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Preliminary report on the geology of hydrothermally altered areas within the upper Alamosa River Basin, Colorado

by

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ABSTRACT

The geology of mineralized and altered areas in the vicinity of the Summitville Mine is currently being studied to understand contributions of individual drainages to the downstream contamination in the Alamosa River. These areas, which include the Iron-Alum-Bitter Creek basins (IABC) and the Jasper area, are essentially undisturbed by mining or exploration activity and will offer unique opportunities to characterize background sites adjacent to the Summitville mining area.

Rocks within the upper Alamosa River basin study area are mostly within the Platoro caldera complex. The Platoro caldera, a large volcanic collapse structure, formed about 30 to 29 Ma in response to the eruption of the voluminous Treasure Mountain tuff. Renewed ash-flow eruption led to the further collapse of a series of calderas nested within the older Platoro caldera. The Platoro caldera complex served as the structural locus of numerous intrusions ranging from monzonite to quartz monzonite in composition. Generally, these intrusions are spatially associated with intense hydrothermal alteration and varied mineralization.

Two main episodes of hydrothermal alteration have been recognized within the upper Alamosa River basin. An early period of alteration denoted as Conejos age has affected rocks within the IABC basins and Jasper area. A later period of alteration (Fisher age) is present in the Summitville mining area and postdates Conejos alteration by as much as 8 Ma. The zone of hydrothermal alteration around the IABC basins is about 11 km^2 and is roughly equivalent in size to that in the Jasper area. In contrast, the zone of younger hydrothermal alteration around the Summitville mine is about 3 km^2.

The Summitville Mine, IABC basins, and Jasper area are all located along an arcuate fault zone that has localized repeated intrusion, hydrothermal alteration, and mineralization. The intrusions related to hydrothermal alteration and mineralization within the IABC basins and Jasper area have been well exposed by erosion. In contrast, the intrusive body associated with the Summitville orebody is present nearly 600 m beneath the surface, buried beneath the quartz latitic lavas of the South Mountain dome.

One of the strong similarities between the Summitville mining district and the IABC basins is the presence of classic acid-sulfate alteration assemblages. Alteration in the Summitville Mine area is characterized by subvertical tabular zones consisting of vuggy silica cores surrounded by successive zones of quartz-alunite and clay alteration. Similarly, small localized zones of quartz-alunite altered rock are present in the Lookout Mountain and Alum Creek areas in the western part of the IABC basins. However, unlike Summitville, these small zones are not mineralized and lack a central vuggy silica zone.

The Summitville and Lookout Mountain-Alum Creek areas also show a similar vertical sequence of hydrothermal alteration assemblages. Hydrothermal alteration in both areas grades downward from magmatically derived acid-sulfate assemblage into underlying zones of quartz-sericite-pyrite alteration with quartz-pyrite stockwork veinlets. Sparse molybdenite is present in the deep assemblage in the Alum Creek area, and copper and molybdenum anomalies have been reported in the deeper levels of the Summitville deposit. Both systems are genetically related to hypabyssal quartz monzonite intrusions that have generated an upper level acid-sulfate system, which grades into a weak porphyry copper-molybdenum system at depth.

Although hydrothermal assemblages in the Summitville and IABC areas show some clear similarities, the hydrothermal fluids related to mineralization in the IABC basins appear to have been devoid of gold and silver, which along with copper characterize mineralization within the Summitville area.

INTRODUCTION

Detailed geologic and geochemical studies of the upper Alamosa River basin/Summitville Mine area are critical to understanding the contributions of individual drainages to downstream contamination in the Alamosa River and will offer exceptional opportunities to characterize "background" sites that are essentially undisturbed by mining or exploration activity. Such specific sites of intense alteration and mineralization within the Alamosa River basin include the Iron, Bitter, and Alum Creek basins and the Jasper area. The purpose of this preliminary report is to summarize the geology, mineralization, and alteration within these areas. This report is mostly based on previously published data, but draws upon preliminary data from roughly two weeks of field work during the fall of 1993. This paper provides the geologic framework for related stream geochemical studies in the upper Alamosa River basin.

VOLCANIC HISTORY

The upper Alamosa River basin study area is in the southeastern part of the 42,000 km^2 San Juan Volcanic Field in southwestern Colorado and adjacent parts of New Mexico (fig. 1). Volcanic activity in the San Juan field commenced about 38 million years ago (Ma) during which time large volumes of intermediate composition lavas were erupted from local stratovolcanoes. In the eastern San Juan Mountains these lavas and associated volcaniclastic rocks constitute the Conejos Formation (Cross and Larsen, 1935). At about 29 Ma, the style of volcanism shifted to explosive ash-flow eruptions associated with about 16 large calderas in the San Juan Mountains. The Platoro caldera complex (fig. 2), which erupted about 29 Ma, represents the major source of ash-flow tuffs present in the upper Alamosa River basin study area. A later period of bimodal basalt-rhyolite volcanism, which began about 26 Ma, differs petrologically from earlier volcanic rocks, and is related to crustal extension and opening of the Rio Grande Rift (Christiansen and Lipman, 1972; Lipman and others, 1978).

The Conejos Formation, named by Cross and Larsen (1935) for the great cliff exposures in the Conejos River canyon, includes all the intermediate-composition lavas and related volcaniclastic rocks in the southeastern San Juan Mountains. Rocks of the Conejos Formation were erupted from at least eight stratovolcanoes in the southeastern San Juan Volcanic Field. Volcaniclastic sedimentary rocks form aprons derived from the erosion of these volcanic centers. The Conejos Formation has been generally divided by Lipman (1975) into a vent facies, consisting mainly of lavas and breccias, and a volcaniclastic facies, made up of conglomerates, mudflow breccias, and other sedimentary deposits relating to erosion of the stratovolcanoes. Later studies by Colucci and others (1991) separated three volcanic members of the Conejos Formation into the Horseshoe Mountain, Rock Creek, and Willow Creek members.

Pyroclastic eruptions from the Platoro caldera complex in the southeastern San Juan field began about 29 Ma. The Platoro caldera complex is a nested collapse structure about 20 km in diameter, which is centered within a cluster of older stratovolcanoes (Conejos Formation). Pyroclastic units erupted from the Platoro caldera complex comprise five members of the Treasure

Mountain tuff (Lipman, 1975) and possibly later eruption of the eastern portion of the Masonic Park tuff (P.W. Lipman, oral commun.). The Treasure Mountain tuff includes three regional ash-flow sheets that cover nearly 8,000 km^2; from oldest to youngest these are the La Jara Canyon, Ojito Creek, and Ra Jadero members. Recent studies indicate that part of the Masonic Park tuff--a major ash-flow sheet in the southeastern San Juan Mountains--was probably erupted late from the Platoro caldera complex (P.W. Lipman, oral commun.). Units of the Treasure Mountain tuff are dominantly dacitic to silicic dacitic in composition; however, a few phenocryst-poor tuffs and pumice blocks are low silica rhyolite.

The 28.4-Ma Masonic Park tuff overlies the Treasure Mountain tuff to the north and east of the Platoro caldera complex. Because this unit does not crop out in the study area it will not be further described in this report.

Pyroclastic volcanism associated with the Platoro caldera was followed by emplacement of andesitic to rhyodacitic lavas within and around the margins of the caldera complex. These lavas were erupted between about 29 to 20 Ma and include from oldest to youngest, the generally sparsely porphyritic Summitville andesite, the more silicic and coarsely porphyritic lavas of the rhyodacite of Park Creek, the quartz latite of South Mountain, and the rhyolite of Cropsy Mountain.

Thick accumulations of the Summitville Andesite ponded mostly within the Platoro caldera complex after collapse. These lavas have been divided by Lipman (1975) into a lower member, which followed the eruption of the La Jara Canyon member of the Treasure Mountain tuff, and an upper member, which postdates the Ojito Creek and Ra Jadero Members and predates the Masonic Park tuff. Although both members of the Summitville Andesite are petrographically very similar, the upper lavas (54-66 percent SiO_2) are generally more silicic than the lower lavas (54-61 percent SiO_2).

The rhyodacite of Park Creek includes the porphyritic biotite-bearing assemblage of lavas, breccias, and minor pyroclastic rocks that form an annular ring of lava domes on the north and northwest margins of the Platoro caldera complex. These rocks partly overlie the upper member of the Summitville Andesite within the northern boundaries of the Platoro caldera complex and rest on older rocks of the caldera wall ranging from the Conejos Formation to younger ash-flow tuffs.

The quartz latite of South Mountain is a porphyritic lava dome covering about 4 km^2 on the western rim of the Platoro caldera complex. The lava dome consists of at least four intragradational phases (Perkins and Nieman, 1983) that rest partly on the upper Summitville Andesite and partly on the rhyodacite of Park Creek. Mineralization within the Summitville orebody is hosted almost entirely by the South Mountain quartz latitic lava dome. Potassium-argon age determinations on alunite from the Summitville deposit and sanidine from the South Mountain lava dome indicate that emplacement of the lava dome and mineralization were nearly coincident at about 22.5 Ma and followed the initial collapse of the Platoro caldera complex by about 6 Ma (Mehnert and others, 1973; Perkins and Nieman, 1982).

The rhyolite of Cropsy Mountain consists of coarsely porphyritic lava flows that crop out in the Summitville and Lookout Mountain areas. In striking contrast to the earlier lavas upon which it rests, the rhyolite of Cropsy Mountain is nowhere altered. These rocks are similar petrographically to the older quartz latite of South Mountain, which also contains large sanidine megacrysts and quartz; however, the Cropsy Mountain flows are slightly more silicic. The

Cropsy Mountain unit appears to be a single flow in all places and varies considerably in thickness from place to place due to irregular pre-eruption topography and erosion near the top of each flow. In addition, these flows are characterized by a basal vitrophyre zone typically 5-10 m thick. A potassium-argon age of 20.2 Ma on the unaltered Cropsy Mountain rhyolite (Lipman and others, 1970) constrains the maximum age of alteration and accompanying mineralization in the Summitville mining area.

The Platoro caldera complex served as a structural locus for intrusion of numerous stocks and dikes ranging in composition from monzonite to porphyritic dacite. The Alamosa River stock (fig. 2), the largest of these intrusions, is an elongate intrusive body measuring about 3 by 7 km. South of the Alamosa River, the stock is mostly unaltered, fine- to medium-grained, equigranular monzonite. However, the northwestern part of the intrusion is petrographically and compositionally more complex and has been affected by intense hydrothermal alteration. It is in this area that the Alamosa River stock is intruded by a later more silicic intrusion mapped by Calkin (1967) as the Alum Creek quartz monzonite porphyry. Emplacement of the Alum Creek Porphyry was probably responsible for most of the intense hydrothermal alteration in the vicinity of Alum Creek and Lookout Mountain. Although the Alum Creek Porphyry has not been dated, a maximum age can be inferred because the older Alamosa River stock is intrusive into La Jara Canyon tuff, the latter associated with early post-caldera collapse volcanism (about 29 Ma).

Other stocks in the region that are similar in age and composition to the Alamosa River stock include the Cat Creek, Jasper, Bear Creek, Wightman Fork, and Cataract Creek stocks and are described in detail by Lipman (1975; pp. 78-86).

Quartz and sanidine-bearing dikes and plugs of coarsely porphyritic dacite to rhyolite are the youngest and most conspicuous intrusions in the area. In general, the dikes range from 10 to 100 m across and many crop out for several kilometers along strike. The intrusions are generally small plug-like bodies less than 1 km across and are present outside of the Platoro caldera complex. Due to their similarity in mineralogy and chemistry, Lipman (1975) speculated that these dikes and plugs are the intrusive equivalents of both the quartz latite of South Mountain and the rhyolite of Cropsy Mountain.

Rain and melt water from several large areas underlain by altered, mineralized rock in the Summitville-Platoro area drains into the upper Alamosa River. These areas include the Summitville mining district, the Iron-Alum-Bitter Creek basins (IABC basins), and the Jasper area. As shown in figure 2, alteration and mineralization in these areas are closely associated with intrusive centers localized along the structural margins of the Platoro caldera complex.

HYDROTHERMAL ALTERATION AND MINERALIZATION

Early studies by Steven and Ratté (1960) recognized two main episodes of hydrothermal activity in the Summitville-Platoro area. The large masses of altered rock in the IABC basins and Jasper area (fig. 2) were mostly altered during an early period of alteration denoted as Conejos age by Steven and Ratté (1960). Rocks within these areas were altered prior to the eruption of the South Mountain quartz-latite and the overlying rhyolite of Cropsy Mountain. These temporal relations are best observed on the northern side of Lookout Mountain, near Cropsy Ridge, where Conejos-age alteration is overlain by unaltered flows of the South Mountain quartz latite and the rhyolite of Cropsy Mountain. A later period of alteration, which was named Fisher age by Steven and Ratté (1960), has affected rocks in the Summitville mining area. The altered area extends from the north base of South Mountain south to Cropsy Ridge. The main mass of Fisher age alteration encompasses most of the South Mountain volcanic dome and envelops the Summitville orebody. The presence of unaltered Cropsy Mountain rhyolite flows overlying altered rocks of the South Mountain dome near the Summitville mine constrains the minimum age of Fisher alteration to about 20.2 Ma, the age of the Cropsy Mountain rhyolite.

Summitville Area

Discovery of gold in the Summitville area in 1870 led to one of the first large mining ventures in the San Juan Mountains (Steven and Ratté,1960). Gold, silver, and copper ore in the Summitville area are present in a shallow volcanic environment. Ore is hosted almost entirely by the coarsely porphyritic South Mountain quartz latite dome. The volcanic dome, with its associated alteration and mineralization, was emplaced along the northwestern margin of the Platoro caldera complex. Alteration and mineralization at Summitville occurs in near-vertical tabular zones and pods of quartz-alunite replaced South Mountain porphyry along northwest-trending fracture zones. Alteration occurred prior to mineralization in these zones and grades out from a core of leached vuggy silica through quartz-alunite and a quartz-kaolinite zone, and finally into strong illitic alteration. Ore minerals, mainly pyrite and enargite, fill irregular cavities within the vuggy silica zone. The zone of vuggy silica is generally present within 100-200 m of the surface and appears to be transitional downward into better defined but narrower vein structures. Most of the ore mined at Summitville was from the oxidized zone, which extends to 50 to 100 m of the surface. Ore from this zone generally consists of native gold intergrown with hematite, goethite, and lesser jarosite and barite. High-grade ore beneath the oxidized zone contains covellite, enargite, luzonite, and gold with accessory sphalerite and galena (Stoffregen, 1987).

Radiometric dating in the Summitville area (Mehnert and others, 1973) has established a close temporal association between mineralization and magmatic activity. The classic acid-sulfate alteration at Summitville is interpreted by Stoffregen (1987) to have formed by extreme leaching by acid fluids produced by an influx of magmatic SO_2. However, alteration preceded mineralization, the latter being associated with less extreme acid conditions.

Iron Creek, Alum Creek, Bitter Creek (IABC) Basins

The IABC basins (figs. 2 and 3) encompass roughly 10 km^2 of intensely altered and mineralized rock that corresponds spatially with the northern margin of the Alamosa River stock (fig. 2). A later phase of this stock, called the Alum Creek porphyry (Calkin, 1967), is the focus of the most intense alteration in this area and contains zones of anomalously high lead, copper, molybdenum, and zinc (Sharp and Gualtieri,1968; Calkin, 1967). Classic porphyry-style quartz-sericite-pyrite alteration is centered around the Alum Creek porphyry and is characterized by stockwork quartz-pyrite veinlets containing sparse molybdenite. Pyrite, which occurs ubiquitously throughout altered rocks in the IABC basins, is most prevalent in zones of quartz-sericite-pyrite alteration, where it averages about 1 to 2 volume percent of the rock (Calkin, 1967). Pyrite concentration generally decreases outward into the outlying argillic and propylitic alteration assemblages. Zones of decreasing alteration intensity generally extend outward from the Lookout Mountain and Alum Creek areas. Aside from the quartz-pyrite-gold-silver telluride veins mined in the Stunner and Gilmore districts (Patton, 1917; Lipman, 1975), these basins are largely undisturbed by mining activity.

The style of alteration, the occurrence of anomalous copper, lead, zinc, and the intimate association with a porphyritic quartz monzonite intrusion spurred substantial exploration activity in the Alum Creek area, specifically as a porphyry copper-molybdenum target. However, the IABC basins were considered poor exploration targets for gold and silver (Sharp and Gualtieri, 1968) because concentrations of these metals in over 200 samples were below analytical detection limits (< 0.1 ppm and <0.5 ppm, respectively). The presence of trace to appreciable amounts of both metals in altered rocks in the Summitville area (Fisher age alteration) is an important distinction between the IABC basins (Conejos age alteration), where altered rocks are apparently devoid of these metals.

Jasper Area

Hydrothermal alteration centered over a 10 km^2 area around the Jasper area is associated with intrusions that range from andesite to quartz monzonite porphyry (fig. 2). Previous investigations (Patton, 1917) indicate that quartz-pyrite veins with ore shoots containing gold and silver are localized along the southern margin of these highly altered rocks. Preliminary investigations during our 1993 field studies suggest that the character of alteration may be similar to that in the IABC basins. Although no modern geologic studies have been done in this area, we plan soon to access the wealth of exploration data from Jasper and the surrounding area in the Anaconda reference collection.

DISCUSSION

The Summitville mine, IABC basins, and the Jasper area are all localized along an arcuate fault zone, generally referred to as the ring fracture zone of the Summitville caldera (Lipman 1975; Stoffregen, 1987). This fault zone, from Summitville south to the Alamosa River and east to Jasper is marked by repeated intrusion, hydrothermal alteration and mineralization. As shown in figure 2, there is an intimate association between hydrothermal alteration, mineralization, and shallow intrusion of quartz monzonite to monzonite stocks. The intrusions related to hydrothermal alteration and mineralization within the IABC basins and Jasper area have been well exposed by erosion; in contrast, the younger quartz monzonite intrusion(s) associated with the Summitville orebody is present about 700 m beneath the surface, buried by a thick accumulation of quartz latitic lavas of the South Mountain extrusive dome.

One of the striking similarities between the Summitville mining district and the IABC basins to the south is the presence of classic acid-sulfate alteration assemblages. Mineralization and alteration in the Summitville area are in fault-controlled, subvertical tabular zones consisting of vuggy silica cores surrounded by successive zones of quartz-alunite, quartz-kaolinite, kaolinite-sericite, and smectite-chlorite. Similarly, small localized zones of quartz-alunite altered rock also are present in the Lookout Mountain and Alum Creek vicinities, in the western portion of the IABC basins (fig. 3). However, unlike the Summitville mining area, these zones are not mineralized and lack a central zone of vuggy silica rock. Due to the lack of data from the Jasper area, we are at present unable to make any meaningful comparisons between it and the Summitville mining district.

The vertical progression of hydrothermal alteration in the Summitville and the Lookout Mountain-Alum Creek areas is also strikingly similar. Both hydrothermal systems grade downward from magmatically derived acid-sulfate altered rock (Rye and others, 1992; R.O. Rye oral commun.) into underlying zones of quartz-sericite-pyrite alteration with accompanying quartz-pyrite stockwork veinlets. Sparse molybdenite is present within the deeper quartz-sericite-pyrite assemblage in the Alum Creek area, and anomalous copper and molybdenum are reported in the deeper levels of the Summitville deposit (Gray and others, 1993). Both the Summitville and Lookout Mountain-Alum Creek hydrothermal systems are characterized by upper level acid-sulfate and deeper level, weak "porphyry" copper-molybdenum systems. In both areas, these hydrothermal systems were both genetically related to hypabyssal quartz monzonite intrusions.

From these data it is apparent that the depth of erosion--relatively shallow in the Summitville area compared to the IABC basins and Jasper area--is an important factor when comparing specific geologic and geochemical characteristics of the Summitville mining district to the IABC basins and the Jasper mining district. For example, it would be misleading to compare the geochemical characteristics of water from the Alum Creek drainage to waters from upper Cropsy Creek in the Summitville area (fig. 3) because different levels of the alteration assemblage are exposed in each area. Although no quantitative data are yet available, one would expect significantly higher pyrite abundances within the deeply dissected Alum Creek area relative to the higher level alteration assemblage drained by upper Cropsy Creek.

Finally, geochemical sampling of highly altered rock in the Summitville and IABC basins (Sharp and Gualtieri, 1968) show extensive lead anomalies in both areas with smaller anomalies of copper, molybdenum, and zinc. However, traces to appreciable amounts of gold and silver were also detected (<0.1 ppm Au; <0.5 ppm Ag) in altered rocks from the Summitville area, whereas these metals were not detected in samples from the IABC basins.

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Figures

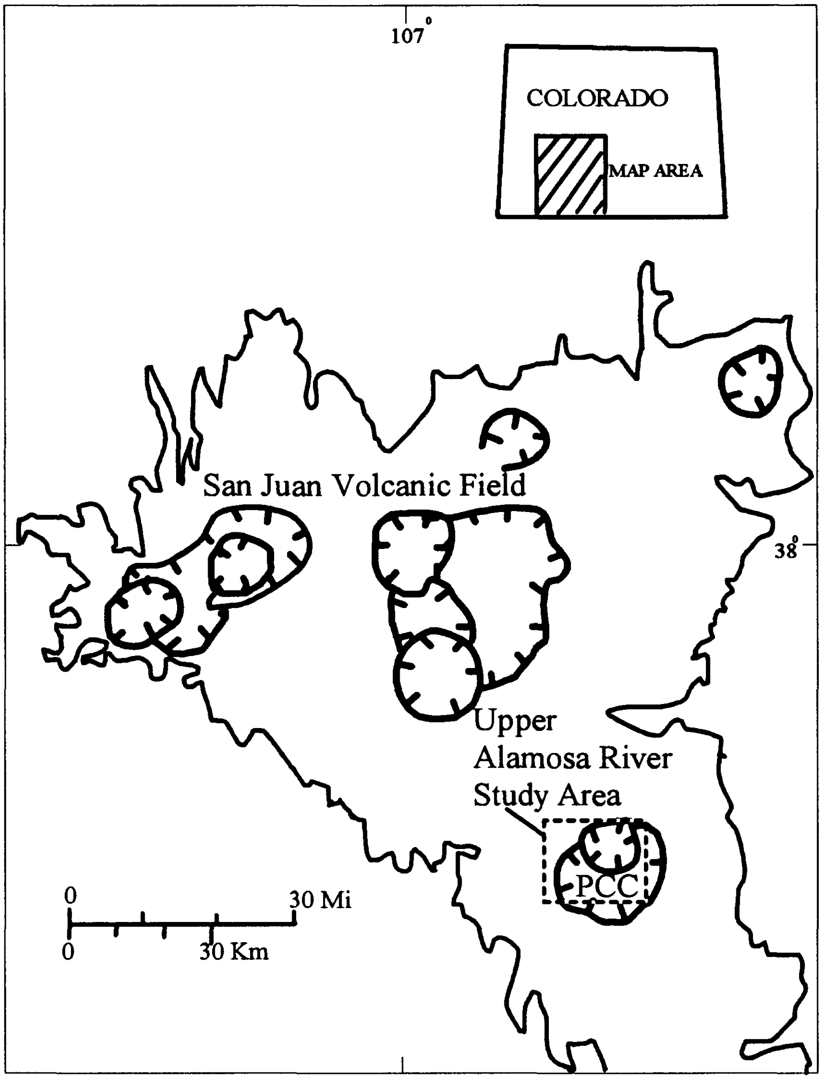

Fig. 1. Map of the San Juan Volcanic Field showing the Platoro caldera complex (PCC), and the upper Alamosa River basin study area. Major calderas denoted by thick hatched lines.

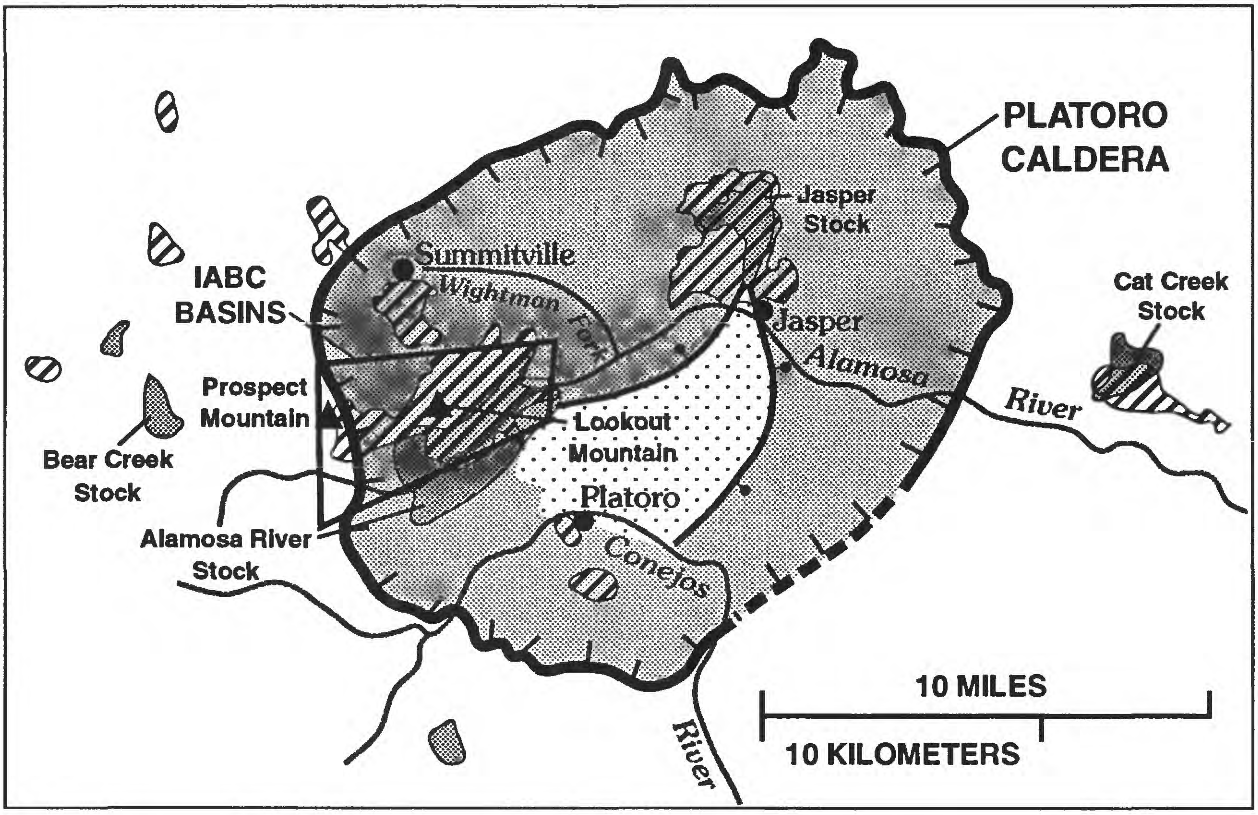

Figure 2. Simplified geologic map of the Platoro caldera complex. Diagonal hatched areas are zones of hydrothermal alteration; dotted area is intracaldera Treasure Mountain tuff.

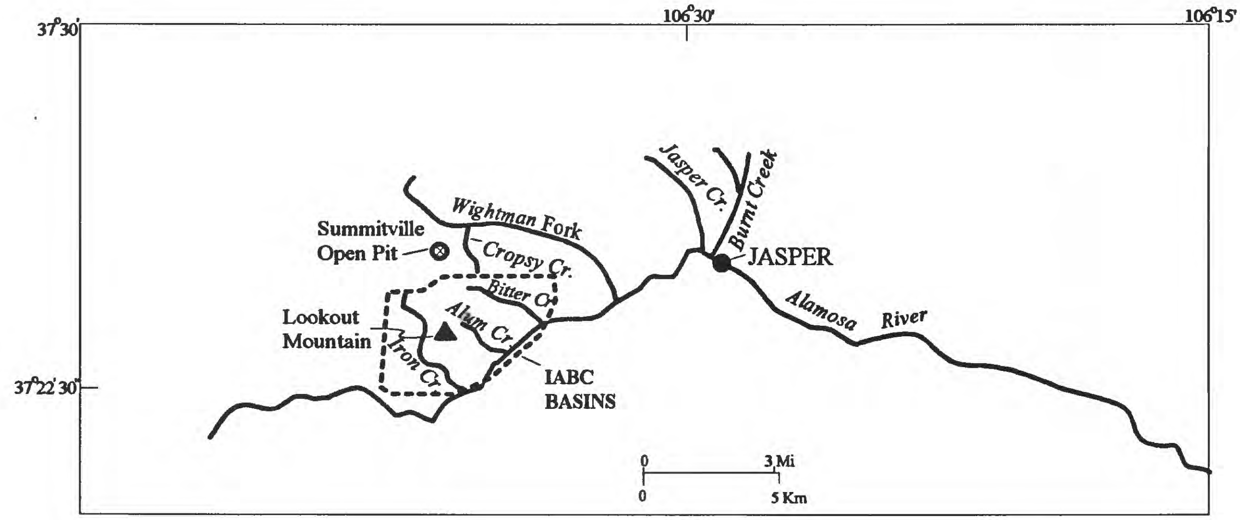

Fig. 3. Map of major drainages within the upper Alamosa River basin study area.