Surficial geologic maps along the riparian zone of the Animas River and its headwater tributaries, Silverton to Durango, Colorado, with upper Animas River watershed gradient profiles

By Robert W. Blair, Jr., Douglas B. Yager, and Stanley E. Church

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View looking north of talus and debris cone material weathered from the steep slopes of Red Mountain No. 2 near the headwaters of the upper Animas River watershed. Rocks of Silverton Volcanics in foreground are bleached white by intense hydrothermal alteration. Purple-hued rocks in distance are mostly older volcanics of San Juan Formation.

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INTRODUCTION

The Animas River originates in the San Juan Mountains north of the historic mining town of Silverton, Colo. The accompanying 10 surficial geologic strip maps show the distribution of surficial deposits along the riparian zone of the Animas River and its upper headwater tributaries approximately 400 ft (130 m) above the valley floor (fig.1). These deposits have been mapped in the larger tributaries of the Animas River in its headwaters north of Silverton and along the Animas River south to Durango, Colo. The Animas River watershed is the site of an interdisciplinary, multi-agency study designed to effectively characterize lands impacted by historical mining activities and to aid land managers in making restoration decisions (Buxton and others, 1997; U.S. Geological Survey, 2000).

Today, stream waters in Mineral and Cement Creeks are acidic and range in pH from 3.5 at base flow to 7 at high flow. In contrast, the Animas River above Silverton ranges in pH from 6 to 7.5 (Mast and others, 2000). Evidence of acidic drainage is readily apparent in stream reaches and tributaries in the watershed above Silverton. Red, yellow, and white precipitates from waters draining hydrothermally altered areas are strong visual indications of acidic, metal-rich waters in tributary basins of the Animas River watershed. Physical and chemical weathering of altered and mineralized rock undisturbed by mining activity contributes high concentrations of major and trace elements that exceed average crustal abundances in streambed sediments (Church and others, 2000). After the mining of mineral deposits and milling of polymetallic vein materials in the study area, transport and deposition of mine and mill wastes into streams and floodplains concentrated metal abundances in sediments (Nash, 2000a, b; Church and others, 2000).

One of the fundamental questions to be addressed in watersheds affected by historical mining is: "What was the water quality in the watershed prior to mining?" In addressing this question, geologists must find field evidence that indicates what the water chemistry was prior to mining. We have approached this question by mapping and determining the chemistry of fluvial deposits such as stream terraces that are older than the initiation of mining activity, which began in 1871.

Prior to mining, acidic waters transported trace and major elements from mineralized areas and deposited these elements in stream terraces and other surficial deposits. Surficial geologic mapping may be used with other data sets, such as alteration assemblage maps, to infer possible sources of acid rock drainage. Surficial deposits in the Animas River watershed are often derived from the downslope transport of weathered, hydrothermally altered and mineralized rock. Surficial deposits that contain pyrite are porous and permeable pathways for groundwater and are sources for acidic drainage (Yager and others, 2000). Conversely, when minerals such as chlorite or calcite are present, the surficial deposits have the ability to neutralize acidic waters (Desborough and Yager, 2000).

SURFICIAL DEPOSITS AND THE GEOCHEMICAL BASELINE

The determination of the pre-mining geochemical baseline is a key component in understanding the effect that historical mining has had on the riparian habitat in the watershed. Geochemical analyses of samples collected from the pre-1860 surficial deposits (Church and others, 2000) provide a measure of the pre-mining geochemical baseline. We have included several examples of the types of deposits used to determine the pre-mining geochemical baseline in streambed sediments preserved in terrace deposits. ***Click the following links (figs. 2–8, indicated in blue) for examples of surficial deposits and their corresponding geochemical profiles.***

Figure 2. Mineral Creek terrace
Figure 3. Cement Creek terrace
Figure 4. Upper Animas River silt
Figure 5. Pre-1890 fluvial deposits, upper Animas River
Figure 6. Fluvial mill tailings, upper Animas River
Figure 7. Overbank deposits along the Animas River at Elk Park
Figure 8. Oxbow deposits along the Animas River near Durango

Several surficial deposit types are useful in the characterization of the pre-mining geochemical baseline. These deposits include:

(1) Pre-1860 valley deposits: These deposits are located on the slightly concave surface of narrow, approximately 100-m-wide valley floors of smaller tributaries, where there are no distinct fluvial terraces or alluvial fans. The valley sediment consists of unconsolidated sand and gravel with a silty matrix, and occasionally larger stones often derived from valley sides. Deposits are derived from a complex of fluvial and colluvial processes and include slope wash from valley sides and overbank deposits from periodic floods.

Figure 1. Index to surficial deposits mapped in the ten 7.5-minute quadrangles in the Animas River watershed. Click on a shaded quadrangle of interest to launch .pdf versions of a selected map.

(2) Terrace deposits: Terraces are relatively flat, narrow surfaces elevated above and commonly parallel to the active stream channel. The fluvial sediment in terraces represents old floodplain deposits and consists of unconsolidated, poorly sorted, rounded sand and gravel mixed with silt. Gravels are often imbricated. In the upper Animas River, boulders as much as 0.5 m in diameter are not uncommon. Terrace sediment is deposited during spring and storm discharge events associated with overbank flow. Since deposition, water infiltration and weathering of detritus have contributed to soil and peat development, particularly on terraces higher than several meters above the existing channel.
(3) Oxbow deposits: These deposits are remnants of the once active river channel and they are preserved as curved, shallow depressions in the floodplain. They are found in gently dipping to flat, meandering river floodplains such as in the lower Animas River Valley north of Durango and they are associated with cutoff meander channels (oxbow lakes). Oxbow deposits consist of unconsolidated silty sand often mixed with peat near their upper surface. Discontinuous lenses of gravel are common at depth. These abandoned channels range in age from pre-1860 to post-1860. Older oxbow deposits eventually fill with silt to become dry swales on the active floodplain.

SURFICIAL GEOLOGIC MAPS

We have mapped surficial deposits along parts of ten 1:24,000-scale topographic quadrangles from Silverton to Durango. ***Each surficial deposit map may be viewed in .pdf format by clicking the map of interest in figure 1.*** On several of the maps, we have developed interactive links to photographs that represent surficial deposits throughout the Animas River watershed. This allows the user to take a "virtual tour" of the watershed. Camera icons on the maps (in blue) identify the photograph sites. The lens of the camera icon is oriented in the direction in which the photograph was taken. Photographs of surficial deposits that were mapped are included as .pdf format files and are stored in the Photos subfolder on this CD-ROM, which may be viewed and printed with the Adobe Acrobat viewer.

GRADIENT PROFILE MAP

Gradient profiles are useful when interpreting the types of fluvial deposits (mining and non-mining related) that form within a watershed. In the case of the upper Animas River watershed, higher gradient stream reaches, which have abundant boulder and cobble bed sediment loads contribute to turbulent flow. A turbulent flow regime is capable of keeping sediment in suspension longer when compared to laminar flow; however, the circuitous route water molecules must take limits the velocity of turbulent flow. Where stream gradient dramatically decreases, such as occurs along the valley floors at the base of steep gradient reaches, the velocity can decrease resulting in sedimentation. These hydrologic processes related to gradient are key factors in establishing healthy stream habitats from the alpine zones, with frequently higher gradients, to lower elevation habitats where pools and meandering reaches with gravel bars develop that are suitable fish spawning areas.

We have included a map that indicates the change in stream gradient along the main tributaries in the upper Animas River watershed. Gradients along the Animas River south of the Snowdon Peak quadrangle near Durango, Colo., are generally lower than gradients observed in the upper part of the watershed, and thus were not determined because the resolution of the data used for these calculations (10-m digital elevation models) may not be sufficient to resolve subtle changes in elevation along these shallower gradient reaches. ***Click here to open the .pdf format gradient map.*** Specific gradient profiles for a stream reach are viewed by clicking a stream segment on the map. These gradient profiles can be used as an analysis tool to help evaluate the fluvial geomorphologic processes influencing sediment transport and deposition that have occurred in the upper Animas River watershed prior to and after mining. One specific example of how we might use this information is to try to understand the relationship between gradient, sediment transport, and deposition of processed mineral deposits from the high-gradient reaches of the upper Animas River above Eureka townsite to the lower gradient braided stream reach of the Animas River near Howardsville.

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