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COMPOSITIONS AND METAL LOADINGS FROM SEVERAL SEEPS AT THE SUMMITVILLE MINE: PRELIMINARY RESULTS OF SAMPLING IN AUGUST, 1995, AND COMPARISON TO AUGUST, 1994, RESULTS

by

Geoffrey S. Plumlee[1]
Kathleen S. Smith[1]
Maria R. Montour[1]

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[1] U.S. Geological Survey, DFC, Box 25046, MS 973, Denver, CO 80225

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INTRODUCTION

The Summitville Mine, located in the eastern San Juan Mountains of southwestern Colorado, is the focus of extensive efforts by the U.S. Environmental Protection Agency (EPA) to remediate the environmental effects of recent open-pit gold mining operations; for a summary of Summitville's mining and remediation history, see Pendleton and Posey (1995). As part of an ongoing project examining the geologic and geochemical controls on the formation of acid-mine drainage waters at Summitville (see Plumlee and others, 1995, a and b), we visited the mine site on August 21, 1995, to collect samples of seep waters, including one seep draining the eastern side of the North Waste Dump (SA-2: Fig. 1), and two seeps draining undisturbed rock southeast of the Chandler adit (SA-7 and SA-14: Fig. 1). Seeps SA-7 and SA-14 were among a number of seeps along the northern and eastern edge of the Summitville mine that had deposited extensive ferricrete deposits (composed of brown iron hydroxides) prior to historic underground mining. These seeps had largely ceased flowing after the opening of the Reynolds adit in 1903, and have been reactivated as a result of the plugging of the Reynolds adit in 1994. Seep SA-7 was sampled a year earlier (August 30, 1994; Ch Seep from Plumlee and others, 1995b) and presented a good opportunity to evaluate annual changes in the seep's composition for a year in which the nearby Chandler adit was replugged and the backfilling of the open pit was largely completed.

DESCRIPTION OF SEEPS

Seep SA-2 is located on the eastern side of the North Waste dump (Fig. 1), and is one of several seeps draining the dump (see Plumlee and others, 1995a and b, for the location and 1994 composition of a seep draining the southeastern corner of the dump). At the time of the August 21, 1995, sampling, we visually estimated the flow rate to be approximately 3 gallons per minute (Table 1). The water flowed from several small openings in the graded side of the dump, and was depositing hard, brown ferricrete on the surrounding soils and rock material. We had not observed or sampled this seep in earlier years.

Seeps SA-7 and SA-14 are located to the south and downhill from the Chandler adit (Fig. 1), in an area of undisturbed rock covered by spatially extensive ferricrete deposits that were largely formed prior to historic underground mining activity and prior to the driving of the Reynolds adit in 1903. Geologic controls on the location of these seeps are uncertain, although they may reflect the surface expression of concealed fractures or vuggy silica zones extending downhill from the main area of mineralization (Fig. 1). At the time of sampling, Seep SA-14 filled a small, ~3/4 m-wide, 1/5 m-deep pool that had been excavated sometime prior to our sampling. The water was a deep, emerald green color. We visually estimated flow rate to be around 1/4 gallon per minute; no flow had been visible from this general area a year previously. Seep SA-7 flowed from several openings in thin ferricrete deposits. By channeling the seep's flow, we were able to measure the time needed to fill a 2-liter container, and thus determined a flow rate of 0.3 liter per second (4.5 gallons per minute). A year previously, the flow from seep SA-7 was measured (using a hypodermic syringe) to be approximately 60 ml per 8 seconds (0.1 gallon per minute). The significant increases in flow volumes from seeps SA-7 and SA-14 between late August, 1994, and late August, 1995, most likely reflect the replugging of the nearby Chandler adit (Fig. 1) in late 1994 and the resulting decrease in fluid flow outlets from the northwest portion of South Mountain.

SAMPLING AND ANALYTICAL PROCEDURES

At each of the three sample sites, field measurements were made of air and water temperature, pH, conductivity, and dissolved oxygen content. The pH meter was calibrated at each site prior to measurement using pH 4 and 7 buffers, and verified using pH 3 buffer; the verified pH was always within 0.03 of the 3.0 buffer value.

Samples were collected at each site by filling a 1-L bottle with water. The liter bottle was shaken and then an unfiltered sample collected for total metals analysis. Filtered samples for dissolved metals, dissolved ferrous iron, and anions were collected from the bulk sample bottle using a syringe and 0.2 µm syringe filter. Prior to filling, each bottle was rinsed 3 times with a small amount of the filtered or unfiltered water. Samples for metals were preserved using 10 drops of concentrated nitric acid per 120 ml of water, the ferrous iron sample was preserved with 10 drops of concentrated HCl per 60 ml of sample, and the anion sample was placed on ice. The remainder of the bulk sample was placed on ice and returned to the lab for acidity measurement.

Concentrations of major cations and metals in the water samples were measured using an Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES) technique. Concentrations of trace metals were determined using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). Ferrous iron concentrations were determined in the laboratory using a Hach digital spectrometer and ferrous iron test ampoules/protocol. Concentrations of anions were determined using ion chromatography (IC); IC results are still being verified, and so are not included in this report. Acidity was determined on all samples using titrimetric methods.

RESULTS

Results of the 1995 sampling are given in Table 1, along with a comparison between the compositions of and metal loadings from Seep SA-7 collected in August, 1994 and August, 1995. The 1995 pH values and compositions of the seep SA-2 and SA-14 waters are mostly similar to those measured in waters draining the Reynolds and Chandler adits, and the North Waste dump in previous years of our study (Plumlee and others, 1995b). Although the pH (3.1) of seep SA-7 waters is similar to those of the Reynolds and Chandler waters measured in previous years, the concentrations of some metals in SA-7 are substantially greater than those measured in nearly all other water samples over the course of our studies at Summitville (Table 1). For example, the dissolved copper concentration of 825 ppm is the highest we've measured to date at Summitville, as is the lead concentration of 1300 ppb. When compared to August 1994 levels (last two columns of Table 1), the 1995 SA-7 metal concentrations and loadings are extreme. Concentrations increased by 1.5 to as much as 50 times the 1994 values for various metals; for example copper concentrations tripled and arsenic concentrations increased by 50 times. Due to the great increase in flow rates, the loadings of the same metals increased by anywhere from 60 to 1860 times; copper loadings increased from 1/2 pound per day to 45 pounds per day.

DISCUSSION AND CONCLUSIONS

The data presented in this report indicate that, as of late summer, 1995, the seeps on the north-northeast side of the Summitville mine site had increased substantially in volume and deteriorated substantially in quality from the same time period in 1994. As noted previously, the increase in flows presumably resulted directly from the repairing of the breached plug in the Chandler adit in late 1994 and the corresponding shift of flow to other outlets nearby.

The geochemical causes of the marked increase in metal concentrations in seep SA-7 between late August, 1994 and late August, 1995 are more difficult to interpret. At this time we can only speculate on several possible causes. The increases may reflect increased dissolution of soluble metal salts from underground mine workings remaining beneath the area of the open pit, as proposed for high metal concentrations in the Reynolds and Chandler outflows during spring flush events in previous years (Plumlee and others, 1995a, b). If so, this seems to require extensive evaporation of acid waters and formation of soluble salts in the underground workings during dry periods in the late summer and fall of 1994. Some underground evaporation may have occurred in response to the temporary reopening of the Chandler adit in late 1994 to repair the breached plug; however, the large amounts of evaporation required to account for the great increases in metal concentrations and loadings seem unlikely. An alternative cause for the increased metal concentrations and loadings may be the dissolution of soluble ferric iron salts present in the Cropsy waste dump material (Plumlee and others, 1995; Flohr and others, 1995) backfilled into the open pit, and the subsequent reaction of the aqueous ferric iron with sulfides in the rocks beneath the open pit. A third alternative is a combination of the previous two. Detailed geochemical modeling is currently underway that may help clarify which if any of these alternatives is most likely.

It is impossible to predict at this time what long-term changes in metal concentrations and loadings might occur from the SA-7 and SA-14 area seeps in the next several years. If our speculations are correct, then the progressive dissolution of soluble salts from the mine workings and rocks beneath the open pit and from the backfilled Cropsy material could lead to declining metal concentrations in the seep waters over time. However, if the water table fluctuates substantially, and evaporation and reformation of soluble salts can occur in the area beneath and within the backfilled open pit, then improvement in water quality may at best be very gradual over the long term. Clearly, much more monitoring of water quality in the seeps, coupled with geochemical modeling of the results, is needed over the next several years in order to better understand and predict potential long-term changes in water composition from the seeps on the north-northeastern side of the Summitville mine site.

As the data for seep SA-2 show, waters draining the North waste dump can be quite acidic and metalliferous. Thus, the North Waste dump, unless further remediated, will remain a substantial source of degraded waters over the long term.

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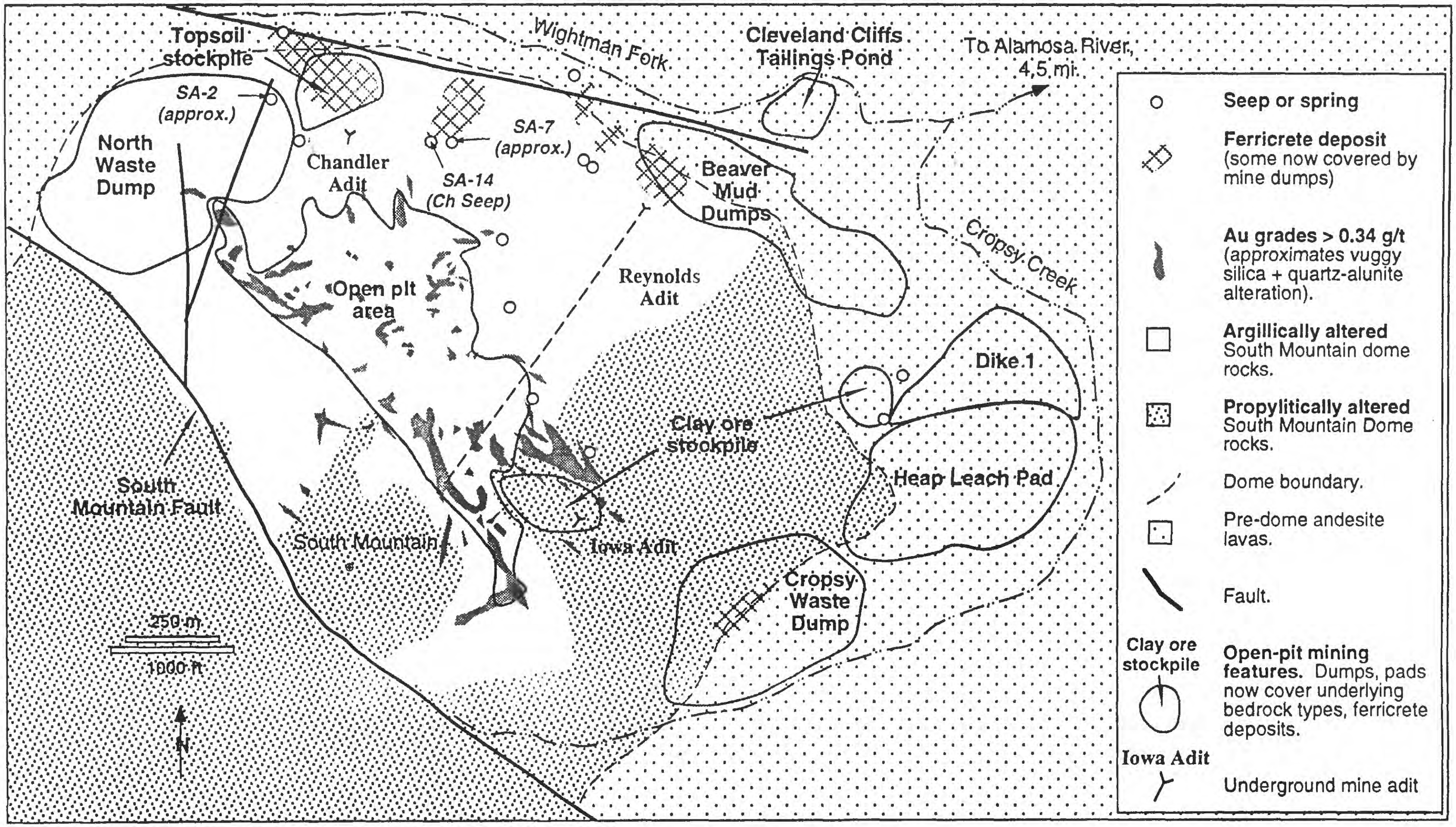

Figure 1. Geologic map of the Summitville Mine showing locations of seeps relative to major geologic and mine features. Locations of seeps sampled in August, 1996, are labeled in italics.

Table 1. Summitville seep data.

	1995 Data						1994 vs. 1995, SA-7 (Ch Seep)					
Parameter	SA-7		SA-14		SA-2		Data		loadings (lbs/day)		Conc. factor	Load factor
	FA0.2	RA	FA0.2	RA	FA0.2	RA	1994*	1995	1994	1995	(=1995/1994)	(=1995/1994)
date	8/21/95		8/21/95		8/21/95		8/30/94	8/21/95	8/30/94	8/21/95		
Flow L/sec	0.3						0.0075	0.285714286			38.1	
Flow (gpm)	4.5		0.25		0.3		0.11887013	4.5283859			38.1	
TEMP °C	3.5		3.5		8		3	3.5				
Spec. Conductivity µS/cm	8900		5600		4600		3670	8900			2.4	
Acidity to pH 8.3 mg/L CaCO3	9282		5509		4115		3024	9282			3.1	
pH	3.1		3.47		3.48		3.01	3.1				
Diss. oxygen ppm	11		11		8		10	11				
Fe++ mg/L	1370		202		770		338	1370	0.5	74.6	4.1	154.4
SO4 mg/L							5000					
F mg/L							-0.5					
Cl mg/L							0.51					
Al ppm	1100	1100	600	600	420	420	280	1100	0.4	59.9	3.9	149.7
As ppb	4000	1600	3	2	20	20	82	4000	1.2E-04	0.2	48.8	1858.3
Ba ppb	74	72	7	7	5	5	41	74	5.9E-05	4.0E-03	1.8	68.8
Be ppb	160	160	45	46	34	34	37	160	5.3E-05	8.7E-03	4.3	164.7
Ca ppm	240	230	140	140	180	170	69	240	0.1	13.1	3.5	132.5
Cd ppb	730	710	300	300	320	310	220	730	3.1E-04	4.0E-02	3.3	126.4
Ce ppb	410	430	430	430	420	430	260	410	3.7E-04	2.2E-02	1.6	60.1
Co ppb	4000	4000	1800	1800	1700	1700	950	4000	1.4E-03	0.2	4.2	160.4
Cr ppb	410	330	90	76	33	32	58	410	8.3E-05	2.2E-02	7.1	269.3
Cu ppb	825000	799000	336000	333000	63000	62000	270000	825000	0.4	44.9	3.1	116.4
Fe ppm	2000	2000	790	800	750	730	540	2000	0.8	108.8	3.7	141.1
K ppm	4.5	4.3	2.8	3	5.1	5	3	4.5	4.3E-03	0.2	1.5	57.1
La ppb	150	150	180	180	160	170	84	150	1.2E-04	8.2E-03	1.8	68.0
Li ppb	160	160	72	72	72	72	11	160	1.6E-05	8.7E-03	14.5	554.1
Mg ppm	140	140	67	68	74	73	31	140	4.4E-02	7.6	4.5	172.0
Mn ppb	102000	99000	44000	45000	49000	49000	28000	102000	4.0E-02	5.6	3.6	138.8
Na ppm	9.1	8.8	5.3	5.3	6.9	6.8	3	9.1	4.3E-03	0.5	3.0	115.6
Ni ppb	5200	5200	2400	2400	2200	2100	1200	5200	1.7E-03	0.3	4.3	165.1
Pb ppb	1300	1300	280	240	0.4	0.5	180	1300	2.6E-04	0.1	7.2	275.1
Si ppm	57	56	38	38	36	35	27	57	3.9E-02	3.1	2.1	80.4
Sr ppb	460	450	400	400	400	400	150	460	2.1E-04	2.5E-02	3.1	116.8
Th ppb	20	21	3	4	3	3	6.5	20	9.3E-06	1.1E-03	3.1	117.2
Ti ppb	94	87	98	100	81	82	20	94	2.9E-05	5.1E-03	4.7	179.0
U ppb	320	370	150	150	59	61	72	320	1.0E-04	1.7E-02	4.4	169.3
V ppb	660	640	110	110	140	140	20	660	2.9E-05	3.6E-02	33.0	1257.1
Zn ppb	94000	94000	42000	42000	39000	38000	29000	94000	4.1E-02	5.1	3.2	123.5
Zn+Cu+Cd+Co+Ni+Pb (ppb)	930230	904210	382780	379740	106220.4	104110.5	301550	930230				

*1995 data from Plumlee et al. (1995)