-L1-b	15	5.2	0.03	2.5	2.3	0.17	0.04	0.03	0.17	79	52
97BMF-103-L1-c	27	8.2	0.01	3.6	3.4	0.26	0.03	0.04	0.20	110	110
97BMF-103-L1-d	38	6.0	0.08	5.7	2.4	0.22	0.08	0.10	0.12	140	100
97BMF-103-L1-e	49	7.3	1.3	4.0	2.8	0.79	1.4	0.05	0.45	470	3

Table 8. Major and trace-element data from core samples analyzed by ICP-AES, lower tailings impoundment below Bullion Mine, Montana (cont.)

FieldNo	As ppm	Ba ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cu ppm	Ga ppm	La ppm	Li ppm	Mo ppm
97BMF-103-T5-a	5700	310	32	32	< 2	6	130	7	18	25	16
97BMF-103-T5-b	3700	140	20	33	< 2	< 2	140	8	20	24	14
97BMF-103-T5-c	2100	700	< 2	43	4	22	190	13	26	24	< 2
97BMF-103-T5-d	400	800	< 2	58	6	9	180	11	32	36	< 2
97BMF-103-T5-e	85	1000	< 2	69	5	10	300	11	34	45	< 2
97BMF-103-T5-f	80	820	< 2	66	9	15	200	12	34	32	4
97BMF-103-T6-a	2100	640	11	69	4	12	91	8	36	18	< 2
97BMF-103-T6-b	1900	100	11	24	< 2	< 2	83	6	13	21	11
97BMF-103-T6-c	2600	180	28	37	8	3	800	15	23	24	17
97BMF-103-T6-d	4900	390	5	46	5	6	720	13	30	35	6
97BMF-103-T7-a	3000	260	18	32	< 2	2	140	5	18	22	11
97BMF-103-T7-b	4000	450	< 2	49	6	12	140	< 4	29	22	7
97BMF-103-T7-c	2400	190	14	34	< 2	< 2	160	10	20	23	15
97BMF-103-T8-a	2500	340	15	30	< 2	< 2	130	6	17	26	12
97BMF-103-T8-b	3500	360	< 2	37	< 2	3	210	6	23	31	15
97BMF-103-T8-c	3200	270	20	28	< 2	< 2	160	6	16	24	14
97BMF-103-T9-a	4400	310	3	34	< 2	6	190	8	20	27	12
97BMF-103-T9-b	3300	390	20	39	< 2	3	160	6	21	30	13
97BMF-103-T9-c	2000	260	12	30	< 2	< 2	94	5	15	31	9
97BMF-103-T9-d	2300	330	< 2	33	2	5	97	5	18	27	11
97BMF-103-T9-e	5100	280	3	32	< 2	2	300	7	22	26	17
97BMF-103-T9-f	640	640	< 2	42	7	12	87	11	22	22	< 2
97BMF-103-L1-a	2000	340	< 2	28	< 2	2	120	5	18	26	9
97BMF-103-L1-b	4100	330	21	36	< 2	< 2	220	9	20	29	16
97BMF-103-L1-c	6200	320	31	40	< 2	8	430	16	25	27	23
97BMF-103-L1-d	7800	180	< 2	28	< 2	8	520	10	19	20	19
97BMF-103-L1-e	150	680	< 2	56	8	6	70	12	30	30	< 2

Table 8. Major and trace-element data from core samples analyzed by ICP-AES, lower tailings impoundment below Bullion Mine, Montana (cont.)

FieldNo	Nb ppm	Nd ppm	Ni ppm	Pb ppm	Sc ppm	Sr ppm	Th ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm
97BMF-103-T5-a	6	14	4	2200	6	65	14	< 100	64	5	< 1	150
97BMF-103-T5-b	8	16	< 2	4600	8	37	18	< 100	91	5	< 1	95
97BMF-103-T5-c	13	20	8	220	7	240	11	< 100	86	11	2	130
97BMF-103-T5-d	15	25	11	100	8	270	15	< 100	110	14	2	190
97BMF-103-T5-e	15	29	16	100	8	290	20	< 100	100	16	2	250
97BMF-103-T5-f	15	31	14	170	11	260	24	< 100	120	17	2	350
97BMF-103-T6-a	15	23	7	480	6	240	15	< 100	130	11	2	130
97BMF-103-T6-b	< 4	10	< 2	1900	5	26	9	< 100	52	4	< 1	82
97BMF-103-T6-c	10	20	4	6300	11	37	21	< 100	110	8	1	640
97BMF-103-T6-d	9	25	10	1500	9	130	15	< 100	78	16	2	480
97BMF-103-T7-a	8	14	< 2	2600	5	33	9	< 100	63	4	< 1	100
97BMF-103-T7-b	11	18	6	1200	7	170	18	< 100	79	9	1	170
97BMF-103-T7-c	7	16	< 2	4000	8	42	16	< 100	92	5	< 1	160
97BMF-103-T8-a	< 4	13	< 2	2500	4	27	7	< 100	55	3	< 1	140
97BMF-103-T8-b	10	16	< 2	4200	7	27	10	< 100	73	4	< 1	150
97BMF-103-T8-c	< 4	13	< 2	4000	6	30	10	< 100	67	4	< 1	280
97BMF-103-T9-a	9	14	< 2	3600	6	26	11	< 100	69	4	< 1	120
97BMF-103-T9-b	6	15	< 2	3200	5	30	9	< 100	63	4	< 1	190
97BMF-103-T9-c	6	11	< 2	2000	4	26	6	< 100	48	3	< 1	120
97BMF-103-T9-d	8	14	4	1500	5	84	9	< 100	54	5	< 1	170
97BMF-103-T9-e	< 4	16	< 2	6200	8	31	15	< 100	88	5	< 1	300
97BMF-103-T9-f	13	19	9	310	8	250	16	< 100	100	11	1	100
97BMF-103-L1-a	< 4	13	< 2	2400	5	61	6	< 100	56	3	< 1	120
97BMF-103-L1-b	6	15	< 2	4200	7	30	11	< 100	86	4	< 1	140
97BMF-103-L1-c	14	19	< 2	8000	11	32	20	< 100	130	6	< 1	230
97BMF-103-L1-d	7	15	3	6100	12	29	24	< 100	96	5	< 1	160
97BMF-103-L1-e	19	24	11	150	10	260	14	< 100	130	14	2	180

Table 8. Major and trace-element data from core samples analyzed by ICP-AES, lower tailings impoundment below Bullion Mine, Montana (cont.)

FieldNo	DEPTH	Al %	Ca %	Fe %	K %	Mg %	Na %	P %	Ti %	Mn ppm	Ag ppm
97BMF-103-L2-a	5	3.6	0.03	1.5	1.6	0.12	0.04	0.03	0.15	68	33
97BMF-103-L2-b	14	3.7	0.08	3.6	1.6	0.13	0.03	0.0	0.09	71	47
97BMF-103-L2-c	22	2.8	0.14	1.0	1.3	0.14	0.17	0.02	0.12	110	17
97BMF-103-L2-d	30	1.9	0.01	0.44	0.82	0.06	0.02	0.02	0.08	38	28
97BMF-103-L2-e	38	4.7	0.09	2.8	1.8	0.15	0.06	0.06	0.10	82	48
97BMF-103-L2-f	45	6.3	1.3	4.6	2.6	0.72	1.5	0.05	0.40	490	11
97BMF-103-L3-a	9	2.8	0.03	0.94	1.3	0.09	0.03	0.02	0.13	59	18
97BMF-103-L3-b	21	2.0	0.03	0.69	0.87	0.07	< 0.005	0.03	0.08	43	26
97BMF-103-L3-c	29	4.0	0.14	5.9	1.8	0.18	0.12	0.05	0.11	110	82
97BMF-103-L3-d	42	5.7	1.0	3.9	2.6	0.54	1.2	0.03	0.34	560	2
97BMF-103-R1-a	6	4.0	0.46	4.9	1.7	0.34	0.45	0.05	0.20	200	20
97BMF-103-R1-b	27	4.7	0.65	5.4	2.5	0.28	0.83	0.02	0.19	430	11
97BMF-103-R1-c	44	5.1	0.71	4.8	2.8	0.28	0.89	0.03	0.17	260	21
97BMF-103-R1-d	50	5.9	0.38	2.5	2.5	0.34	0.30	0.05	0.18	200	60
97BMF-103-R2-a	7	7.2	0.01	2.9	3.1	0.22	0.04	0.04	0.19	92	90
97BMF-103-R2-b	16	2.7	0.03	0.97	1.2	0.09	0.04	0.02	0.12	56	29
97BMF-103-R2-c	22	5.8	0.02	1.5	2.4	0.19	0.05	0.04	0.18	72	110
97BMF-103-R2-d	31	6.6	1.2	3.6	3.3	0.62	1.6	0.06	0.34	360	< 2
97BMF-103-R3-a	2	8.2	0.08	4.5	3.4	0.27	0.05	0.05	0.19	110	130
97BMF-103-R3-b	8	5.9	0.95	3.4	2.0	0.61	0.95	0.09	0.31	380	17
97BMF-103-R3-c	26	7.3	1.1	3.6	2.4	0.60	1.4	0.07	0.44	390	< 2

Table 8. Major and trace-element data from core samples analyzed by ICP-AES, lower tailings impoundment below Bullion Mine, Montana (cont.)

FieldNo	As ppm	Ba ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cu ppm	Ga ppm	La ppm	Li ppm	Mo ppm
97BMF-103-L2-a	3100	260	18	28	< 2	< 2	150	5	16	25	12
97BMF-103-L2-b	5900	160	2	24	< 2	4	350	6	16	13	11
97BMF-103-L2-c	1200	190	6	21	< 2	< 2	53	5	12	24	9
97BMF-103-L2-d	580	77	3	18	< 2	< 2	48	4	10	22	8
97BMF-103-L2-e	7100	120	4	25	< 2	3	250	8	17	24	58
97BMF-103-L2-f	4000	520	< 2	42	6	12	88	9	26	31	4
97BMF-103-L3-a	2000	180	11	24	< 2	< 2	91	< 4	12	25	10
97BMF-103-L3-b	1400	80	< 2	19	< 2	< 2	72	< 4	11	24	11
97BMF-103-L3-c	13000	140	8	20	< 2	9	450	< 4	18	21	42
97BMF-103-L3-d	970	590	4	50	5	11	86	8	29	23	< 2
97BMF-103-R1-a	6100	270	< 2	36	2	9	230	6	23	26	11
97BMF-103-R1-b	7000	530	36	40	3	7	120	6	24	18	9
97BMF-103-R1-c	8200	620	43	45	< 2	6	91	8	25	17	10
97BMF-103-R1-d	3100	280	17	35	< 2	20	150	13	20	19	14
97BMF-103-R2-a	5300	330	28	37	< 2	6	360	14	23	27	20
97BMF-103-R2-b	2100	200	12	24	< 2	< 2	75	< 4	14	23	9
97BMF-103-R2-c	3000	250	17	37	< 2	3	190	12	22	24	20
97BMF-103-R2-d	350	750	< 2	59	5	6	180	8	40	20	< 2
97BMF-103-R3-a	12000	310	68	39	< 2	14	690	15	24	25	25
97BMF-103-R3-b	1900	460	< 2	58	6	6	1000	11	39	28	4
97BMF-103-R3-c	84	760	< 2	50	7	12	220	14	27	32	< 2

Table 8. Major and trace-element data from core samples analyzed by ICP-AES, lower tailings impoundment below Bullion Mine, Montana (cont.)

FieldNo	Nb ppm	Nd ppm	Ni ppm	Pb ppm	Sc ppm	Sr ppm	Th ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm
97BMF-103-L2-a	7	13	< 2	2500	5	28	7	< 100	60	4	< 1	130
97BMF-103-L2-b	4	13	< 2	3500	6	21	13	< 100	58	5	< 1	200
97BMF-103-L2-c	6	9	< 2	1500	4	47	6	< 100	46	3	< 1	84
97BMF-103-L2-d	< 4	< 4	< 2	1700	3	17	< 4	< 100	31	< 2	< 1	75
97BMF-103-L2-e	< 4	12	3	6100	8	34	19	< 100	74	5	< 1	210
97BMF-103-L2-f	16	20	10	1500	9	250	17	< 100	110	12	2	140
97BMF-103-L3-a	5	9	< 2	1600	4	23	6	< 100	46	3	< 1	96
97BMF-103-L3-b	< 4	< 4	< 2	2300	3	15	< 4	< 100	33	2	< 1	63
97BMF-103-L3-c	5	13	4	16000	6	45	15	< 100	87	4	< 1	280
97BMF-103-L3-d	14	20	8	690	8	240	15	< 100	110	10	1	120
97BMF-103-R1-a	5	17	5	2000	7	88	22	< 100	81	8	1	210
97BMF-103-R1-b	8	17	5	1100	5	180	22	< 100	82	7	1	200
97BMF-103-R1-c	12	18	4	1300	6	200	22	< 100	79	7	1	110
97BMF-103-R1-d	9	17	3	3100	11	89	23	< 100	100	8	1	110
97BMF-103-R2-a	11	18	< 2	6300	10	32	16	< 100	110	5	< 1	180
97BMF-103-R2-b	< 4	10	< 2	2400	4	24	6	< 100	45	3	< 1	120
97BMF-103-R2-c	8	17	< 2	6100	8	31	13	< 100	89	4	< 1	180
97BMF-103-R2-d	14	24	8	150	8	280	12	< 100	130	12	1	110
97BMF-103-R3-a	14	20	< 2	7700	13	36	25	< 100	140	6	< 1	240
97BMF-103-R3-b	12	29	9	1100	9	170	19	< 100	100	21	2	180
97BMF-103-R3-c	13	20	11	80	8	260	11	< 100	120	12	2	310

Table 9. Major and trace-element data from core samples analyzed by ICP-AES, Uncle Sam Gulch below Crystal Mine, Montana

FieldNo	DEPTH	Al %	Ca %	Fe %	K %	Mg %	Na %	P %	Ti %	Mn ppm	Ag ppm
97BMF-109-1-a	15	5.6	0.30	2.1	3.8	0.22	0.68	0.02	0.14	800	6
97BMF-109-1-b	38	5.3	0.23	1.6	3.6	0.16	0.66	0.005	0.10	600	7
97BMF-109-1-c	56	5.9	0.35	2.6	3.2	0.23	0.80	0.02	0.15	860	9
97BMF-109-2-a	15	6.0	0.49	0.88	4.5	0.18	1.4	0.009	0.11	280	< 2
97BMF-109-2-b	38	7.0	0.74	3.0	2.6	0.45	1.3	0.04	0.23	440	10
97BMF-109-2-c	51	6.0	0.60	4.5	2.7	0.29	1.2	0.04	0.20	1500	7
97BMF-109-3-a	2	3.8	0.40	2.6	1.3	0.21	0.58	0.05	0.12	310	7
97BMF-109-3-b	8	6.7	0.76	2.3	3.8	0.32	1.6	0.02	0.20	1500	< 2
97BMF-109-3-c	18	7.4	0.99	5.1	2.2	0.51	1.6	0.05	0.31	3100	< 2
97BMF-109-3-d	29	6.5	0.78	3.3	3.3	0.31	1.6	0.01	0.21	3500	< 2
97BMF-109-4-a	10	6.1	0.45	3.7	2.9	0.35	0.72	0.02	0.23	800	13
97BMF-109-4-b	32	6.1	0.53	4.9	2.9	0.35	0.93	0.05	0.23	430	18
97BMF-109-4-c	53	2.8	0.32	13	1.3	0.81	0.44	< 0.005	0.11	6200	26

FieldNo	As ppm	Ba ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cu ppm	Ga ppm	La ppm	Li ppm	Mo ppm
97BMF-109-1-a	1100	510	4	43	9	< 2	200	5	23	43	5
97BMF-109-1-b	840	590	7	40	7	< 2	190	7	23	35	3
97BMF-109-1-c	1500	510	< 2	51	9	3	220	7	29	40	7
97BMF-109-2-a	140	720	< 2	53	2	< 2	58	9	28	22	< 2
97BMF-109-2-b	2400	440	3	85	5	< 2	400	12	50	41	6
97BMF-109-2-c	3400	570	4	79	28	< 2	660	8	46	27	8
97BMF-109-3-a	1900	310	9	34	5	< 2	1600	5	21	19	6
97BMF-109-3-b	150	730	< 2	68	25	6	220	7	36	25	4
97BMF-109-3-c	320	570	< 2	94	60	8	490	12	49	44	13
97BMF-109-3-d	230	800	4	69	49	6	160	14	33	31	11
97BMF-109-4-a	2800	480	18	79	8	< 2	340	11	43	51	11
97BMF-109-4-b	5100	430	3	74	4	4	400	7	45	48	14
97BMF-109-4-c	11100	270	110	33	27	4	1400	9	19	19	74

Table 9. Major and trace-element data from core samples analyzed by ICP-AES, Uncle Sam Gulch below Crystal Mine, Montana (cont.)

FieldNo	Nb ppm	Nd ppm	Ni ppm	Pb ppm	Sc ppm	Sr ppm	Th ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm
97BMF-109-1-a	11	15	3	740	3	140	16	< 100	30	7	1	740
97BMF-109-1-b	7	15	< 2	510	3	150	14	< 100	29	6	< 1	360
97BMF-109-1-c	12	18	3	1200	3	150	15	< 100	35	8	1	420
97BMF-109-2-a	13	16	< 2	100	< 2	210	13	< 100	18	7	< 1	230
97BMF-109-2-b	18	30	5	990	6	210	31	< 100	46	14	2	630
97BMF-109-2-c	13	29	4	830	4	200	28	< 100	55	13	2	630
97BMF-109-3-a	7	14	4	950	3	110	14	< 100	31	10	1	770
97BMF-109-3-b	17	23	3	93	4	270	16	< 100	42	13	2	340
97BMF-109-3-c	22	39	7	200	7	260	31	< 100	77	25	3	1000
97BMF-109-3-d	11	23	4	230	4	250	25	< 100	57	10	1	520
97BMF-109-4-a	15	31	5	1500	5	160	31	< 100	66	12	2	640
97BMF-109-4-b	16	31	5	2300	5	160	29	< 100	63	13	2	780
97BMF-109-4-c	< 4	19	15	2300	3	97	15	< 100	110	14	2	8000

Table 10. Major and trace-element ICP-AES data from total digestions of bed-sediment samples from near Bullion and Crystal Mine areas, Montana

Field No	Latitude (DMS)	Longitude (DMS)	Al %	Ca %	Fe %	K %	Mg %	Na %	P %	Ti %	Mn ppm
97-BMS-102s1	46° 21' 26.2"	112° 17' 40.8"	8.0	3.1	8.2	2.0	1.6	1.8	0.13	0.80	1600
97-BMS-102s2	46° 21' 29.5"	112° 17' 47.8"	7.5	1.6	8.2	2.9	0.94	1.3	0.08	0.45	1000
96-BMS-115	46° 21' 33.8"	112° 17' 48.6"	5.9	0.91	9.0	1.8	0.74	0.82	0.09	0.27	890
97-BMS-105S	46° 21' 47.1"	112° 18' 11.7"	8.4	2.2	3.7	1.9	1.2	1.6	0.07	0.51	750
96-BMS-111	46° 21' 52.4"	112° 18' 32.4"	7.5	2.2	6.2	2.0	1.2	1.4	0.14	0.48	1800
97-BMS-116	46° 21' 52.4"	112° 18' 32.4"	7.9	2.9	12	2.4	1.3	1.8	0.15	0.82	1900
98-BMS-111	46° 21' 52.4"	112° 18' 32.4"	7.3	2.4	6.5	2.2	1.2	1.7	0.13	0.55	1300
97-BMS-108s1	46° 21' 16.9"	112° 15' 36.7"	9.1	2.2	1.9	1.7	0.45	2.8	0.06	0.35	620
96-BMS-116	46° 20' 37.7"	112° 15' 37.3"	7.7	1.2	5.6	2.4	0.48	1.4	0.08	0.29	1200
97-BMS-134	46° 20' 02.8"	112° 15' 47.9"	4.4	1.0	7.8	1.4	0.45	0.98	0.07	0.34	460
96-BMS-118	46° 19' 21.0"	112° 15' 00.0"	7.6	2.0	4.2	2.3	0.72	1.8	0.10	0.40	2200

Field Number	Ag ppm	As ppm	Ba ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cu ppm	Ga ppm	La ppm	Li ppm
97-BMS-102s1	< 2	45	560	< 2	150	19	90	47	19	82	38
97-BMS-102s2	10	2300	650	< 2	110	18	69	320	14	57	29
96-BMS-115	12	4600	390	4	62	15	30	360	11	36	34
97-BMS-105S	< 2	160	540	3	100	16	47	110	21	72	58
96-BMS-111	3	940	460	15	110	31	52	610	17	64	36
97-BMS-116	< 2	760	520	5	180	28	130	290	17	91	28
98-BMS-111	< 2	420	560	3	130	22	63	200	17	66	29
97-BMS-108s1	< 2	39	440	< 2	170	6	24	36	14	96	32
96-BMS-116	13	3600	390	7	130	16	22	560	17	80	56
97-BMS-134	40	3900	650	9	74	9	60	220	11	41	26
96-BMS-118	5	1300	540	39	110	43	26	2300	18	69	34

Table 10. Major and trace-element ICP-AES data from total digestions of bed-sediment samples from near Bullion and Crystal Mine areas, Montana (cont.)

Field Number	Mo ppm	Nb ppm	Nd ppm	Ni ppm	Pb ppm	Sc ppm	Sr ppm	Th ppm	U ppm	V ppm	Y ppm
97-BMS-102s1	3	30	69	21	59	22	370	38	< 100	290	45
97-BMS-102s2	4	16	48	14	870	15	240	32	< 100	230	27
96-BMS-115	5	17	30	10	1400	13	150	34	< 100	83	25
97-BMS-105S	4	30	61	19	120	18	290	23	< 100	110	49
96-BMS-111	< 2	28	48	19	370	19	290	41	< 100	170	42
97-BMS-116	3	24	73	18	330	21	330	39	< 100	460	42
98-BMS-111	3	22	50	20	210	18	340	29	< 100	240	33
97-BMS-108s1	3	36	57	10	34	7	540	31	< 100	48	23
96-BMS-116	16	27	49	6	1900	8	270	58	< 100	75	31
97-BMS-134	10	9	34	9	1600	7	260	6	< 100	190	14
96-BMS-118	< 2	28	45	11	920	11	370	37	< 100	86	35

Field Number	Yb ppm	Zn ppm
97-BMS-102s1	5	240
97-BMS-102s2	3	690
96-BMS-115	2	630
97-BMS-105S	5	1100
96-BMS-111	4	1700
97-BMS-116	5	890
98-BMS-111	3	570
97-BMS-108s1	3	160
96-BMS-116	3	920
97-BMS-134	2	2700
96-BMS-118	3	3800

Table 11. Major and trace-element data analyzed by ICP-AES following 2M HCl-1% H_2O_2 leach digestions of bed-sediment samples from near Bullion and Crystal Mine areas, Montana

Field Number	Al ppm	Ca ppm	Fe ppm	K ppm	Mg ppm	Na ppm	P ppm	Si ppm	Ti ppm	Mn ppm	Ag ppm	As ppm
97-BMS-102s1	7700	6600	17000	1200	3100	67	1200	1400	590	760	< 1	30
97-BMS-102s2	4800	1500	23000	1100	2000	48	750	1200	490	540	7.3	1800
96-BMS-115	5600	1200	75500	1600	2400	110	750	1200	450	750	12	4400
97-BMS-105S	10000	4900	16000	1200	3300	57	470	1200	510	310	< 1	150
96-BMS-111	8400	5100	26000	2100	4400	69	1200	1500	650	1600	2.6	830
97-BMS-116	5000	4000	15000	1300	2700	45	1400	1300	630	800	2	510
98-BMS-111	6400	4200	18000	2100	3700	150	1300	1400	650	760	< 1	330
97-BMS-108s1	5100	4200	9500	840	2100	69	480	1300	360	420	< 1	39
96-BMS-116	4400	2000	31700	730	1300	32	730	1000	160	1000	9.3	2200
97-BMS-134	1600	1400	31000	900	750	100	730	980	270	82	35	3900
96-BMS-118	5000	3000	17000	840	1900	44	890	1100	280	2000	5.4	900

Field Number	Ba ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cu ppm	La ppm	Li ppm	Mo ppm	Ni ppm	Pb ppm	Sb ppm
97-BMS-102s1	180	1	57	13	13	30	33	14	1	8.4	48	< 3
97-BMS-102s2	42	2	37	9.9	5.5	220	19	7.2	2	4.3	710	3.0
96-BMS-115	49	1.6	36	9.8	6.7	340	19	9.5	2.9	4.0	1400	16
97-BMS-105S	180	4.7	60	10	12	96	52	14	< 1	9.0	140	< 3
96-BMS-111	110	16	54	22	10	610	30	13	1.3	10	410	< 3
97-BMS-116	55	6.8	53	16	7.5	210	27	8.4	1	5.9	260	< 3
98-BMS-111	93	4.2	50	9.4	6.0	180	24	11	< 1	8.0	190	< 3
97-BMS-108s1	70	2	36	6.7	7.4	32	22	13	2	4.3	29	< 3
96-BMS-116	64	5.5	40	11	3.1	510	19	7.6	7.0	2.5	1500	16
97-BMS-134	96	< 1	14	1	3.7	100	8.4	1	7.3	1	1600	12
96-BMS-118	80	41	35	36	4.4	2400	20	7.2	2.7	5.6	790	9.2

Table 11. Major and trace-element data analyzed by ICP-AES following 2M HCl-1% H_2O_2 leach digestions of bed-sediment samples from near Bullion and Crystal Mine areas, Montana (cont.)

Field Number	Sr ppm	Th ppm	V ppm	Y ppm	Zn ppm
97-BMS-102s1	42	< 2	44	20	180
97-BMS-102s2	7.5	8.5	19	11	280
96-BMS-115	11	13	25	14	350
97-BMS-105S	36	< 2	56	38	1100
96-BMS-111	37	7.0	36	20	1700
97-BMS-116	15	8.5	31	14	710
98-BMS-111	22	12	36	13	490
97-BMS-108s1	53	< 2	21	15	130
96-BMS-116	13	19	13	15	610
97-BMS-134	13	5.2	14	4.0	190
96-BMS-118	18	6.3	16	16	3700

Table 12. Major and trace-element data analyzed by ICP-AES following total digestion of residues of 2M HCl-1% H_2O_2 leach of bed-sediment samples from near Bullion and Crystal Mine areas, Montana

Field No	Al %	Ca %	Fe %	K %	Mg %	Na %	P %	Ti %	Mn ppm	Ag ppm	As ppm
97-BMS-102s1	6.9	2.5	6.6	1.6	1.2	1.7	0.03	0.69	970	< 2	17
97-BMS-102s2	6.4	1.4	5.6	2.3	0.71	1.3	0.02	0.38	460	< 2	340
96-BMS-115	5.2	0.85	2.0	1.7	0.52	0.84	0.02	0.22	230	< 2	370
97-BMS-105S	6.4	1.5	2.0	1.3	0.83	1.3	0.03	0.42	420	< 2	38
96-BMS-111	6.6	1.8	3.8	1.8	0.87	1.5	0.02	0.39	500	< 2	160
97-BMS-116	6.6	2.3	9.6	1.8	0.93	1.6	0.02	0.68	900	< 2	140
98-BMS-111	6.6	2.0	4.8	2.0	0.84	1.6	0.02	0.48	530	< 2	120
97-BMS-108s1	9.1	2.0	1.2	1.5	0.27	3.1	0.02	0.33	310	< 2	11
96-BMS-116	7.2	1.1	2.7	2.4	0.34	1.5	0.02	0.28	300	3	1400
97-BMS-134	4.2	0.86	4.4	1.2	0.37	0.92	0.01	0.31	350	7	230
96-BMS-118	6.9	1.7	2.6	2.1	0.53	1.9	0.01	0.38	540	< 2	360

Field No	Ba ppm	Cd ppm	Ce ppm	Co ppm	Cr ppm	Cu ppm	Ga ppm	La ppm	Li ppm	Mo ppm	Nb ppm
97-BMS-102s1	360	< 2	100	9	76	14	12	56	24	2	43
97-BMS-102s2	550	< 2	71	8	74	47	10	42	20	2	24
96-BMS-115	350	< 2	32	5	23	42	12	19	24	< 2	15
97-BMS-105S	330	< 2	47	6	33	23	14	27	41	3	30
96-BMS-111	380	< 2	62	8	44	41	14	35	22	< 2	23
97-BMS-116	360	< 2	130	10	110	39	12	76	17	< 2	34
98-BMS-111	420	< 2	86	12	53	22	14	50	16	< 2	36
97-BMS-108s1	400	< 2	130	< 1	17	6	11	75	19	2	57
96-BMS-116	350	< 2	92	4	20	87	16	55	48	4	29
97-BMS-134	170	9	48	6	46	98	8	29	23	2	16
96-BMS-118	440	< 2	96	6	22	81	16	59	25	< 2	27

Table 12. Major and trace-element data analyzed by ICP-AES following total digestion of residues of 2M HCl-1% H_2O_2 leach of bed-sediment samples from near Bullion and Crystal Mine areas, Montana (cont.)

Field No	Nd ppm	Ni ppm	Pb ppm	Sc ppm	Sr ppm	Th ppm	U ppm	V ppm	Y ppm	Yb ppm	Zn ppm
97-BMS-102s1	44	13	17	20	310	35	< 100	250	29	4	87
97-BMS-102s2	29	9	130	13	220	26	< 100	210	17	2	340
96-BMS-115	15	6	220	11	150	17	< 100	60	11	1	300
97-BMS-105S	22	10	22	13	230	26	< 100	60	15	2	150
96-BMS-111	25	8	44	16	270	18	< 100	140	22	2	190
97-BMS-116	54	11	52	18	280	35	< 100	400	28	4	180
98-BMS-111	32	13	31	15	290	29	< 100	200	23	2	120
97-BMS-108s1	43	5	10	7	480	52	< 100	30	14	2	52
96-BMS-116	34	4	620	7	270	27	< 100	66	18	2	310
97-BMS-134	22	8	190	7	240	8	< 100	160	9	1	2300
96-BMS-118	35	5	150	10	360	21	< 100	74	18	2	250

Appendix

Discussion of results in tables A1 through A6

The ICP-AES analyses of the core samples were done by an outside laboratory; the analyses of the bed-sediment samples were done in-house in the USGS laboratories in Denver, Colorado. The results from the contract laboratory are generally acceptable, but there are several notable exceptions. The recoveries were somewhat less accurate, and the variances were higher for samples run by the contract laboratory than for those run by the USGS laboratory. Arsenic is biased high below 100 ppm, and somewhat low above 100 ppm, relative to recommended NIST values. No recommendations are presented to normalize these analyses; at the high As levels contained in the cores, the values are acceptable. Cobalt is biased low, but is not an important element in this study. Chromium recoveries are very low, due to incomplete digestion, and we do not recommend using the chromium analyses. Lead shows a high bias at levels below 50 ppm, is relatively neutral at several hundred ppm, and shows a low bias at levels greater than 1,000 ppm. The analyses are still quite acceptable for the purpose of this report. The values for titanium from both laboratories tend to be low, due to the refractory nature of titanium oxides, which may not be completely dissolved in this acid digestion.

TABLE A1 Comparison of contract laboratory results with NIST values for SRM-2704

SRM-2704 n=20					
Element	observed conc.	observed % RSD	NIST value	NIST C.I.*	PERCENT RECOVERY
Al %	5.71	2.8	6.11	0.16	93
Ca %	2.61	5.6	2.6	0.03	100
Fe %	3.73	3.9	4.11	0.10	91
K %	1.84	4.9	2.00	0.04	92
Mg %	1.12	3.3	1.2	0.02	93
Na %	0.56	4.8	0.55	0.014	102
P %	0.08	8.1	0.099	0.003	81
Ti %	0.33	5.3	0.457	0.018	72
Mn, ppm	550	4.3	555	19	99
Ag, ppm	<2	--	--	--	--
As, ppm	33.6	60	23.4	0.8	144
Ba, ppm	405	14	414	12	98
Cd, ppm	<2	--	3.45	0.22	--
Ce, ppm	62	3.7	72	--	86
Co, ppm	10.9	0.7	14	0.6	78
Cr, ppm	76.6	20	135	5	57
Cu, ppm	88.9	5.5	98.6	5	90
Ga, ppm	10.9	3.5	15	--	73
La, ppm	29.2	0.8	29	--	101
Li, ppm	39.5	1.3	50	--	79
Mo, ppm	3.6	0.5	--	--	--
Nb, ppm	6.2	3.8	--	--	--
Nd, ppm	28.9	1.3	--	--	--
Ni, ppm	38.4	1.8	44	3	87
Pb, ppm	161	20	161	17	100
Sc, ppm	10.6	0.5	12	--	88
Sr, ppm	125	4.5	130	--	96
Th, ppm	7.4	2	9.2	--	80
V, ppm	88.4	9.8	95	4	93
Y, ppm	18.9	0.9	--	--	--
Yb, ppm	2.1	0.3	2.8	--	75
Zn, ppm	375	22	438	12	86

* 95% confidence interval

This table shows the results for twenty analyses for SRM-2704 submitted as blind samples to the contract laboratory.

TABLE A2 Comparison of contract laboratory results with NIST values for SRM-2709

SRM-2709 n=20					
Element	observed conc.	observed % RSD	NIST value	NIST C.I.*	PERCENT RECOVERY
Al %	7.02	3.4	7.5	0.06	94
Ca %	1.82	3.4	1.89	0.05	96
Fe %	3.26	3.4	3.50	0.11	93
K %	1.89	5.3	2.03	0.06	93
Mg %	1.41	5.1	1.51	0.05	93
Na %	1.11	6.5	1.16	0.03	96
P %	0.05	11	0.062	0.005	81
Ti %	0.35	2.8	0.342	0.024	102
Mn, ppm	482	4.80	538	17	90
Ag, ppm	<2	--	0.41	0.03	--
As, ppm	27.7	14	17.7	0.8	156
Ba, ppm	903	24	968	40	93
Cd, ppm	<2	--	0.38	0.01	--
Ce, ppm	42.6	2.1	42	--	101
Co, ppm	10.6	0.7	13.4	0.7	79
Cr, ppm	41.2	16	130	4	32
Cu, ppm	30.1	1.3	34.6	0.7	87
Ga, ppm	14.2	--	14	--	101
La, ppm	21.7	1.2	23	--	94
Li, ppm	47.5	1.3	50	--	95
Mo, ppm	<2	--	2	--	--
Nb, ppm	8.1	4.6	--	--	--
Nd, ppm	18.5	0.7	19	--	97
Ni, ppm	72.5	2.5	88	5	82
Pb, ppm	30	12	18.9	0.5	159
Sc, ppm	11	0.3	12	--	92
Sr, ppm	215	7.8	231	2	93
Th, ppm	9.8	0.8	11	--	89
V, ppm	108	8.3	112	5	96
Y, ppm	13.4	0.5	18	--	74
Yb, ppm	1.8	0.2	1.6	--	113
Zn, ppm	95.6	8.6	106	3	90

* 95% confidence interval

This table shows the results for twenty analyses for SRM-2709 submitted as blind samples to the contract laboratory.

TABLE A3 Comparison of contract laboratory results with NIST values for SRM-2711

SRM-2711 n=20					
Element	observed conc.	observed % RSD	NIST value	NIST C.I.*	PERCENT RECOVERY
Al %	6.33	2.79	6.53	0.09	97
Ca %	2.81	3.73	2.88	0.08	98
Fe %	2.70	1.75	2.89	0.06	93
K %	2.34	4.76	2.45	0.08	95
Mg %	0.99	3.62	1.05	0.03	94
Na %	1.16	4.30	1.14	0.03	101
P %	0.07	9.59	0.086	0.007	83
Ti %	0.29	1.69	0.306	0.023	96
Mn, ppm	575	4.1	638	28	90
Ag, ppm	4.5	15	4.63	0.39	97
As, ppm	93.8	13	105	8	89
Ba, ppm	747	21	726	38	103
Cd, ppm	34.6	4.9	41.7	0.25	83
Ce, ppm	70	6.6	69	--	101
Co, ppm	8	8.3	10	--	80
Cr, ppm	18.1	34	47	--	39
Cu, ppm	106	5.6	114	2	93
Ga, ppm	13.7	18	15	--	91
La, ppm	37.2	4.7	40	--	93
Li, ppm	24.1	4.1	--	--	--
Mo, ppm	<2	--	--	--	--
Nb, ppm	15	21	--	--	--
Nd, ppm	31.1	2.9	31	--	100
Ni, ppm	17.8	4	20.6	1.1	86
Pb, ppm	1060	3.8	1162	31	91
Sc, ppm	8.8	4.2	9	--	98
Sr, ppm	236	2.3	245	0.7	96
Th, ppm	12.1	12	14	--	86
V, ppm	79.4	7.9	81.6	2.9	97
Y, ppm	23	4.3	25	--	92
Yb, ppm	2.9	11	2.7	--	107
Zn, ppm	304	3.9	350	4.8	87

* 95% confidence interval

This table shows the results for twenty analyses for SRM-2711 submitted as blind samples to the contract laboratory.

TABLE A4 Comparison of USGS laboratory results with NIST values for SRM-2704

SRM-2704 n=7					
Element	USGS conc.	USGS % RSD	NIST value	NIST C.I.*	PERCENT RECOVERY
Al %	6.04	2.5	6.11	0.16	99
Ca %	2.64	2.8	2.6	0.03	102
Fe %	4.07	2.5	4.11	0.10	99
K %	1.93	3.6	2.00	0.04	96
Mg %	1.20	0.0	1.2	0.02	100
Na %	0.61	4.1	0.55	0.014	110
P %	0.10	4.4	0.099	0.003	104
Ti %	0.29	11.5	0.457	0.018	64
Mn, ppm	580	5.6	555	19	105
Ag, ppm	<2	--	--	--	--
As, ppm	23	19	23.4	0.8	98
Ba, ppm	406	3.9	414	12	98
Cd, ppm	<2		3.45	0.22	--
Ce, ppm	60	9.5	72	--	83
Co, ppm	15.7	2.9	14	0.6	112
Cr, ppm	146	3.4	135	5	108
Cu, ppm	96	7.5	98.6	5	97
Ga, ppm	15	6.2	15	--	100
La, ppm	30.9	0.8	29	--	107
Li, ppm	46.7	1.3	50	--	93
Mo, ppm	<2	--	--	--	--
Nb, ppm	14.3	14	--	--	--
Nd, ppm	28.4	9.4	--	--	--
Ni, ppm	42.3	2.7	44	3	96
Pb, ppm	149	6.7	161	17	93
Sc, ppm	11.7	3.4	12	--	98
Sr, ppm	133	4.5	130	--	102
Th, ppm	9.6	17	9.2	--	104
V, ppm	89	3.3	95	4	94
Y, ppm	23.3	5	--	--	--
Yb, ppm	2	0	2.8	--	71
Zn, ppm	431	3.6	438	12	98

* 95% confidence interval

This table shows the results for seven analyses for SRM-2704 analyzed in-house in the USGS analytical laboratories in Denver, Co.

TABLE A5 Comparison of USGS laboratory results with NIST values for SRM-2709

SRM-2709 n=7					
Element	USGS conc.	USGS % RSD	NIST value	NIST C.I.*	PERCENT RECOVERY
Al %	7.26	1.6	7.5	0.06	97
Ca %	1.93	2.3	1.89	0.05	102
Fe %	3.47	1.3	3.50	0.11	99
K %	1.89	3.4	2.03	0.06	93
Mg %	1.49	2.4	1.51	0.05	98
Na %	1.20	4.5	1.16	0.03	103
P %	0.07	6.7	0.062	0.005	108
Ti %	0.32	1.4	0.342	0.024	93
Mn, ppm	537	1.9	538	17	100
Ag, ppm	<2	--	0.41	0.03	--
As, ppm	18.7	20	17.7	0.8	106
Ba, ppm	895	2.6	968	40	92
Cd, ppm	<2	--	0.38	0.01	--
Ce, ppm	41.3	4.0	42	--	98
Co, ppm	15.0	5.0	13.4	0.7	112
Cr, ppm	124.3	5.9	130	4	96
Cu, ppm	31.3	5.3	34.6	0.7	90
Ga, ppm	15.3	4.6	14	--	109
La, ppm	23.6	3.1	23	--	102
Li, ppm	53.6	2.6	50	--	107
Mo, ppm	<2	--	2	--	--
Nb, ppm	14.3	18	--	--	--
Nd, ppm	17.9	6.3	19	--	94
Ni, ppm	83.1	2.0	88	5	94
Pb, ppm	14.4	20	18.9	0.5	76
Sc, ppm	11.9	3.0	12	--	99
Sr, ppm	227	3.1	231	2	98
Th, ppm	10.7	8.2	11	--	97
V, ppm	110.0	0.0	112	5	98
Y, ppm	17.9	5.5	18	--	99
Yb, ppm	1.9	19	1.6	--	116
Zn, ppm	98.9	1.3	106	3	93

* 95% confidence interval

This table shows the results for seven analyses for SRM-2709 analyzed in-house in the USGS analytical laboratories in Denver, Co.

TABLE A6 Comparison of USGS laboratory results with NIST values for SRM-2711

SRM-2711 n=7					
Element	USGS conc.	USGS % RSD	NIST value	NIST C.I.*	PERCENT RECOVERY
Al %	6.39	3.3	6.53	0.09	98
Ca %	2.93	3.5	2.88	0.08	102
Fe %	2.86	3.2	2.89	0.06	99
K %	2.34	6.0	2.45	0.08	96
Mg %	1.04	4.7	1.05	0.03	99
Na %	1.21	5.3	1.14	0.03	107
P %	0.08	5.9	0.086	0.007	98
Ti %	0.26	3.5	0.306	0.023	84
Mn, ppm	677	14	638	28	106
Ag, ppm	3.6	14	4.63	0.39	77
As, ppm	100	6.6	105	8	95
Ba, ppm	688	4.7	726	38	95
Cd, ppm	37.3	1.9	41.7	0.25	89
Ce, ppm	67.4	4.1	69	--	98
Co, ppm	11.6	4.3	10	--	116
Cr, ppm	47.0	3.4	47	--	100
Cu, ppm	108	6.5	114	2	95
Ga, ppm	16.0	6.7	15	--	107
La, ppm	37.9	3.8	40	--	95
Li, ppm	26.7	4.8	--	--	--
Mo, ppm	<2	--	--	--	--
Nb, ppm	17.0	31	--	--	--
Nd, ppm	28.9	4.3	31	--	93
Ni, ppm	19.6	2.5	20.6	1.1	95
Pb, ppm	1070	6.7	1162	31	92
Sc, ppm	9.3	4.9	9	--	103
Sr, ppm	244	3.7	245	0.7	100
Th, ppm	13.9	4.6	14	--	99
V, ppm	77.6	2.7	81.6	2.9	95
Y, ppm	26.9	5.0	25	--	107
Yb, ppm	2.7	17	2.7	--	101
Zn, ppm	353	5.4	350	4.8	101

* 95% confidence interval

This table shows the results for seven analyses for SRM-2711 analyzed in-house in the USGS analytical laboratories in Denver, Co.

TABLE A7 ICP-AES elements and their limits of determination

Element	Symbol	Total Digestion Procedure	HCl H2O2 Leach Procedure
Aluminum	Al	.005 %	30 ppm
Calcium	Ca	.005 %	30 ppm
Iron	Fe	.005 %	30 ppm
Potassium	K	.01 %	30 ppm
Magnesium	Mg	.005 %	30 ppm
Sodium	Na	.005 %	30 ppm
Phosphorous	P	.005 %	30 ppm
Silicon	Si	--	30 ppm
Titanium	Ti	.005 %	30 ppm
Manganese	Mn	4 ppm	1.2 ppm
Silver	Ag	2 ppm	1.2 ppm
Arsenic	As	10 ppm	6 ppm
Barium	Ba	1 ppm	.6 ppm
Cadmium	Cd	2 ppm	1.2 ppm
Cerium	Ce	4 ppm	2.4 ppm
Cobalt	Co	1 ppm	.6 ppm
Chromium	Cr	1 ppm	.6 ppm
Copper	Cu	1 ppm	.6 ppm
Gallium	Ga	4 ppm	--
Lanthanum	La	2 ppm	1.2 ppm
Lithium	Li	2 ppm	2 ppm
Molybdenum	Mo	2 ppm	1.2 ppm
Niobium	Nb	4 ppm	--
Neodymium	Nd	4 ppm	--
Nickel	Ni	2 ppm	1.2 ppm
Lead	Pb	4 ppm	2.4 ppm
Antimony	Sb	--	3 ppm
Scandium	Sc	2 ppm	--
Strontium	Sr	2 ppm	1.2 ppm
Thorium	Th	4 ppm	2 ppm
Uranium	U	100 ppm	--
Vanadium	V	2 ppm	1.2 ppm
Yttrium	Y	2 ppm	1.2 ppm
Ytterbium	Yb	1 ppm	--
Zinc	Zn	2 ppm	.6 ppm