GEOLOGICAL SURVEY CIRCULAR 592

Interpreting Pan-Concentrate Analyses of Stream Sediments in Geochemical Exploration for Gold

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Abstract

A study of methods of collecting and processing samples to determine whether or not gold is present in areas of moderate size was undertaken in the northwestern part of the San Juan Mountains, Colo. As part of this study, 57 samples of pan concentrates were taken from streams draining three types of areas: (1) "barren" areas, where gold mineralization might be geologically possible but no deposits are known, (2) slightly mineralized areas that contain only a few known veins and prospects and small mines, and (3) well-mineralized areas that contain numerous veins and some very productive mines. The concentrate samples were analyzed by the fire-assay–atomic-absorption method.

Replicate analyses of large samples gave results consistent enough to permit placing considerable confidence in the results obtained for smaller samples on which only one analysis was made. For general field practice, it is necessary to pan only enough sand and gravel to yield about 15 grams of concentrate.

The analytical results are also quantitatively compatible with known geologic relations and indicate that a few samples from a stream are adequate to distinguish between "barren" and mineralized areas and to determine the relative amount of gold in mineralized areas. In other areas of similar gold deposits, data of this type should help decide whether more intensive search for gold deposits is justified.

INTRODUCTION

As part of its Heavy Metals program to appraise and enhance domestic resources of mineral raw materials that are in short supply, the U.S. Geological Survey is studying techniques of geologic sampling and their application to mineral exploration. In 1967 a project was started in the northwestern San Juan Mountains, Colo., to study several methods of collecting and processing samples in order to determine easily and quickly whether or not gold is present in areas of a few square miles. One method tried is described here. It consisted of panning known amounts of sand and gravel from selected streams, weighing the heavy-mineral concentrates and analyzing them by fire assay and atomic absorption. The panning practice used did not differ from that of the oldtime prospector, but the more sensitive analytical procedure available today offers a distinct advantage. Reasonably reproducible results that seem to be quantitatively meaningful were obtained from 57 samples. This type of sampling should be usable in other areas where similar gold deposits might be present, and the results should help decide whether more intensive search for gold deposits might be justified.

Willard Leedy and Mark Voultsos helped in the collection and panning of samples in the field. W. D. Goss, L. B. Riley, Claude Huffman, Jr., and J. A. Thomas of the U.S. Geological Survey did the gold analyses.

SAMPLING AND ANALYTICAL TECHNIQUES

All samples were sand and gravel from the upper part of the alluvial fill, and at each sample locality this material was taken from one or more places along the stream where placer gold is apt to accumulate, such as the head or foot of stream bars, behind boulders, in moss-covered banks, and in natural riffles on bedrock. The samples were taken to determine the presence of gold in the stream sediments and its relative amount; they were not adequate to determine or estimate the gold content of the streambed fill.

Samples were panned in the field in 11- and 14-inch gold pans. They were not weighed individually, but it was determined that the small pan contained about 3,500 grams (nearly 8 pounds) of sand and gravel when filled and the large pan, about 7,000 grams (nearly 16 pounds). Samples ranged in size from those that filled only one small pan to those that filled seven or eight pans of both sizes and totaled 40,000 to 50,000 grams, or about 100 pounds. The samples were concentrated by panning until most of the light-colored (light weight) mineral grains were washed from the pan. Concentrates consisted mostly of dark-colored heavy minerals, commonly with some fresh sulfides, mainly pyrite. At each locality where two or more pans of sand and gravel were taken, the concentrates from each pan were combined into one sample for analysis. Samples of concentrate ranged in weight from a few grams to as much as 775 grams. Some samples were panned by one person alone; others, by two, three, or four people.

In the laboratory, concentrate samples weighing more than about 50 grams were split in a Jones splitter to samples of about 50 grams. Using ceramic plates, these 50-gram splits were then ground to about 80 to 100 mesh. If the original concentrate sample was less than about 50 grams, the entire sample was ground. If the ground sample weighed less than about 15 grams, the whole sample was analyzed in one run. If the ground sample weighed more than about 15 grams, it was poured into a cone-shaped pile on a flat surface, and was spread out rather evenly; enough spatula scoops, each containing about 1 gram of sample, were taken to make two or three separate splits for analysis, usually of about 15 grams each. For each analysis, a gold-silver bead was obtained by the standard fire-assay method. This bead was dissolved in acid and the gold was determined quantitatively by atomic-absorption spectrometry (Huffman and others, 1967). The limit of detection is 0.02 part per million (ppm) gold for samples of 10–15 grams and is slightly higher for smaller samples.

SAMPLE DATA AND ANALYTICAL RESULTS

Tables 1, 2, and 3 show sample data and analytical results. Not much significance is placed on the calculated amount of gold in the field samples beyond its order of magnitude—the weight of the field sample was only estimated; thus the concentration ratio cannot be figured precisely. Furthermore, the amount of gold in the concentrate is minimal, because gold can be lost in panning; however, the amount that might have been lost is not known. On the other hand, considerable significance can be placed on the consistency of the analytical results and their quantitative compatibility with geologic relations.

Consistency of analytical results

Because gold is particulate in habit, has a high specific gravity, and is malleable, it is commonly difficult to grind and mix a sample sufficiently to obtain consistent analytical results between sample splits. Splits of the pan concentrates used in this study, however, gave reasonably consistent results, as shown both by graphic plotting and by statistical analyses. The consistency between splits permits placing considerable confidence in the determinations for those samples on which only one analysis was made.

The analytical determinations for the samples listed in tables 2 and 3 that were analyzed as two or three separate splits are plotted on a logarithmic scale in figure 1. For most samples, the logarithmic range (length of line) between plotted points is small and is about the same for low-grade and high-grade samples. For a few low-grade samples (054, 114, and 335), as might be reasonably expected, the logarithmic range appears large although the actual differences are small—indeed, the happenstantial inclusion or exclusion of perhaps a single particle of gold in a sample split might make the difference between splits.

Quantitative compatibility of samples with known geologic relations

The 57 samples used in this study were taken from streams draining three geologic types of ground—apparently barren, weakly mineralized, and well-mineralized (fig. 2). The analytical results show a quantitative compatibility between the samples and their source areas.

Table 1 lists samples taken from the Middle and West Forks of Cimarron Creek. These two drainage areas contain no known ore deposits and only a few fractures along which hydrothermal alteration was relatively weak. All 21 samples, which are concentrates from a total of about 600 pounds of sand and gravel, and which were analyzed in 42 splits, were reported to contain less than the limit of detection, usually <0.02 ppm gold. Calculating these results into the volumes of the field samples gives values not exceeding tenths or hundredths of a part per billion (ppb), or 0.000X to 0.0000X ppm, probably one to two orders of magnitude less than crustal abundance.

Table 2 lists samples from streams that drain areas classed as weakly mineralized, in which veins are not abundant and only a few prospects or small mines are known. Table 3 lists samples from streams draining well-mineralized areas that contain numerous veins and some very productive mines. Of the 36 samples shown on these two tables, all were reported to be gold-bearing except one, sample 354 (table 2), which is from a stream draining a weakly mineralized area. The calculated gold content of the sand and gravel from streams draining weakly mineralized areas (table 2) ranges from a few tenths of a ppb to several ppb, or 0.0003 to 0.009 ppm. The samples from streams draining well-mineralized areas have calculated gold values ranging from several ppb to a few hundred ppb, or 0.006 to 0.3 ppm. Gold was reported in the analyses of all samples and sample splits, and was observed in the field in the pan concentrates in 13 out of 15 samples that were found on analysis to contain a calculated gold content of at least 0.01 ppm. It is worth noting that 0.01 ppm of gold is equivalent to about 1 cent per cubic yard of sand and gravel and is below the limit of detection by common analytical methods. Obviously, a fairly consistent field recognition of such low gold values gives useful information on the spot.

CONCLUSIONS

The consistency of replicate analyses permits placing considerable confidence in the sampling and analytical methods used, and the quantitative compatibility with known geologic relations indicates that a few samples are adequate to distinguish between "barren" and mineralized areas and to determine the relative amount of gold in mineralized areas. In other areas where similar gold deposits might be present, the analytical results of this type of sampling should be useful to determine easily and quickly whether more intensive search for gold deposits might be justified.

REFERENCE CITED

Huffman, Claude, Jr., Mensik, J. D., and Riley, L. B., 1967, Determination of gold in geologic materials by solvent extraction and atomic-absorption spectrometry: U.S. Geol. Survey Circ. 544, 6 p.

FIGURES 1, 2 AND TABLES 1-3

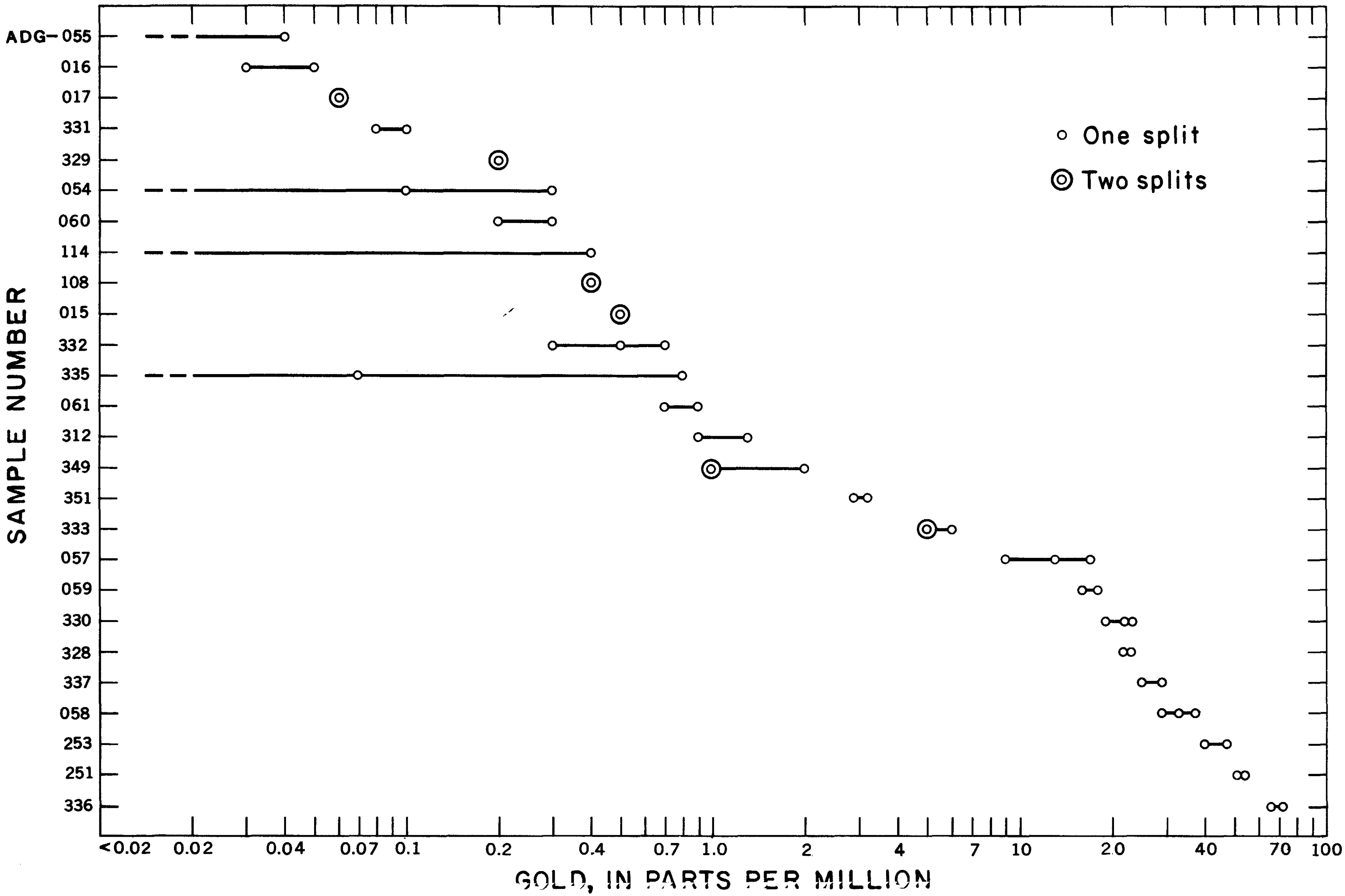

Figure 1.—Graph of the range, on a logarithmic scale, of analytical determinations for samples listed in tables 2 and 3 that were analyzed as two or three separate splits.

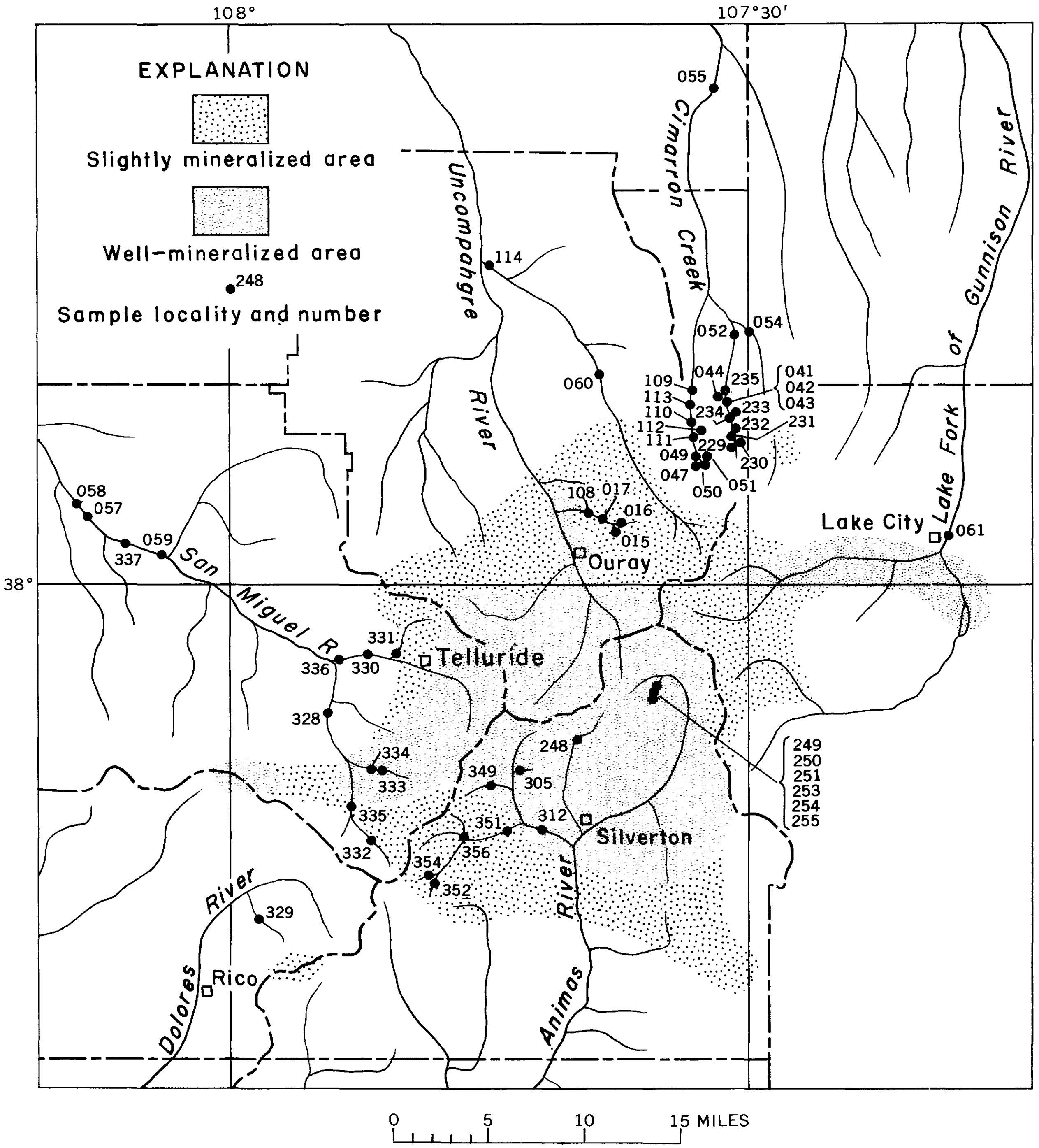

Figure 2.—Map showing sample localities and character of mineralized areas in San Juan Mountains, Colo.

Table 1.--Samples from streams

Sample No.	Field sample	Concentrate	Concentration ratio	Concentrate analyzed (weight in grams)	
	Weight in grams			Split 1	Split 2
		West Fork Cimarron Creek			
ADG-047	10,000	26.77	380	15	11.77
049	7,000	18.35	380	10	8.35
050	7,000	36.31	200	15	21.31
051	7,000	24.27	280	12	12.27
109	40,000	775.8	50	15	15.
110	50,000	89.8	550	15	15.
111	40,000	483.1	80	15	15.
112	3,500	40.2	90	15	15.
113	20,000	219.4	90	15	15.
		Middle Fork Cimarron Creek			
041	7,000	142.7	50	15	15
042	7,000	96.8	70	15	15
043	7,000	3.8	1,800	3.8	---
044	7,000	33.68	200	15	10
052	14,000	359.0	40	15	15
229	40,000	278.7	140	15	15
230	3,500	28.90	120	15	13.90
231	15,000	16.47	900	10	6.47
232	20,000	19.68	1,000	10	9.68
233	3,500	19.04	180	10	9.04
234	20,000	186.2	110	15	15
235	3,500	64.1	60	15	15

Table 2.—Samples from streams draining weakly mineralized areas

Sample No.	Sample locality	Field sample	Concentrate	Concentration ratio	Concentrate analyzed (weight in grams)	
		Weight in grams			Split 1	Split 2
			Cimarron Creek drainage area			
ADG—055	Cimarron Creek	14,000	266.9	50	15	15
054	East Fort	17,000	270.1	60	15	15
			Uncompahgre River drainage area			
060	Cow Creek	14,000	214.5	60	15	15
114	------do------	40,000	460.6	90	15	15
015	Dexter Creek	14,000	17.22	800	10	7.22
016	------do------	7,000	53.5	130	15	15
017	------do------	9,000	59.7	150	15	15
108	------do------	40,000	265.3	150	15	15
			Animas River drainage area			
351	South Fork Mineral Creek	8,000	19.73	420	10	9.73
352	------do------	8,000	3.00	2,500	3.00	---
354	------do------	8,000	124.9	60	15	15
356	------do------	8,000	14.28	550	14.28	---
			San Miguel River drainage area			
331	Mill Creek	16,000	103.9	150	15	15
332	Lake Fork	25,000	46.60	550	15	15
335	------do------	16,000	34.23	480	15	10
			Dolores River drainage area			
329	Barlow Creek	20,000	43.5	460	15	15

1/ Gold was recognized visually in the pan.

draining apparently barren areas

Sample No.	Concentrate analyzed—Con. (weight in grams)	Gold content in parts per million				
		Concentrate				Field sample (calculated)
	Split 3	Split 1	Split 2	Split 3	Average	
		West Fork Cimarron Creek				
ADG-047	---	<0.02	<0.02	---	<0.02	<0.0000X
049	---	<.02	<.02	---	<.02	<.0000X
050	---	<.02	<.02	---	<.02	<.0000X
051	---	<.02	<.02	---	<.02	<.0000X
109	---	<.02	<.02	---	<.02	<.000X
110	---	<.02	<.02	---	<.02	<.0000X
111	---	<.02	<.02	---	<.02	<.000X
112	---	<.02	<.02	---	<.02	<.000X
113	---	<.02	<.02	---	<.02	<.000X
		Middle Fork Cimarron Creek				
041	---	<0.02	<0.02	---	<0.02	<0.000X
042	---	<.02	<.02	---	<.02	<.000X
043	---	<.05	---	---	<.05	<.0000X
044	8.68	<.02	<.02	<0.02	<.02	<.0000X
052	---	<.02	<.02	---	<.02	<.000X
229	---	<.02	<.02	---	<.02	<.000X
230	---	<.02	<.02	---	<.02	<.000X
231	---	<.02	<.04	---	<.03	<.0000X
232	---	<.02	<.02	---	<.02	<.0000X
233	---	<.02	<.02	---	<.02	<.000X
234	---	<.02	<.02	---	<.02	<.000X
235	---	<.02	<.02	---	<.02	<.000X

that contain only a few veins and prospects or small mines

Sample No.	Concentrate analyzed--Con. (weight in grams)	Gold content in parts per million				
		Concentrate				Field sample (calculated)
	Split 3	Split 1	Split 2	Split 3	Average	
		Cimarron Creek drainage area				
ADG—055	---	<0.02	0.04	---	0.03	0.0006
054	15	.1	<.02	0.3	.1	.002
		Uncompahgre River drainage area				
060	---	0.3	0.2	---	0.2	0.003
114	15	<.02	.4	<0.02	.1	.002
015	---	.5	.5	---	.5	.0006
016	---	.05	.03	---	.04	.0003
017	---	.06	.06	---	.06	.0004
108	---	.4	.4	---	.4	.003
		Animas River drainage area				
351	---	3.2	2.9	---	3.0	[1]0.007
352	---	1.3	---	---	1.3	.0005
354	---	<.02	<.02	---	<.02	<.000X
356	---	5.1	---	---	5.1	.009
		San Miguel River drainage area				
331	---	.08	0.1	---	0.09	0.0006
332	16.60	.3	.7	.5	.5	.001
335	9.23	.07	<.02	.8	.3	.0006
		Dolores River drainage area				
329	---	0.2	0.2	---	0.2	0.0004

Table 3.--Samples from streams draining well-mineralized areas

Sample No.	Sample locality	Field sample (Weight in grams)	Concentrate (Weight in grams)	Concentration ratio	Concentrate analyzed (weight in grams) Split 1	Concentrate analyzed (weight in grams) Split 2
	Lake Fork of Gunnison River drainage area					
ADG-061	Lake Fork	5,000	25.79	190	12	13.79
	Animas River drainage areas					
248	Cement Creek---	8,000	11.49	700	11.49	---
249	Placer Gulch---	8,000	5.41	1,500	5.41	---
250	------do-------	8,000	4.46	1,800	4.46	---
251	------do-------	16,000	15.72	1,000	10	5.72
253	------do-------	8,000	15.73	500	10	5.73
254	------do-------	8,000	8.23	1,000	8.23	---
255	------do-------	8,000	1.35	6,000	1.35	---
305	Brown Gulch, (North Fork Mineral Creek).	8,000	5.62	1,400	5.62	---
312	Mineral Creek--	3,500	21.21	170	12	9.21
349	Middle Fork Mineral Creek.	16,000	51.4	320	15	15
	San Miguel River drainage area					
057	San Miguel River, bench.	15,000	39.14	380	15	15
059	------do-------	15,000	65.0	240	15	15
058	San Miguel River	15,000	65.5	320	15	15
330	------do-------	25,000	103.6	240	15	15
336	------do-------	8,000	32.02	240	15	17.02
337	------do-------	16,000	107.4	150	15	15
328	South Fork, San Miguel River.	25,000	98.4	260	15	15
333	Howard Fork, South Fork, San Miguel River.	16,000	43.22	380	15	15
334	------do-------	12,000	12.04	1,000	12.04	---

1/ Gold was recognized visually in the pan.

that contain numerous veins and some very productive mines

Concentrate analyzed--Con. (weight in grams)	Gold content in parts per million				
	Concentrate				Field sample (calculated)
Split 3	Split 1	Split 2	Split 3	Average	
Lake Fork of Gunnison River drainage area--Continued					
---	0.7	0.9	---	0.8	0.004
Animas River drainage areas--Continued					
---	98	---	---	98	1/0.1
---	41	---	---	41	1/.03
---	32	---	---	32	1/.02
---	52	54	---	53	1/.05
---	40	47	---	44	1/.08
---	45	---	---	45	1/.05
---	71	---	---	71	1/.01
---	9.3	---	---	9.3	.007
---	1.3	.9	---	1.1	.006
15	2	1	1	1.3	.044
San Miguel River drainage area--Continued					
9.14	9	13	17	13	1/0.03
---	18	16	---	17	1/.07
15	43	39	47	43	1/.2
15	23	19	22	21	.09
---	71	67	---	69	1/.3
---	25	29	---	27	1/.2
---	23	22	---	22	1/.09
13.22	6	5	5	5	1/.01
---	5.8	---	---	5.8	.006

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