COLORADO GEOLOGICAL SURVEY

ROCKTALK

VOLUME FOUR, NUMBER TWO APRIL, 2001

Field Notes from the Director

GEOLOGY, MINING, AND THE ENVIRONMENT

A HISTORY OF THE UPPER ALAMOSA RIVER BASIN

The late 19th and early 20th century history of Colorado *is* its mining history. Colorado's endowment of mineral resources initiated gold rushes, mine development, related industries, settlement, and community organization. Mining in the Alamosa River basin was an important part of our State's early development, especially in the Summitville mining district. In 1883 this district was the third largest gold producer in Colorado. Mining activity in the Alamosa River basin has waxed and waned over the years, but the area has always attracted interest because of its significant gold occurrences.

Unfortunately, without environmentally sound development of our natural resources, there may be undesirable consequences. Adverse effects on water quality resulting from mining activity at Summitville between 1984 and 1992 have dominated the most recent history of the Alamosa River. The Summitville Mine became a Superfund cleanup site in 1992. It was placed on the National Priority List in 1994, identifying it as one of the nation's priority sites for remediation. Reclamation is currently in progress.

The Summitville Mine site is not the only source of poor-quality water in the Alamosa River, however. The geologic setting of the upper Alamosa River basin causes much of the upper Alamosa River and its tributaries to carry naturally acidic, metal-rich water resulting from acid rock drainage (see below). New stream water-quality standards set in 1998 reflect, in part, this natural situation. The new standards and treatment of contaminants at Summitville should allow fish to return to past habitats.

In the following pages you will read about the geological, mining, and environmental history of the Upper Alamosa River basin. This information is intended to provide a broad perspective for understanding present activities in the basin.

Many other locations across Colorado also have degraded water quality as a result of natural geologic conditions. CGS continues to study and report on these natural conditions to help regulators, industry and citizens set attainable water quality standards and realistic remediation goals.

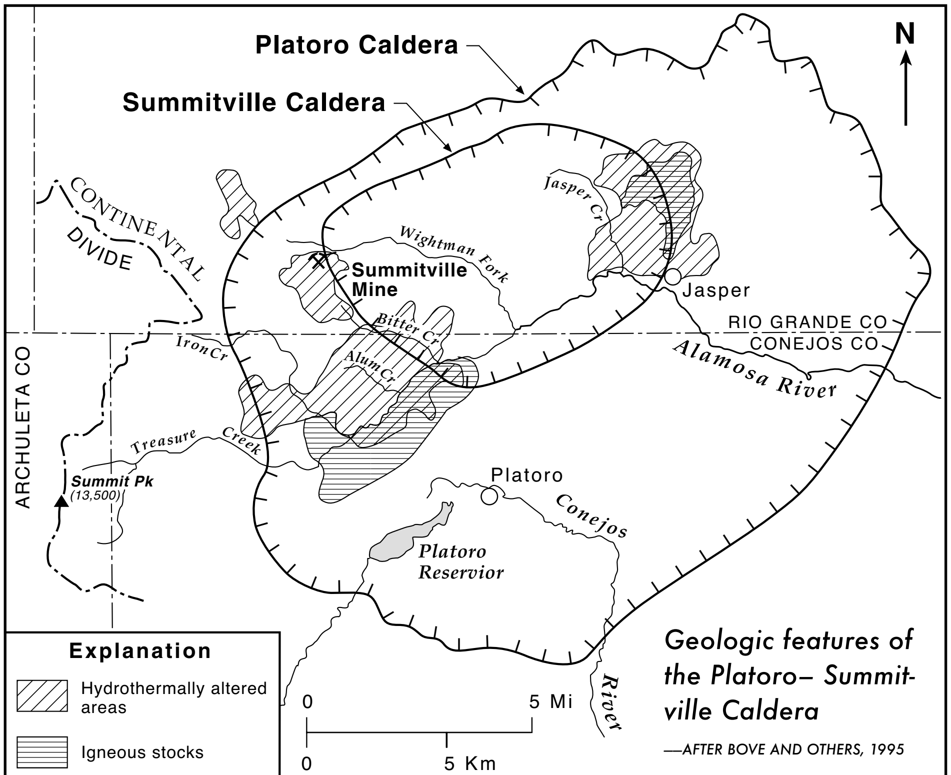
ACID ROCK DRAINAGE

Acid rock drainage occurs when water from rain or snowmelt, and oxygen from the air react with sulfide minerals such as pyrite to form sulfuric acid. The acidic water dissolves minerals from the bedrock, often adding significant amounts of trace metals to headwater streams. Natural acid rock drainage has been active in Colorado for thousands of years, even millions of years in places, including Summitville.

Summitville circa 1890?

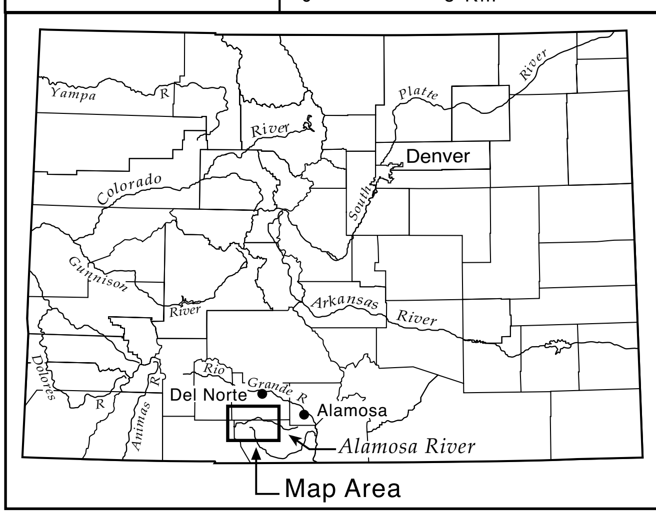
COURTESY COLORADO HISTORICAL SOCIETY

GEOLOGY OF THE UPPER ALAMOSA RIVER AREA



Geologic features of the Platoro– Summitville Caldera

—AFTER BOVE AND OTHERS, 1995



The upper Alamosa River lies in the southeastern part of the San Juan volcanic field that covers much of southwestern Colorado. The San Juan Volcanic Field began forming about 35 to 40 million years ago during the eruption of large volumes of lava from cone-shaped stratovolcanoes. Mount St. Helens in Washington State is a good example of a stratovolcano. These volcanoes consist of alternating layers of lava and ejected material such as ash. Many of the volcanic features and flows associated with this early phase of volcanism have been eroded or covered with later flows. About 30 million years ago, another period of volcanism began. These lava and ash flows were lighter in color because they contained more silica, and the volcanic activity became more explosive. After tremendous volumes of ash and lava were erupted, the roofs of the subsurface magma chambers collapsed, forming topographic depressions called calderas. The calderas are usually somewhat circular in shape and are 5 to 20 miles in diameter. At least 15 calderas are well documented in the San Juan Mountains. Many of these calderas formed within larger, slightly older calderas. These "nested" calderas are usually highly fractured because of multiple episodes of resurgence and collapse.

The nested Platoro and Summitville calderas are the dominant geologic features in the upper Alamosa River drainage basin. The Platoro Caldera began forming about 30 million years ago and is one of the oldest of the San Juan Volcanic Field. Pre-caldera stratovolcanoes were deeply eroded, and the terrain was relatively flat when eruption of large volumes of silicic ash flows (Treasure Mountain Tuff) began. Subsequent collapse of the magma chamber formed the Platoro Caldera. This caldera had at least one period of resurgence, when the magma chamber was partly refilled with lava and formed a dome within the caldera.

Between 29 and 30 million years ago, eruption of additional ash flows from within the Platoro Caldera formed the Summitville Caldera. The Summitville Caldera is nested in the northern part of the Platoro Caldera.

Multiple episodes of large-scale volcanic activity caused extensive faulting and fracturing, especially near the margins of the calderas. The broken rocks were zones of weakness that served as plumbing and as hosts for later igneous activity and mineralization. At least five post-caldera igneous episodes occurred between 29 and 20 million years ago. Extensive hydrothermal alteration (see inset text on page 3) and base- and precious-metal deposits are related to hot, mineralized fluids that were injected into the "plumbing system" in the latter stages of some of these post-caldera igneous events.

Stocks are formed when relatively small bodies (a few miles or less in diameter) of molten rock from deep within the earth move up, but cool and solidify before reaching the surface. The Alamosa River, Summitville, and Jasper stocks are responsible for mineralization and extensive hydrothermal alteration in the upper Alamosa River drainage basin. Intrusion of the Alamosa River stock altered the rocks in the drainage basins of Iron, Alum, and Bitter Creeks, tributaries of the upper Alamosa River upstream of Wightman Fork, and part of the Alamosa River basin itself. Mineral deposits in the Stunner mining district are probably related to the Alamosa River stock. Intrusion of the Jasper stock altered the bedrock in Jasper and Burnt Creeks, tributaries of the Alamosa downstream of Wightman Fork. Mineralization in the Jasper mining district is probably related to this stock. A buried stock beneath South Mountain caused the mineralization and alteration at Summitville. Massive opaline ledges and isolated siliceous sinter deposits overlying all of the altered igneous stocks in the upper Alamosa River basin probably represent hot springs and geysers similar to the system still active at Yellowstone Park. The intense alteration associated with these stocks was caused primarily by the release of large volumes of sulfur dioxide and other gases during the igneous activity.

Highly altered rocks exposed on the south side of Lookout Mountain in the Iron Creek drainage basin.—PHOTO BY JOHN NEUBERT

Alteration at South Mountain and the emplacement of the Summitville ore body occurred about 23 million years ago. Alteration occurred just before mineralization when an igneous stock was emplaced about 2,000 feet below the present-day surface. Ore at Summitville was found mostly in the South Mountain lava dome, along the northwestern margin of the Summitville and Platoro Calderas.

At Summitville, nearly vertical, northwest-trending mineralized veins and lenses in fracture zones cut intensely altered rocks of the lava dome. The mineralized zones have a core of vuggy silica. Ore minerals are richest in these central vuggy silica zones and are also present in lower concentrations in surrounding rocks. Deeper in the system the vuggy silica zones grade into thinner and better defined, steeply dipping quartz veins. Veins at Summitville are generally short, but one is at least 1,600 feet long. Mineralization extended over a vertical range of about 1,000 feet, and ore shoots were up to 30 feet wide. Ore also occurred in vertical pipe-shaped masses and at the intersection of fractures. Because many of the high grade veins were closely spaced and lower grade disseminated gold occurred close to these veins, open-pit production was selected for the most recent mining efforts.

Most ore mined at Summitville was from the oxidized zone (upper 300 feet), where gold was enriched through weathering processes. Below the oxidized zone, covellite (copper sulfide), enargite (copper-arsenic sulfosalt),

Hydrothermal Alteration

Hydrothermal alteration is a process whereby hot water circulating within the earth changes the composition of the rocks. This process commonly deposits disseminated metal-sulfide minerals such as pyrite (iron sulfide—fool's gold) in the affected rocks. When these rocks are exposed at the surface, they are often stained red, yellow, and orange because of the oxidation of the pyrite. This oxidation process is similar to rust forming on an old car.

The intensity of hydrothermal alteration can vary considerably, resulting in different mineral assemblages in the altered rocks. More intensely altered rocks often contain higher percentages of sulfide minerals.

chalcocite (copper sulfide), chalcopyrite (copper-iron sulfide), and gold were the primary ore minerals with lesser amounts of sphalerite (zinc sulfide) and galena (lead sulfide).

The Alamosa River stock is 26 to 29 million years old, slightly older than the stock at Summitville. This stock was intruded in several phases. A late phase called the Alum Creek porphyry in the northern part of the stock is the most intensely altered and contains high concentrations of lead, copper, molybdenum, and zinc. Overall, alteration related to the Alamosa River stock was less intense than at Summitville. Pyrite up to 2 percent extends to several hundred feet in depth; but near the surface some has been oxidized and dissolved by rain and snowmelt. This process created acid that leached the host rocks, altering them to a variety of clay minerals. Silica-rich rocks were more resistant to this alteration and are easily recognizable because the soft clay-rich rocks around them have eroded, leaving spires (see photo on page 3).

The Alamosa River stock and the associated Stunner mining district have far fewer of the richly mineralized zones of vuggy quartz that are present at Summitville. Quartz, pyrite, gold-silver tellurides, chalcopyrite (copper sulfide), and occasionally tetrahedrite and stibnite (antimony sulfide) occur in veins in the Stunner district. Generally the veins are 2 to 4 feet wide and a few hundred feet long. Interestingly, early in the 1900s the Gilmore Mine (see map page 5) followed a rich gold telluride vein for about 15 feet before it abruptly disappeared. Numerous holes excavated nearby failed to find the "lost" vein. In 1913 an examination by CGS geologist Horace Patton revealed that the vein disappeared because the mine was driven in a large block of relatively intact rock within a landslide. The rest of the vein was never found.

The Jasper stock is similar to the Alamosa River stock, but smaller. In the Jasper mining district, gold, sphalerite, galena, and pyrite occur in a few small, widely scattered northwest-trending quartz veins. The Jasper and Stunner mining districts were not economically important, especially when compared to the highly mineralized Summitville district.

Because of the presence of pyrite and other acid-generating minerals, all of the altered stocks in the upper Alamosa River basin produce poor-quality water. The waters are similar in that they are acidic and carry high concentrations of dissolved aluminum and iron. Trace metal concentrations in waters from the less mineralized stocks (Jasper and Alamosa River stocks) vary considerably, but are generally less than the water from Summitville. Water associated with the more mineralized Summitville deposit carries higher concentrations of trace metals such as copper, manganese, and zinc.

—JOHN NEUBERT

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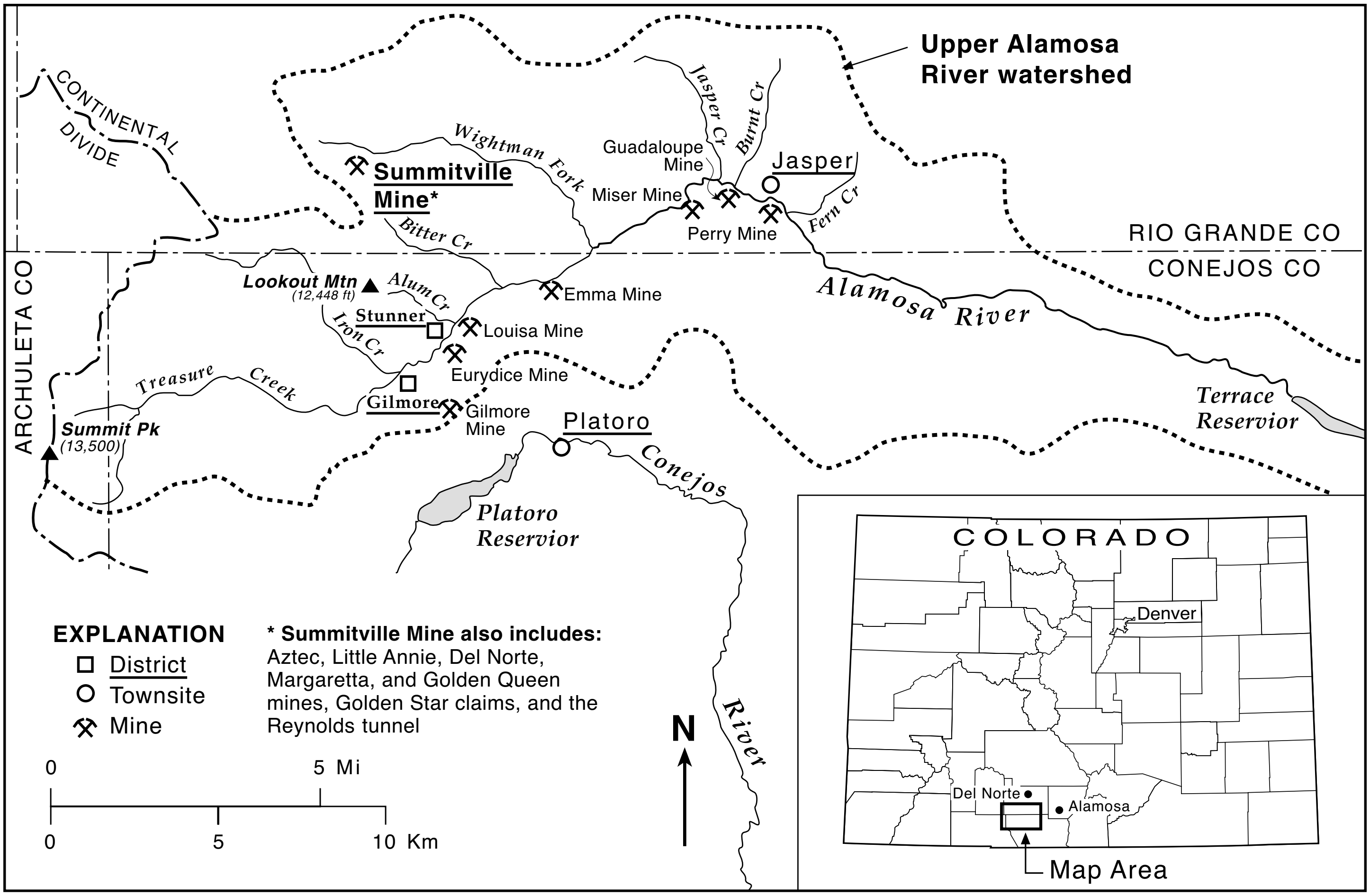
ALAMOSA RIVER MINING HISTORY

Most of the production from the Alamosa River basin was from mines in the Summitville mining district in southern Rio Grande County. All of the important producing mines in the district were located on South Mountain. Other mining districts include the Gilmore, Stunner, and Jasper in northern Conejos County. Patton (Colorado Geological Survey, 1917, Bulletin 13) published the first detailed geology and mining history of the area. Steven and Ratte (USGS, 1960, Professional Paper 343) conducted more recent geological work on the Summitville district and included additional historical information.

Summitville District

Wightman, Baker, French, Reese, and Borman first discovered placer gold in Wightman Gulch during the summer of 1870. In the spring of 1871 hundreds of people flooded into the area. Although several



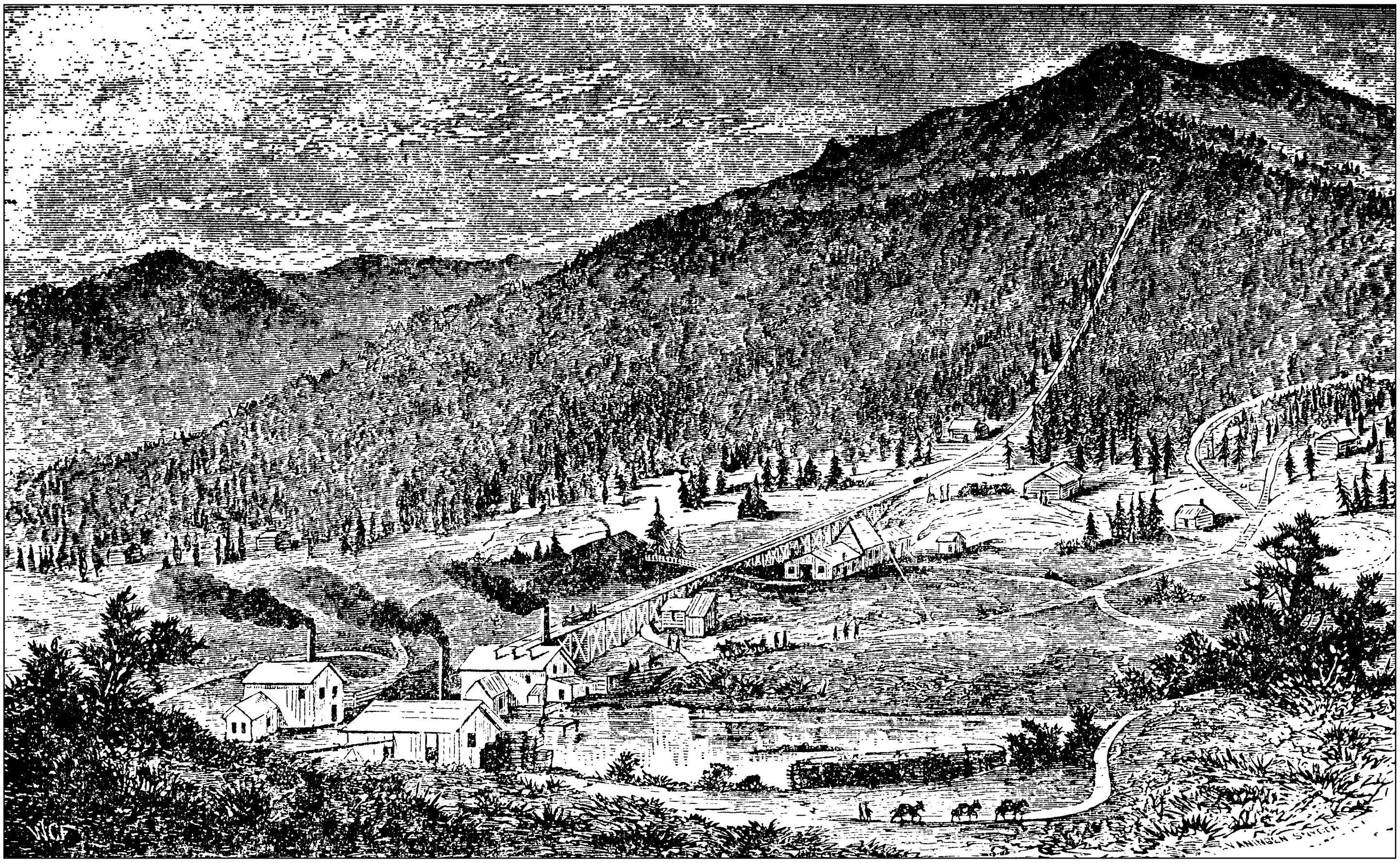
Mining districts and selected mines of the Alamosa River watershed —BASE FROM KIRKHAM AND OTHERS, 1995

lode claims were located, the prospectors were unsuccessful and all but three men left by the end of August. Wightman, Peterson, and Johnson departed in October and sold their placer gold recovered during the summer's work to the Denver Mint for $170. Placer deposits were worked intermittently until at least 1888. Specific production records are generally not available. Total production from placer mining was probably minor. Placer gold recovered in 1887 and 1888 totaled only $7,000 at the time of production.

Some of the richest lode deposits were located in 1872 and 1873. Goupil located the Esmond (later renamed Aztec), and sold the claim to Adams. Adams located the Summit and Brandt and Peterson located the Little Annie, Del Norte, and Margaretta. Numerous claims were staked in 1874. Following satisfactory test results of ore from the Summit Mine, Adams staked a mill-site claim and ordered milling equipment. Owners of some of the other mines (Little Annie, Del Norte, Margaretta, Golden Queen, and Golden Star) contracted with investors for constructing mills. The year 1875 marked the beginning of significant lode mining in the district. A five-stamp mill (a stamp was an early kind of crusher) was put into operation at the Summit Mine early in the year and by the end of September the Little Annie and Golden Queen Mills were in place.

Rich and easily processed oxidized ore was initially mined from near surface deposits. In 1883 the district became Colorado's third largest gold producer. Nine mills were operating a total of 155 stamps. Gold (95 percent) and silver production between 1873 and 1887 was worth over $2 million. During the 15-year period, 1881 was the year with highest recorded annual production ($290,000). Most of the production in 1881 was from the Little Annie Mine. During 1876 a 2,125-foot-long tramway was constructed between the Little Annie Mine and Mill. In 1884 eleven mills were in operation with a combination of over 165 stamps. Production started to decrease by 1888 as oxidized ore became depleted and underlying lower-grade sulfide ore was mined. Most of the miners had left the district by 1893.

Between 1894 and 1915 total production was valued at nearly $350,000. As the mines became deeper, gold values decreased and the base-metal content of the ore increased. Gold recovery decreased to 85 percent and silver increased



South Mountain and Little Annie mining camp, Summit district, Colorado. Tramway brought oxidized ores from the Little Annie Mine to the first stamp mill in the district. South Mountain comprises the southwestern part of a large volcanic dome.—FROM STEVEN AND RATTÉ, 1960

to 10 percent of the total production value. Copper and lead production were first recorded in 1896. Copper values amounted to 4 percent of the production. In 1897 the 2,500-foot-long Reynolds adit was completed. The adit was dug near the base of South Mountain as access for the underground workings and to drain the mines.

By 1915 Reynolds and the Consolidated Gold Mining Company owned all of the mines in the district. The two companies merged and formed Summitville Gold Mines Inc. Between 1916 and 1925 the company concentrated on mine development. Between 1926 and 1931 the Little Annie group shipped 864 tons high-grade gold ore worth $501,261.

Summitville Consolidated Mines Inc. acquired most of the mines in the district in 1934. A 100-ton flotation-cyanidization mill, a gold retort plant, and a high-tension power line were built. In 1935 the capacity of the mill was increased to 300-tons per day. Between 1942 and 1946 the Gold Links Mining Company operated the property. The mill was converted to a straight flotation mill (without cyanidization). In 1946 the Summitville Mining Company acquired the property. Production between 1934 and 1947 was worth over $4 million.

Between 1948 and 1949 the flotation mill was used to treat dump material and surface ore. In 1953 Newmont Mining Corporation conducted an extensive exploration program including sampling, drilling, and geophysical work. General Minerals Corporation leased the property and began exploration and rehabilitation work in 1956. Between 1956 and 1984, a few companies engaged in exploration or underground mining activities. Prior to 1984 the Summitville ore zone was mined mostly underground. An extensive network of underground workings was left behind. Galactic Resources Limited, parent company of Summitville Consolidated Mining Company Inc. (SCMCI), started an open pit heap leach operation in 1984. SCMCI was the last company to operate at the site. Between 1984 and 1992, 259,000 troy ounces of gold were produced, estimated to be $81 million in value. The property was worked until December 1992 when Galactic Resources declared bankruptcy and mining was discontinued. In 1994 the Reynolds adit was plugged.

Alamosa River Mining Timeline

Placer mining–COLORADO HISTORICAL SOCIETY

- 1870—Placer gold discovered (Summitville)
- 1872–1873—Richest lode claims located (Summitville)
- 1874—Town of Jasper founded. First mine in Jasper district driven.
- 1875 First mill in operation (Summitville)
- 1884—11 mills in operation (Summitville)
- 1888—Surface oxidized deposits depleted. Last placers worked. (Summitville)
- 1896—First copper/lead produced (Summitville)
- 1897—Reynolds adit completed (Summitville)
- 1906

SUMMITVILLE MINING DISTRICT

Significant Production (1875–1906)

Jasper–USGS PROF. PAPER 343

- 1912—Gold telluride discovered in Gilmore district
- 1913—Guadaloupe Mine last to produce in Jasper district
- 1916

Significant Mine Development (1916–1925)

- 1925

COLORADO HISTORICAL SOCIETY

Summitville

Significant Production (1925–1949)

- 1934—100-ton floatation-cyanidization mill built at Summitville
- 1949

INTRASEARCH

Summitville

Predominantly Exploration Activity with Minor Production (1949–1984)

- 1984—Open-pit/heap-leach operations begin at Summitville Mine

Significant Production (1984–1991)

- 1991
- 1992—Galactic Resources filed bankruptcy (Summitville)
- 1994—Reynolds adit plugged (Summitville)

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History, Geology, Hydrogeology, Summitville Mine and Downstream Effects, and Other Nearby Mines of the San Luis Valley, Colorado $15.00

continued on p. 12

Gilmore District

In 1912 Gilmore discovered gold telluride ore on the west slope of Klondyke mountain two miles southwest of Stunner. The ore assayed several hundred dollars per ton. After a depth of fifteen feet the rich ore zone was lost in broken rock. Efforts to find additional ore were unsuccessful. It was eventually determined that the ore occurred in a large block of landslide material.

Stunner District

Stunner and Jasper were established as local centers for the flood of prospectors that arrived in the area following the discoveries at Summitville. Numerous prospects, shafts and tunnels were worked within three miles of Stunner. Only a few of the properties were known to ship any ore. Thirty-two tons of ore worth $5,000 were shipped from the Eurydice mine around 1890. Located down stream from Stunner, the Eurydice and Louisa shafts were sunk on the same quartz vein. Pyrite, chalcopyrite, and gold and silver telluride and sulfide minerals were recovered from the up to 4-foot-wide vein. A small quantity of ore was shipped around 1881 from the Emma tunnel (Watrous claim group) three miles downstream from Stunner. Tetrahedrite (copper-antimony sulfosalt) and telluride ore was mined but didn't even cover the cost of production.

Jasper District

Located near the base of the northern slope of Cornwall Mountain, the town of Jasper was founded around 1874. The Perry Mine was excavated around 1874, the first mine in the district. Assay results commonly ran up to 1,200 ounces per ton in silver and 2.2 ounces per ton in gold. Eventually the Cornwall Mining Company was formed and controlled the Perry and Guadaloupe mines. Patented in 1882 the Guadaloupe Mine was the only operating mine in the district during 1913. Vugs with sphalerite, galena, and pyrite were exposed in a quartz vein up to 6-feet-wide. The Miser Mine was the only other mine of any significance in the district. Most of the development was done in the 1880s, when the mine was opened. Assay values from specimens were as much as $52,000 per ton in gold. —Bob Wood

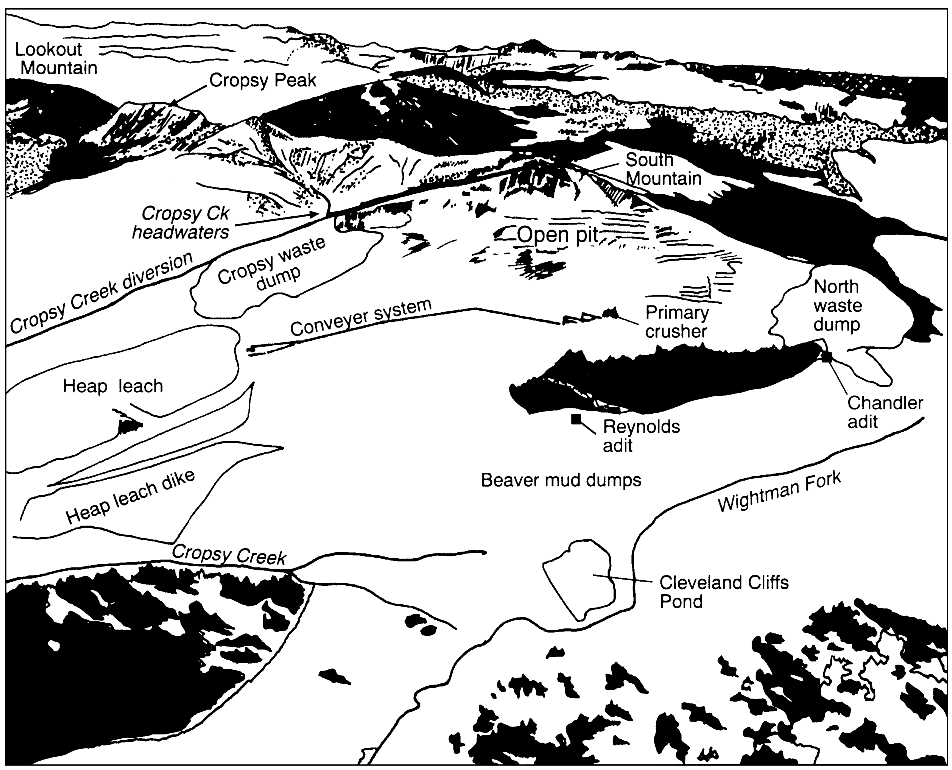
HISTORY OF SUMMITVILLE MINE RECLAMATION

Gold and silver mining began in the Summitville area in the 1870s from underground workings. Many mining districts in the western United States were reactivated in the early 1980s as a result of technological advances that allowed extraction of low-grade ores with cyanide heap leach techniques. The most recent operator was Summitville Consolidated Mining Company, Inc. (SCMCI). Their active mining operation spanned the period from July 1986 through October 1991, and they abandoned the site in December 1992. The Summitville Mine was a 1,400-acre site located approximately 18 miles southwest of Del Norte, Colorado in Rio Grande County (see map on page 5). The active mine disturbed 550 acres within the Rio Grande National Forest at an elevation of 11,500 feet in the San Juan Mountains. Summitville Consolidated Mining Company, Inc. operated an open pit heap leach process that used cyanide to extract the gold.

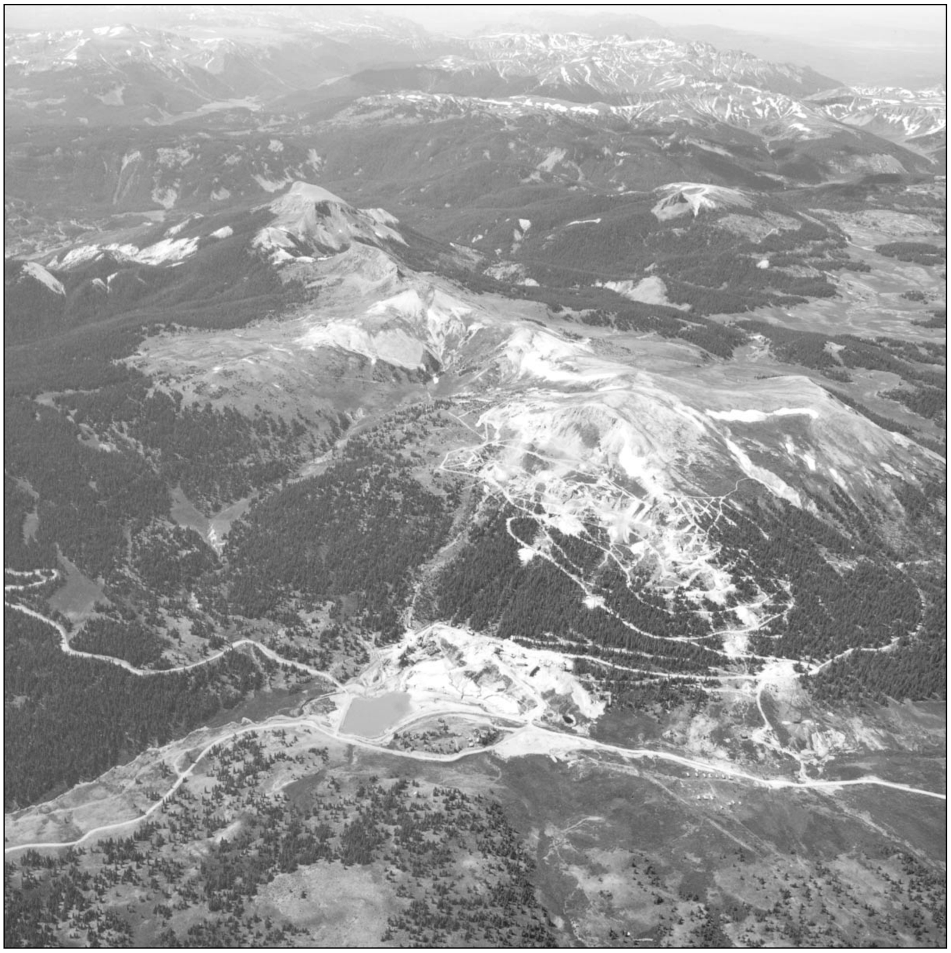
The deserted townsite of Summitville, last occupied in the mid-1930s, and the Wightman Fork of the Alamosa River form the northern boundary of the site. Cropsy Creek, a tributary to Wightman Fork, bounds the site on the east. Wightman Fork joins the Alamosa River approximately 4.5 miles below its confluence with Cropsy Creek. The Alamosa River and its tributaries flow from the site through forest and agricultural land of the San Luis Valley in Rio Grande and Conejos Counties. The Alamosa River is the source for Terrace Reservoir located approximately 18 miles downstream from the site. Terrace Reservoir is used for irrigation. A 1991 photograph of the Summitville region and accompanying line drawing, displayed at right, depict the mine layout in relation to surface waters.

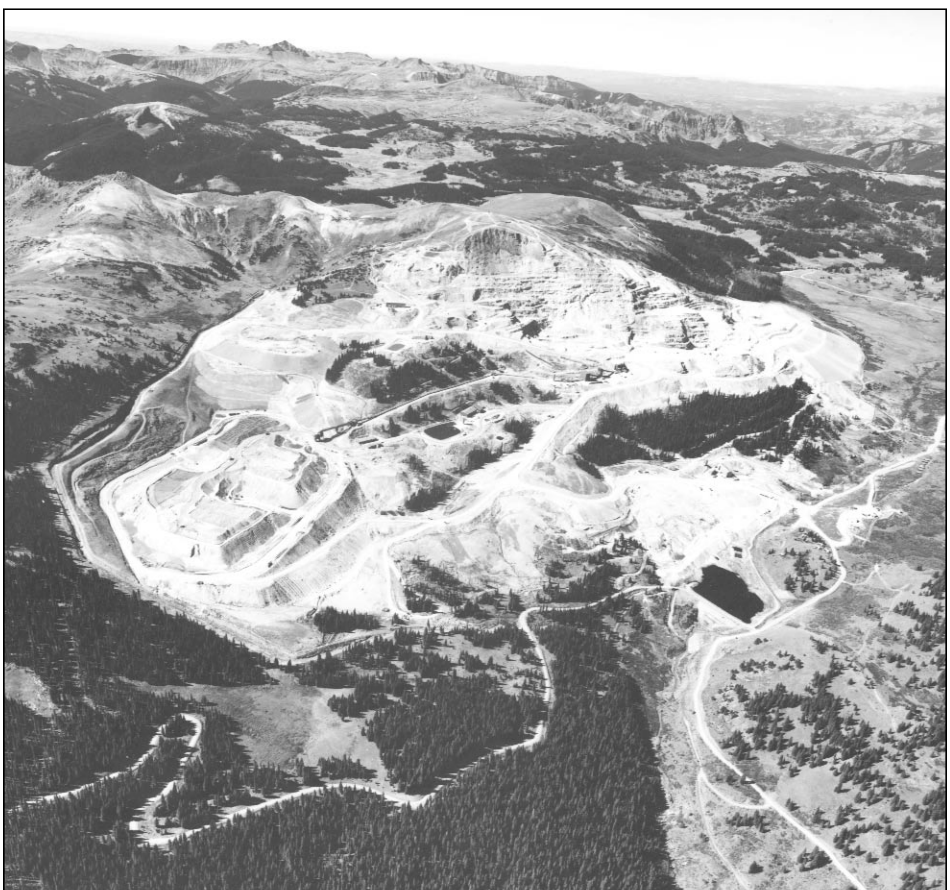
During their operation, SCMCI mined, crushed, heaped, and leached ten million tons of ore. Problems developed soon after their initiation of open-pit mining. The company underestimated the water inputs (mostly snowfall) and overestimated the evaporative losses at the site. In conjunction with numerous other sources on site, including the Reynolds adit and the Cropsy waste dump, acidic metal-rich water drained into the Wightman Fork of the Alamosa River. Cyanide-laden process solutions were also discharged into this tributary from leaks in the transfer pipes and the underdrain system beneath the heap leach pad, where they mixed with acidic groundwater from the Cropsy waste dump.

On December 1, 1992, Galactic Resources Limited, the parent company of SCMCI, notified the State of Colorado of their intent to declare bankruptcy and abandon operation of the Summitville mine. Abandonment of the mining operations could have had profound ramifications to the environment. Cyanide and metal-bearing process fluids in the heap leach pad were in jeopardy of overflowing the spillway under normal winter precipitation. In addition, a power shutdown would have caused acidic, cyanide-laden water from the heap leach underdrain effluent to overflow the underdrain sump. Given that scenario, the effluent would have discharged directly into Cropsy Creek.



Aerial photo and line drawing of Summitville region, 1991—PHOTO BY INTRASEARCH, DRAWING BY RICHARD WALKER





The State requested emergency response assistance from the U.S. Environmental Protection Agency (EPA) to assess the situation and to institute mitigation measures to avert a direct contaminant release from the site. Steps were taken to assure that necessary water circulation and water treatment systems remained operable. A technical team composed of EPA, Colorado Division of Minerals and Geology, and Colorado Department of Public Health and Environment (CDPHE) personnel began assessing longer-term consequences of the mining operation. In the eighteen-month period prior to filing for bankruptcy, SCMCI had been under constant state agency enforcement mandates to evaluate contaminant releases from the site. Through the involvement of both state and federal regulatory agencies and Summitville's contractors, considerable environmental monitoring data had been collected with which to evaluate the Summitville mine and its environmental impacts. Following Galactic Resources Limited abandonment of the site, federal and state agencies initiated numerous environmental site characterization and monitoring projects. These projects involved state and federal employees, contractors, university staff, private sector technical consultants, water conservancy district officials, local government officials and concerned citizens. Potential contaminant generation and exposure risks were

Summitville landscape over the last twenty years:

Top: *1980, before SCMCI mining operation*
Bottom: *1991, during SCMCI mining operation*
Bottom next page: *1999, after partial site reclamation*

THREE PHOTOS ON P. 10 AND 11 COURTESY INTRASEARCH evaluated both within the mine area and off-site. The Summitville mine site was placed on the National Priorities List of Superfund sites in May 1994.

Since the 1992 emergency response action, remedial activities have concentrated on minimizing the release of contaminants and reducing acid mine drainage emanating from the site. Almost all of the freshly exposed quartz latite bedrock from mining operations at the site is capable of acid generation. These interim remedial measures have included detoxifying, capping and revegetating the heap leach pad, removing waste rock piles and filling the mine pits, plugging the adits or underground mine entrances, and enlarging the water-runoff holding ponds. The on-site wastewater treatment plant remains operative to treat mine effluent. CDPHE is the lead agency implementing the largest interim measure: Site-Wide Reclamation and Revegetation project. The reclamation project will span four years and began in May 1999. The total cost of the cleanup was estimated at the time to be from $100 million to $120 million, but $150 million has already been spent.

The accompanying photographs depict the Summitville region before SCMCI mining operations, during SCMCI's mining operations, and in 1999 after partial implementation of reclamation activities (three photos from the June 2000 Summitville Update). To achieve the reclamation objective of minimizing non-point sources of acid mine drainage from the site, a stable, revegetated surface will be established over the site's disturbed areas. The surface cover material will include a combination of vegetation and rock that is not prone to acid generation. The cover is designed to minimize erosion and control water runoff. The major components of the reclamation design are:

- ✦ Grading and road relocation to reduce steep slopes (runoff) and eliminate water ponding;
- ✦ Construction of permanent ditches and road culverts to

Upcoming Events Involving CGS

May 8
Historic Coal Mines of Jefferson County, Friends of Dinosaur Ridge Fireside Chat Lecture at Lutheran Church of the Master, 14099 W. Jewell, Lakewood, 7 pm, Chris Carroll, (303) 866-3501

May 17–19
2001 Northwest Colorado Coal Conference, Rangely and Craig, Colorado, CGS display, AGNC (970) 625-1723 or call Chris Carroll, (303) 866-3501

June 3–6
Annual AAPG Convention, Denver Convention Center, CGS booth and field trip leader ("A Geological Reconnaissance of Dinosaur Ridge and Vicinity", Sun. June 3, 8–4 pm), 1-888-945-2274, ext. 617 or www.AAPG.org

June 21
An Introduction to Meteorites, lecture at Colorado Springs Mineralogical Society, at Senior Center, 1514 N. Hancock, Colorado Springs, 7:30 pm, Matt Morgan, (303) 866-3529

August 6–8
2001 Rocky Mountain Natural Gas Strategy Conference, Denver Convention Center, CGS booth, Mary Johnson, (303) 861-2387

Publications continued from page 8

Information Series 48
Colorado Water Quality Database from the Environmental Protection Agency's STORET Database $20.00

Open-File Report 99-18
History, Geology, and Environmental Setting of Selected Mines near Creede, Rio Grande National Forest, Mineral County, Colorado $5.00

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Room 715, Denver, CO 80203
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Phone: (303) 866-2611
Fax: (303) 866-2461
E-mail: cgspubs@state.co.us
Website:
www.dnr.state.co.us/geosurvey

THIS ISSUE
Editors: Matt Sares, Vicki Cowart
Production: Cheryl Brchan,
Larry Scott

prevent erosion and accommodate maximum flows from 100-year storm events;

- Partial backfilling of mine benches and highwalls to eliminate water ponding and reduce steep slopes; and
- Neutralizing acid generating soils, and revegetating approximately 300 acres of disturbed surface.

As of June 2000, reseeding was completed on 190 acres of the 500 acres of the mine disturbed land. Test plot studies and mixture evaluations indicated that 130 tons of limestone per acre and 40 tons of compost per acre were needed to neutralize the acid generating potential of the exposed ground surface. This mixture constitutes the upper 12 inches of the final graded slope, and is topped with 6 inches of topsoil.

With the efforts and cooperation of local citizens and Conejos County high school students, 420 trees and shrubs were planted in July 2000 during Summitville tree planting day. CDPHE and the EPA purchased the trees and shrubs to be planted in the newly reclaimed Cropsy basin portion of the site. If the project is successful, a tree planting day will probably be planned every year.

Three innovative passive water treatment technologies for the acid mine drainage generated at Summitville were tested last summer. In comparison with conventional water treatment systems, these systems are more cost effective and need less maintenance. The three technologies include the sequential alkalinity producing system (SAPS), the lime settling pond system, and a zeolite system. The SAPS system consists of a series of reactors that filter, settle sludge, and chemically treat the acid mine drainage. The lime settling pond system meters lime into the water and allows sludge settlement. The zeolite system utilizes a naturally occurring clay mineral to adsorb metals.

A Remedial Investigation and Feasibility Study (RI/FS), led by CDPHE, began in May 1999. The ability of proposed remedial actions to curtail the contaminant release and provide a remedy for the impacts of that release are among the primary feasibility evaluations. An interim goal is to restore the Terrace Reservoir to fishery status and meet State instream standards in the Alamosa River. A fishery survivability test conducted by the EPA during the fall of 2000 using 150 rainbow trout concluded that the trout could survive year-round in Terrace Reservoir. The Feasibility Study will be published by the EPA in May 2001. The draft Remedial Investigation Report was issued in February 2000. The general findings of the draft Remedial Investigation are:

1. Ground water contamination exists around the Heap Leach Pad, North Pit, South Pit, and North Waste Dump;
2. The water quality associated with the ground water seeps is acidic and has a high metals content;
3. The water treatment plant and surface water storage impoundment are insufficient to treat all of the contaminated water from the site, releases cause significant impacts to the water quality of the Alamosa River;
4. Surface water quality has improved in the Wightman Fork and Alamosa River; metals concentrations in or flowing into Terrace Reservoir have been reduced by 60–90 percent since 1994; and
5. There are measureable effects, but no adverse impacts to agricultural soils, crops, and livestock. There are no impacts to human health.

Community concerns expressed during public review meetings in conjunction with the findings of the draft Remedial Investigation Report prompted increasing the amount of data collection and investigation planned for the 2000 field season. As a result, the Remedial Investigation Report will be reissued in February 2001 followed by another public review/comment period. Thirty days after the Remedial Investigation Report is distributed, the Feasibility Study and Proposed Plan will be released for public review/comment. The RI/FS will culminate with a Record of Decision, to be released in the fall of 2001, that will establish the final remedy or set of remedies for the site.

—Ralf Topper

Selected References

Proceedings: Summitville Forum '95, Colorado Geological Survey Special Publication 38

http://www.cdphe.state.co.us/hm//summitville.asp

http://www.cdphe.state.co.us/hm/summitvilleupdatejune2000.pdf

http://www.cdphe.state.co.us/hm/reclamat.pdf

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http://www.southfork.org/activities/half/summitville.html

RATING THE ALAMOSA RIVER

Use Classifications, Water Quality Standards, and Recent Changes

Rating the water quality of the Alamosa River, or any stream, is not an easy task. Physical, chemical, and biological characteristics of the stream must be considered. The stream's geological context may be important. Uses of the water must also be taken into account. Finally, all these data must be used by regulators to set water quality standards.

How does Colorado set water quality standards on streams?

The Colorado Water Quality Control Act was enacted in response to the 1972 Federal Water Pollution Control Act, later amended and renamed the Clean Water Act in 1977. Subsequently, regulations were written to implement the Colorado Water Quality Control Act. To set water quality standards for surface water, the State of Colorado has divided all of the state's streams (including lakes) into segments. Each stream segment is given a "use classification" based on its known or presumed ability to support current or potential uses of water in that segment. The defined classes of water use are 1) recreation, 2) agriculture, 3) aquatic life, 4) domestic water supply, and 5) wetlands.

Recreation and aquatic life classifications are further subdivided (see table below).

A stream segment may have several designated uses depending on its current or potential water quality. The Colorado Water Quality Control Commission (WQCC) sets the classifications on each stream segment based on information presented to them. Water-quality standards are then set to maintain the uses of the stream segment. Therefore, the "use classification" of a stream segment is very important in the setting of water-quality standards.

Colorado surface-water use-classifications

Classification	Description	Water Quality Standards
Aquatic Life Class 1—Cold Water	Capable of sustaining a wide variety of biota including sensitive species (trout)	More stringent
Aquatic Life Class 1—Warm Water	As above for warm waters	
Water Supply	Suitable for potable water supplies. Standards for a few constituents are more stringent than Aquatic Life Class 1	
Aquatic Life Class 2	Cold or warm waters not capable of sustaining a wide variety of biota	
Agriculture	Suitable for irrigation of crops or animal consumption	
Recreation 1	Primary contact (swimming, rafting, kayaking, etc.)	
Recreation 2	Secondary contact (other waterside activities)	Less stringent
Wetlands	Standards may be site-specific or related to stream	Variable

What information has been used to set standards for the Alamosa River?

In the early 1970s, initial classifications of streams were sometimes determined with limited data. The only information available may have been the physical suitability of the stream for aquatic life (for example, is the stream too steep, narrow, or shallow for fish to live?) Chemical, biological, and geological data relating to water quality were often sparse, especially in remote areas. Therefore, use classifications were made in the absence of this data. This was mostly the case for the Alamosa River before the Summitville Mine bankruptcy. Some biological data and water-quality data were developed over the years, but no comprehensive studies of water quality in the Alamosa River were done prior to the 1990s.

In the 1990s, before and after the Summitville Mine bankruptcy (see History of Summitville Remediation article), numerous studies by private, federal, state, and local entities were conducted to characterize geology, biology, and water quality in the Alamosa River drainage basin and discern environmental damage from the mine site. Many of these studies are summarized in *Proceedings: Summitville Forum '95* (CGS Special Publication 38).

Many of the studies focused on the Summitville Mine site and the extent of metals contamination downstream in the Wightman Fork, Alamosa River, and Terrace Reservoir. Others addressed water quality concerns of agricultural interests in the San Luis Valley. Some studies investigated geology and water quality in the upper Alamosa River basin, upstream of the influence of Summitville Mine contamination. CGS was involved in this latter effort.

CGS investigated, in detail, the water quality of Iron, Alum, Bitter, and Burnt Creeks, which are tributaries to the upper Alamosa River. The study documented the streams' extremely acidic and metal-rich water. Sources of poor-quality water were documented, whether from mines, prospects, or natural springs. Natural springs were very acidic, having pH values between 2.5 and 4.0 (pH of most natural waters range between 6.0 to 9.0, smaller numbers indicate higher acidity). These springs are prime examples of natural acid rock drainage from hydrothermally altered rock associated with the Alamosa River stock (see Geology of the Upper Alamosa River Area article). Dissolved metal loads from mining and natural sources within the upper Alamosa River basin were compared. Natural sources accounted for 82 percent of aluminum, 89 percent of iron, and 99 percent of copper, manganese, and zinc loads in the upper basin.

With the immense amount of new data available through these studies, a "Use Attainability Analysis" (UAA) was conducted by the Division of Minerals and Geology and Division of Wildlife state agencies in 1997 and 1998. A UAA is an assessment of the factors affecting the stream's ability to fulfill its designated uses, which may include physical, chemical, biological, and economic factors.

Has knowledge gained through Alamosa River water-quality studies in the 1990s impacted water-quality standards on the stream?

The main issue addressed by the UAA was whether high metal concentrations in the Alamosa River and its tributaries were naturally occurring or a result of historic mining, including the Summitville Mine. If historic mining was primarily responsible, then in-stream metals concentrations could possibly be reduced with remedial actions, and more stringent water-quality standards (and uses) could be applied. If in-stream metals were naturally occurring, then the water quality situation was natural and essentially not correctable. After presentation of the UAA, and hearing testimony both for and against its conclusions, the Water Quality Control Commission revised use classifications on the Alamosa River.

Colorado Geological Survey Staff

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James A. Cappa, **Mineral Resources**

Vince Matthews, **Senior Science Advisor**

David C. Noe, **Engineering Geology**

Randal C. Phillips, **GIS and Technical Services**

Patricia Platter, **Administration and Outreach**

Matt Sares, **Environmental Geology**

Knox Williams, **Colorado Avalanche Information Center**

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Betty Fox, Melissa Ingrisano, Dori Vigil

Avalanche Information Center
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Chris Carroll, Laura Wray

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Department of Natural Resources
State of Colorado

The map below summarizes the classification changes from upstream to downstream by stream segments. Several constituent-specific changes are not included. The Alamosa is not used for potable water supply, so the Water Supply classification is not an issue here.

Data from several studies, including the CGS study were instrumental in the two classification changes highlighted in the table and summarized below:

✦ Segment 4b of Iron Creek contains high quality water. This was corroborated by fisheries studies. Inflow of poor-quality water, naturally flowing from the hydrothermally altered area of the Alamosa River Stock, significantly degrades Iron Creek as a whole downstream of segment 4b. Therefore, the WQCC decided to ***upgrade*** segment 4b to Aquatic Life 1 from the previous use classification of Agricultural and Recreation 2.

✦ The identification, calculation, and comparison of mining-related contamination versus natural contamination in the upper Alamosa basin (above Wightman Fork), was important data used in the WQCC decision to ***downgrade*** stream segment 3a.

Other changes in use classifications for the Alamosa River may be justified. The UAA supported downgrading stream segment 3b to Aquatic Life 2, but this was not formally requested during hearings. Additional stream data gathered during the Summitville Mine reclamation will be used to determine whether this change is formally requested. —Matt Sares

Selected References

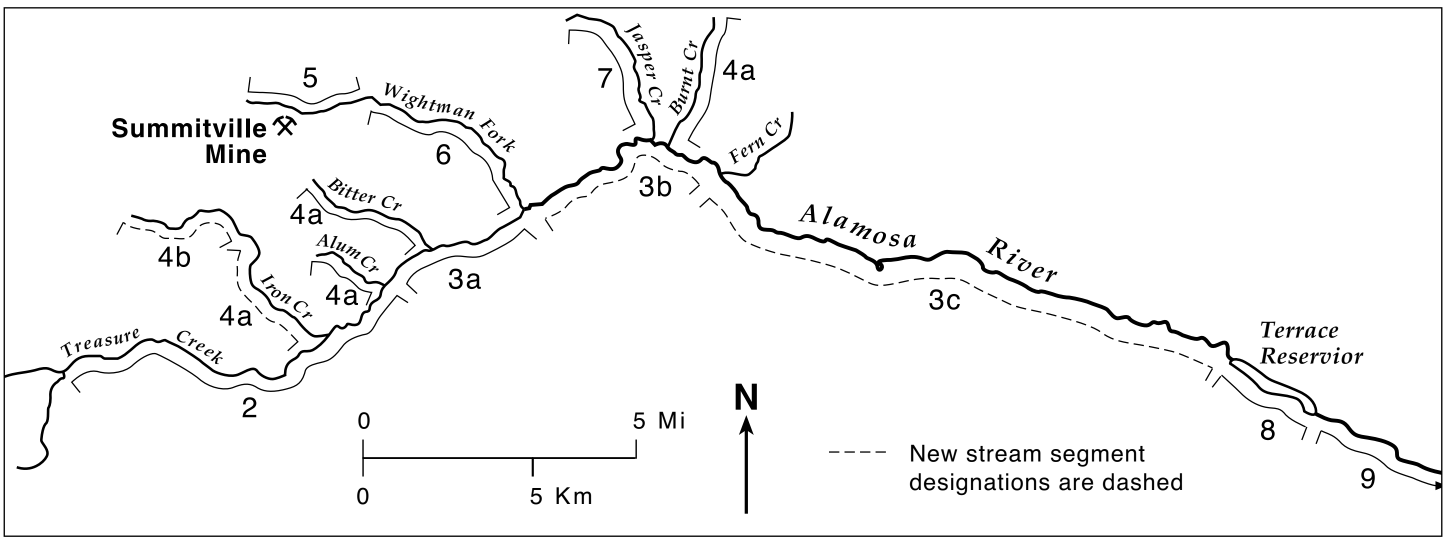
Kirkham, R.M., Lovekin, J.R., and Sares, M.A., in Posey, H.H., Pendleton, J.A., and Van Zyl, D. (editors); 1995, Proceedings: Summitville Forum '95; Colorado Geological Survey Special Publication 38, Denver, Colorado

Posey, H.H. and Woodling, J.D., 1998, Use Attainability Analysis for the Alamosa River Watershed Through 1997 (unpublished report)

http://www.cdphe.state.co.us/cdphereg.asp#—Colorado water quality standards and regulations

http://www.usbr.gov/laws/cleanwat.html—Clean Water Act information

Alamosa River basin stream segments and classification changes



Stream Segment	New Classification	Old Classification
4b) Iron Creek above tributary "G"	***Aq Life 1***, Rec 2/Ag	Rec 2/Ag
4a) Mainstem of Alum, Bitter, Burnt Creeks, and Iron Creek from tributary "G" to Alamosa River	No change	Rec 2/Ag
3a) Alamosa River from Alum Creek to Wightman Fork	***Aq Life 2***, Rec 2/Ag	Aq Life 1, Rec 2/Ag
3b) Alamosa River from Wightman Fork to Fern Creek	No change	Aq Life 1, Rec 2/Ag
3c) Alamosa R from Fern Creek to Terrace Reservoir	No change except copper and aluminum standards made more stringent	Aq Life 1, Rec 2/Ag
8) Terrace Reservoir	No change except copper and aluminum standards made more stringent	Aq Life 2, Rec 2/Ag

CGS GIVES AWARDS AT THE SAN LUIS REGIONAL SCIENCE FAIR

Bob Kirkham, CGS geologist, served as a judge for the 2001 San Luis Valley Regional Science Fair, held on March 1 and 2 at Adams State College in Alamosa. Bob, along with several other judges from San Luis Valley, tackled the challenging but rewarding assignment of evaluating the many science fair projects and interviewing the students for special awards. This is Bob's eighth year as a judge at the San Luis Valley Regional Science Fair.

Included in the special awards category were CGS's Elementary Earth Science Award, Junior Earth Science Award, and Senior Earth Science Award.

Our congratulations to the winners of the CGS awards:

***BETH GARCIA**, Sargent Elementary School, project title: "This Rocks!";*

***MICHAELA KAISER**, Sargent Middle School, project title: "Shaw's Magnetic Springs, What's the Attraction?";*

***LARRY VIALPANDO**, Sierra Grande High School, project title: "Erosion, Mass of Moving Earth"*

CGS THANKS ARCO FOR DONATED ITEMS!

The Colorado Geological Survey (CGS) gratefully acknowledges the donations of equipment and supplies from the Plano, Texas office of Atlantic Richfield Company (ARCO). Following the merger of BP-Amoco with ARCO, a supportive BP executive, David Work, arranged for CGS to be considered for these donations. Thanks to a dedicated and generous staff working to close the Plano office, CGS was given a large format intergraph scanner, two Leitz petrographic microscopes, a Zeiss binocular microscope, a Canon 35-mm camera with several lenses, an Olympus digital camera, and a Tektonix Phaser 350 printer. CGS has put the equipment to good use already and appreciates these valuable gifts.

NEW REPORT ON NATURALLY DEGRADED WATER

A new CGS report identifies and discusses a number of streams in 11 different headwater areas of Colorado where surface water has high concentrations of metals or acidity, or both, upstream of any significant human impacts. The report, *Naturally Degraded Surface Waters Associated with Hydrothermally Altered Terrane in Colorado* (Open-File Report 00-16), by John Neubert, is a reconnaissance-level investigation of specific areas in Colorado that have naturally poor surface-water quality due to the area's geology. Rocks in these areas have been affected by intense hydrothermal alteration (see p. 3) in the geologic past. Rain and snowmelt flowing through and over the altered rocks creates acid-rock drainage (see p. 1), adding dissolved metals and acidity to receiving streams.

For this study, 95 water samples were collected. The 153 page report available on CD-ROM, contains color figures, lab analyses, descriptions of the sample locations, general geology of the area, and previous investigations in the study areas.

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