UNITED STATES

DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

HEXAVALENT CHROMIUM IN GROUND AND SURFACE WATERS NEAR TELLURIDE, COLORADO - A PRELIMINARY DATA REPORT

Open-File Report 79-700

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Denver, Colorado

1979

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GEOLOGICAL SURVEY

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CONTENTS

	Page
Abstract	1
Introduction	2
Geographic and geologic setting	4
Drilling and ground-water sampling	6
Water quality	7
Sample treatment	7
Methods of analysis	8
Occurrence of hexavalent chromium	9
References cited	18

ILLUSTRATIONS

Page

Figure 1. Area of water-quality investigation near Telluride, Colo. 5

2. Location of selected ground- and surface-water sampling sites near Telluride, Colo 10

TABLES

Table 1. Concentration of hexavalent chromium in ground waters near Telluride, Colo. 11

2. Concentration of hexavalent chromium in surface waters near Telluride, Colo. 14

HEXAVALENT CHROMIUM IN GROUND AND SURFACE WATERS

NEAR TELLURIDE, COLORADO

— A PRELIMINARY DATA REPORT —

By

David B. Grove,[1] Ronald L. Miller,[1] Leonard F. Konikow,[2]

and Patrick S. O'Boyle[3]

ABSTRACT

Data showing results of 38 ground-water and 25 surface-water samples analyzed for hexavalent chromium are presented. Most samples were taken within the Telluride, Colo., city limits during October 1978. Twenty-four of the 38 ground-water samples (63 percent) contained more than 50 micrograms per liter of hexavalent chromium. Excluding the mill tailings pond 6 of the 23 surface-water samples (26 percent) contained more than 50 micrograms per liter of hexavalent chromium. Hexavalent chromium concentrations in ground waters ranged from 0 to 2700 micrograms per liter and in surface-waters from 0 to 160 micrograms per liter.

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INTRODUCTION

The U.S. Geological Survey conducted a reconnaissance study of the quality of the surface and ground waters near Telluride, Colo. The purpose of this study was to ascertain if significant concentrations of chemical species existed in these ground waters to test or calibrate current models that describe movement and reactions of dissolved chemicals in porous media. This particular area was chosen for several reasons. First, a mine, mill, and tailings pond exist at the head of the valley, and any anomalous water-quality characteristics in this area may be representative of conditions in other metal mining areas. Second, the hydrologic and geologic data that were available for this narrow alluvial valley indicate the shallow ground-water flow system might be definable with greater precision than in many other areas. Third, by studying a field problem in which uncertainties in the flow field are minimal, effects of other processes affecting solute transport, such as hydrodynamic dispersion and chemical reactions, may be isolated and evaluated more accurately. Finally, there was also local concern that two wells drilled for Telluride's water supply, approximately 1600 feet downvalley from the base of the tailings pond, may have produced water unsuitable for consumption.

On February 9 and 22 and March 6, 1978, during a 30-day pumping test, water samples were collected from one of the town wells (CW-2). Because analyses of these samples indicated the presence of anomalously high concentrations of dissolved hexavalent chromium, more extensive and detailed drilling and ground-water sampling were conducted in the area during October 1978.

This hydrologic data report is being issued because the anomalous concentrations of hexavalent chromium found in the ground and surface waters are of interest to many persons in both the public and private sectors. Later reports will contain interpretations of chromium concentrations, results of more extensive chemical analyses presently being performed on collected samples, and research applications to the development of solute-transport models.

The U.S. Geological Survey wishes to acknowledge the cooperation of the following individuals: Peter Loncar, Mine Superintendent, and Lee Brown, Mill Supervisor, both of the Idarado Mining Co., for allowing drilling and sampling on mine property, and Randy King, Town Manager of Telluride, for providing permission and assistance for drilling and sampling on town property. Special appreciation is due Robert R. Pemberton, who supervised the drilling equipment and provided valuable technical advice on drilling and sampling procedures.

GEOGRAPHIC AND GEOLOGIC SETTING

The town of Telluride is in San Miguel County in southwestern Colorado (fig. 1). It lies in the narrow and nearly straight valley of the San Miguel River, which flows westward out of the nearby San Juan Mountains. Near Telluride, the valley floor averages about 2,000 feet in width and about 8,750 feet in elevation. However, many of the surrounding mountain peaks exceed 13,000 feet in elevation.

The valley bottom is underlain mainly by unconsolidated deposits of alluvium. The alluvium is highly permeable in places, but in turn is underlain and bounded laterally by sedimentary rocks whose permeability is probably several orders of magnitude lower than that of the alluvium. Geology and mineral deposits in the area are described by Vhay (1962) and Burbank and Luedke (1966).

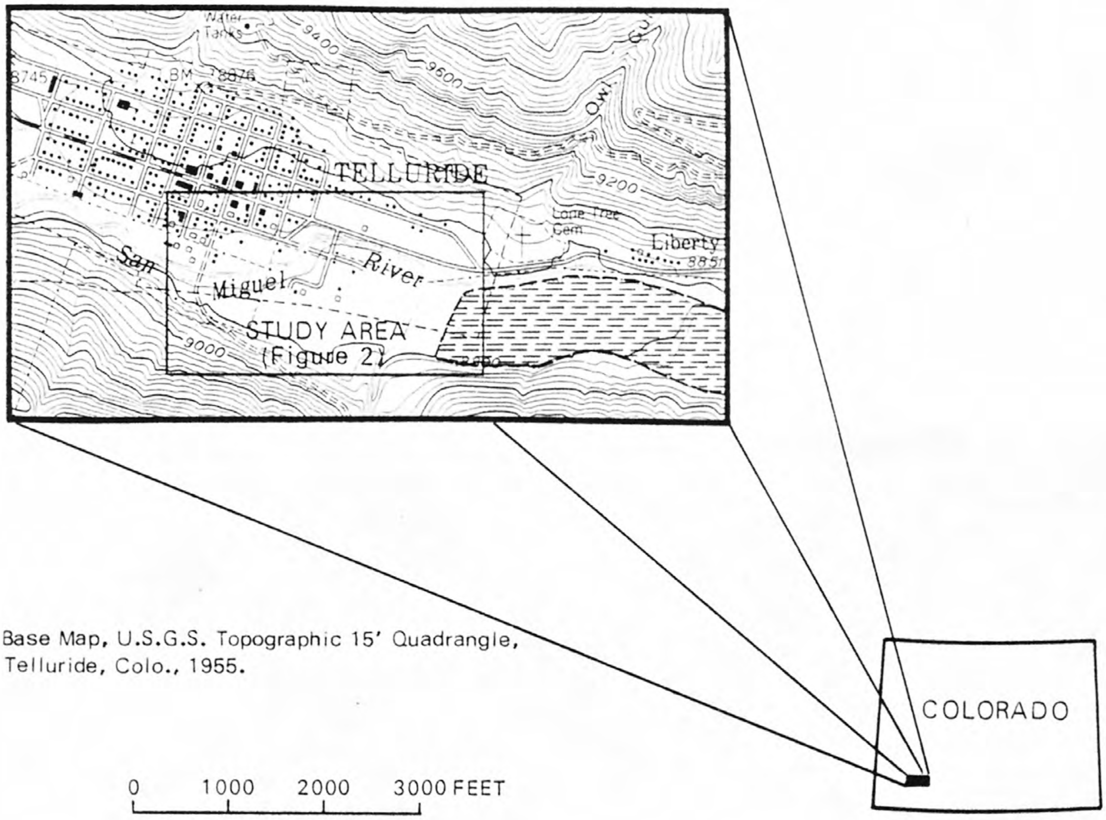

Figure 1.--Area of water-quality investigation near Telluride, Colo.

DRILLING AND GROUND-WATER SAMPLING

Test holes were constructed by drilling with a 7½-inch outside diameter (OD) hollow-stem auger. Water samples were obtained during drilling by inserting a 1 1/2-inch-diameter well screen on a steel pipe through the hollow stem, and either pumping or swabbing from the depth of interest. A sufficient volume of water was withdrawn to completely flush the sampling points and pipes before a sample was collected.

After the final drilling depth was reached, 1 1/2-inch OD X 6-inch-long brass screen samplers were implanted at selected depths. They were connected to land surface with 1/4-inch OD polyethylene tubing. Where the depth to water was too deep to obtain water samples by suction, check valves were attached to the sampler with dual polyethylene tubes to allow sampling by a vacuum-pressure technique. In some holes, shallow samplers were set using 1-inch or 2-inch slotted and screened plastic pipe inserted to depth. Most of the sampling systems were covered with a capped 4-inch plastic pipe for protection.

WATER QUALITY

Sample treatment

Three types of sample treatment were used for samples analyzed for hexavalent chromium (Cr^{+6}). The designation RU means that the sample was raw and untreated (that is, unfiltered, no acid or preservatives added). The RU samples were generally taken when lack of time and equipment were factors, or when the sample was originally collected for other purposes. An FA sample was filtered through a 0.45-micrometer membrane filter, and a 2 mL ampoule of double-distilled, concentrated nitric acid was added immediately to lower the pH below 2. A low-pressure peristaltic pump was used to force the water through the filter. Material passing through the 0.45-micron filter is generally considered to be in solution, while material retained on the filter is generally considered to be in suspension.

Methods of analysis

Hexavalent chromium determinations were performed by two different methods accepted by the U.S. Geological Survey, Water Resources Division. In the first method (Rainwater and Thatcher, 1960, p. 151-152, and Skougstad and others, 1978, p. 573-575) hexavalent chromium is reacted with diphenylcarbazide to produce a soluble red-violet color, which is measured at 540 namometers with an ultra violet (UV) spectrophotometer. The second method is a chelation extraction with an atomic absorption spectrophotometric analysis used by the U.S. Geological Survey, National Water Quality Laboratory, Denver, Colo. In this method the hexavalent chromium is chelated with ammonium pyrrolidine dithiocarbonate (APDC) at pH 2.4 and the chelated chromium is extracted into methyl isobutyl ketone (MIBK). The extract is analyzed with a atomic absorption spectrophotometer at 357.9 nanometers (Skougstad and others, 1978, p. 205-207).

Comparable results were obtained on samples analyzed by both methods.

Occurrence of hexavalent chromium

Ground-water concentrations of hexavalent chromium are shown in table 1. The table presents local well identification numbers, depth of sampling point below land surface, date and time of collection, sample type (or treatment), and concentration of hexavalent chromium in units of micrograms per liter.

Twenty-four of the 38 ground-water samples (63 percent) exceeded 50 μg/L, the criteria for drinking water (U.S. Environmental Protection Agency, 1976, p. 37). Fifteen samples (39 percent) had concentrations above 200 μg/L, and 6 samples (16 percent) were greater than 500 μg/L. Near Telluride, highest concentrations were found along the southern edge of the valley floor.

Figure 2 shows the locations of these ground-water sampling sites. As indicated by table 1, several sites were sampled at various depths, and several sites, such as Telluride city well No. 2, were sampled several times.

Concentrations of hexavalent chromium in surface waters are shown in table 2. Sampling locations shown in this table are more descriptive in nature. Some of the stream sample sites are shown in figure 2. Those sites not shown on this figure can be located by their descriptions. The table has been subdivided into four separate sections: Streams, Lakes and ponds, Springs and seeps, and the Tailings pond.

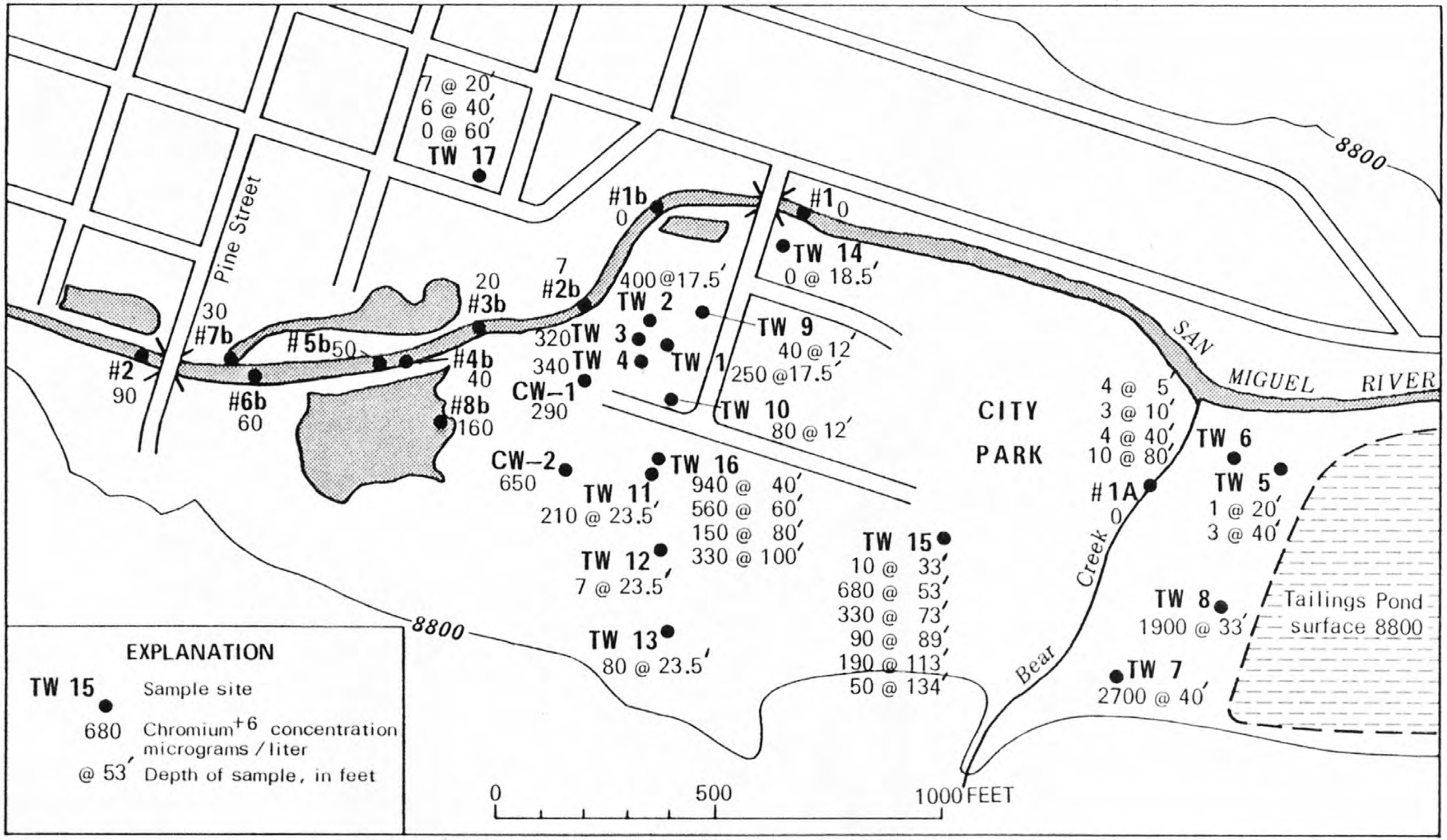

Figure 2.--Location of selected ground- and surface-water sampling sited near Telluride, Colo.

Table 1.--Concentration of hexavalent chromium in ground waters near Telluride, Colo.

[Method 1, Diphenylcarbazide-UV-spectrophotometric method; Method 2, Chelation-extraction and atomic absorption spectrophotometric method. RU = unfiltered unacidified; FA = filtered and acidified.]

Site	Depth (ft)	Date	Time	Sample type	Cr^{+6} (µg/L)	
					Method 1	Method 2
TW-1	17.5	10/12/78	1030	RU	250	
TW-2	17.5	10/13/78	1442	RU	370	
TW-3	17.5	10/14/78	1510	RU	310	
TW-4	17.5	10/13/78	1457	RU	300	
TW-5	20	10/13/78	1630	FA	1	
TW-5	40	10/14/78	1120	FA	3	
TW-6	5	10/16/78	1130	FA	4	
TW-6	10	10/16/78	1420	FA	3	
TW-6	40	10/16/78	1700	FA	4	
TW-6	80	10/17/78	1200	FA	10	
TW-7	40	10/18/78	1100	FA	2700	2100
TW-8	33	10/18/78	1620	FA	1900	2100
TW-9	12	10/19/78	1000	FA	40	
TW-10	12	10/19/78	1130	FA	80	
TW-11	23.5	10/19/78	1530	FA	210	
TW-12	23.5	10/20/78	--	FA	7	
TW-13	23.5	10/20/78	1115	FA	80	

Table 1.--Concentration of hexavalent chromium in ground waters near Telluride, Colo.--Continued

Site	Depth (ft)	Date	Time	Sample type	Cr^{+6} (µg/L) Method 1	Method 2
TW-14	18.5	10/20/78	1400	FA	0	
TW-15	33	10/23/78	0900	FA	10	
TW-15	53	10/23/78	1100	FA	680	1000
TW-15	73	10/23/78	1330	FA	330	
TW-15	89	10/23/78	1545	FA	90	
TW-15	113	10/24/78	0930	FA	190	
TW-15	134	10/24/78	1115	FA	50	
TW-16	40	10/25/78	1310	FA	940	
TW-16	60	10/25/78	1630	FA	560	575
TW-16	80	10/26/78	1100	FA	150	
TW-16	100	10/26/78	1330	FA	330	
TW-17	20	10/27/78	1030	RU	7	
TW-17	40	10/27/78	1200	RU	6	
TW-17	60	10/27/78	1400	RU	0	
Telluride city well (CW-1)	59-84	10/16/78	1555	FA	650	690
Telluride city well (CW-2)	80-111	2/9/78	1030	FA		140
Telluride city well (CW-2)	80-111	2/22/78	1030	FA		130

Table 1.--Concentration of hexavalent chromium in ground waters near Telluride, Colo.--Continued

Site	Depth (ft)	Date	Time	Sample type	Cr^{+6} (µg/L) Method 1	Method 2
Telluride city well (CW-2)	80-111	3/6/78	1200	FA		160
Telluride city well (CW-2)	80-111	6/5/78	1530	RU		190
Telluride city well (CW-2)	80-111	10/12/78	1630	RU	290	250
Telluride city well (CW-2)	80-111	10/12/78	1630	FA	270	

Table 2.--Concentrations of hexavalent chromium in surface waters near Telluride, Colo.

[Method 1, Diphenylcarbazide-UV-spectrophotometric method; all samples were unfiltered and unacidified.]

Site	Date	Time	Cr^{+6} (µg/L) Method 1
Streams			
Bear Creek (1A)	10/16/78	1125	0
San Miguel River upstream of bridge at city park (No. 1)	10/26/78	----	0
San Miguel River at bend (1B)	10/26/78	----	0
San Miguel River at bend (2B)	10/26/78	----	7
San Miguel River at bend 200 ft below 2B riffle, power line crossing (3B)	10/26/78	----	20
San Miguel River at bend 20 ft below spring (5B)	10/26/78	----	50
San Miguel River at bend 200 ft above Pine Street Bridge (6B)	10/26/78	----	60
San Miguel River at Pine Street Bridge (No. 2)	10/26/78	0912	90
San Miguel River at S. Aspen Street (about 0.2 mi downstream from Pine Street Bridge)	10/26/78	0915	80
San Miguel River above confluence of Cornet Creek (10B) (about 1.4 mi downstream from Pine Street Bridge)	10/26/78	----	80
San Miguel River below confluence of Cornet Creek (11B) (about 1.4 mi downstream from Pine Street Bridge)	10/26/78	----	60

Table 2.--Concentrations of hexavalent chromium in surface waters near Telluride, Colo.-Continued

Site	Date	Time	Cr^{+6} (µg/L) Method 1
Streams			
San Miguel River upstream of Sewage Lagoon (12B) (about 2.4 mi downstream from Pine Street Bridge)	10/26/78	----	40
San Miguel River above confluence with South Fork (14B) (about 5.3 mi downstream from Pine Street Bridge)	10/27/78	0930	20
San Miguel River below confluence with South Fork (16B) (about 5.3 mi downstream from Pine Street Bridge)	10/27/78	0930	4
South Fork just above confluence with San Miguel River (15B)	10/27/78	0930	0
Lakes and Ponds			
Trout Pond east side near TW-14	10/20/78	1500	0
Beaver Pond outflow (7B)	10/26/78	----	30
Pond opposite city well (8B)	10/26/78	----	160
Springs and Seeps			
Seep 100 ft S. of TW-17	10/17/78	0930	4
Spring on east side of Beaver Pond (9B)	10/26/78	----	20
Spring above confluence with San Miguel River (4B)	10/26/78	----	40

Table 2.--Concentrations of hexavalent chromium in surface waters near Telluride, Colo.-Continued

Site	Date	Time	Cr^{+6} (μg/L Method 1
Springs and Seeps			
Seep 80 yds SW of TW-5	10/14/78	1405	0
Seep 100 yds SW of TW-5	10/14/78	1400	20
Tailings Pond			
Tailings Pond	10/17/78	1400	8800
Pipe below and draining tailings pond (100 ft S. of TW-5)	10/14/78	1130	3500

Surface waters, excluding the tailings pond and a drain immediately adjacent to it, tended to be lower in hexavalent chromium than groundwaters. However, they show a pattern similar to that of the groundwater; highest concentrations occur directly west of the city wells, where the river turns south and then flows west along the southern side of the valley.

Excluding the tailing pond and drain, hexavalent concentrations in the surface-waters ranged from 0 to 160 μg/L. Six of the 23 samples (26 percent) were greater than 50 μg/L and only 1 was above 100 μg/L, the criterion for freshwater aquatic life (U.S. Environmental Protection Agency, 1976, p. 37).

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