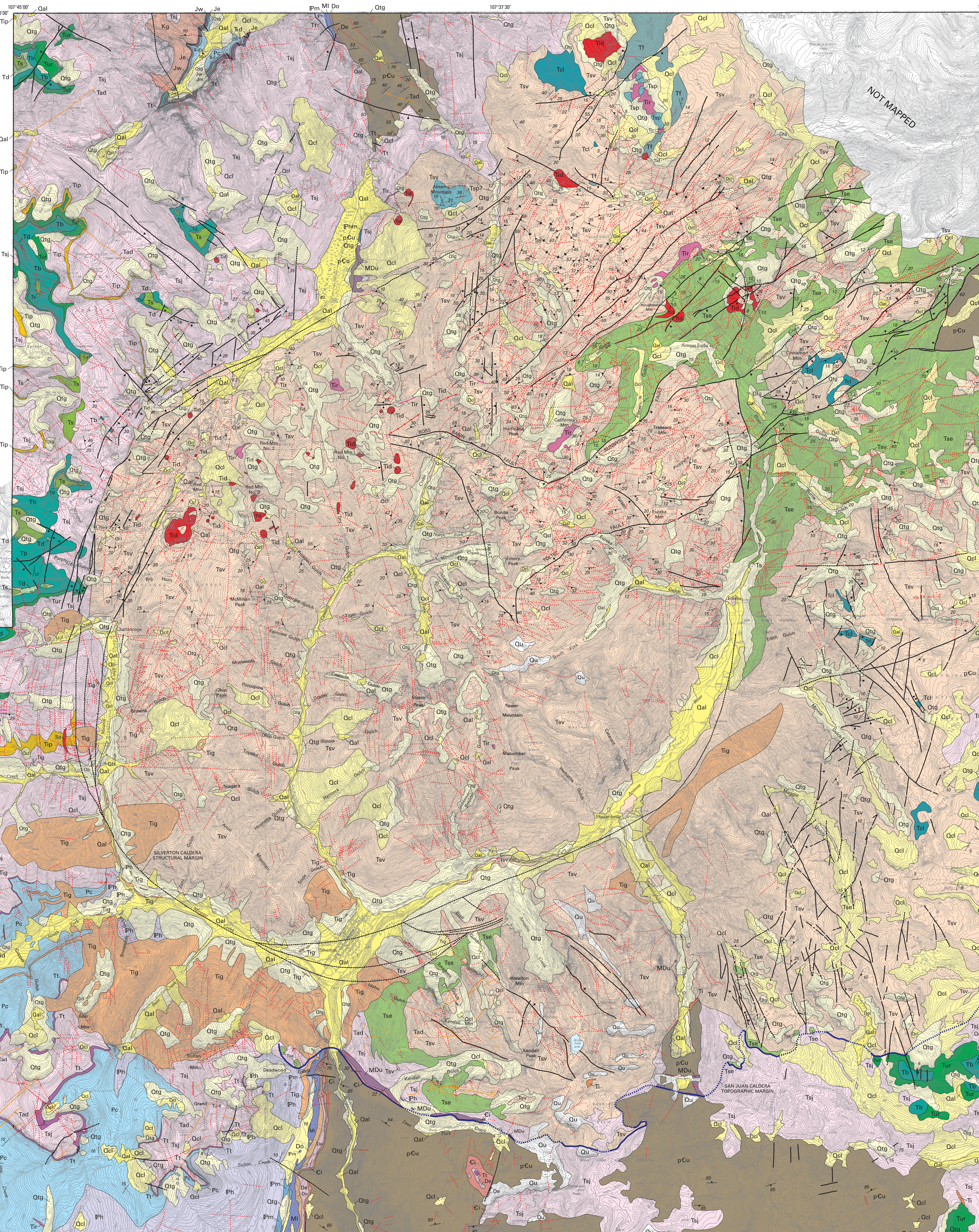
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PROFESSIONAL PAPER 1651
PLATE 1
Version 1.1



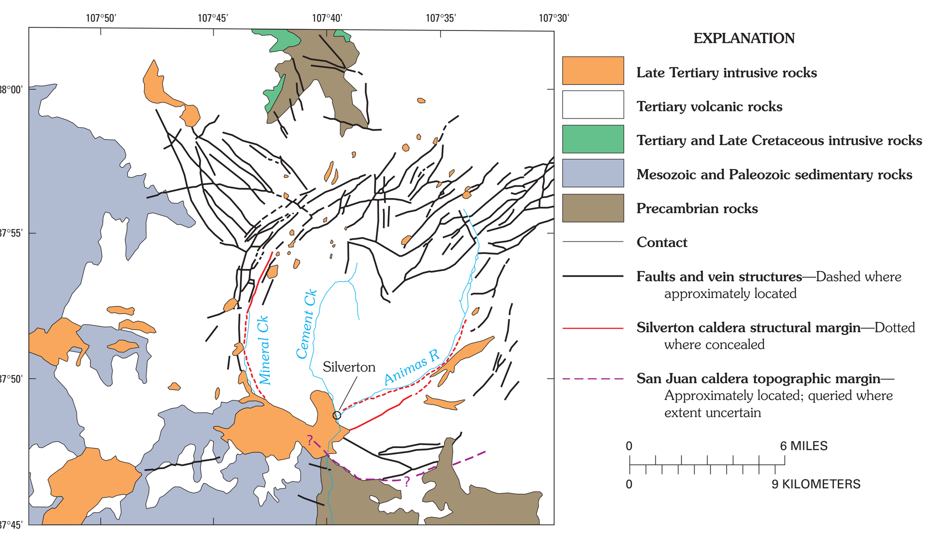
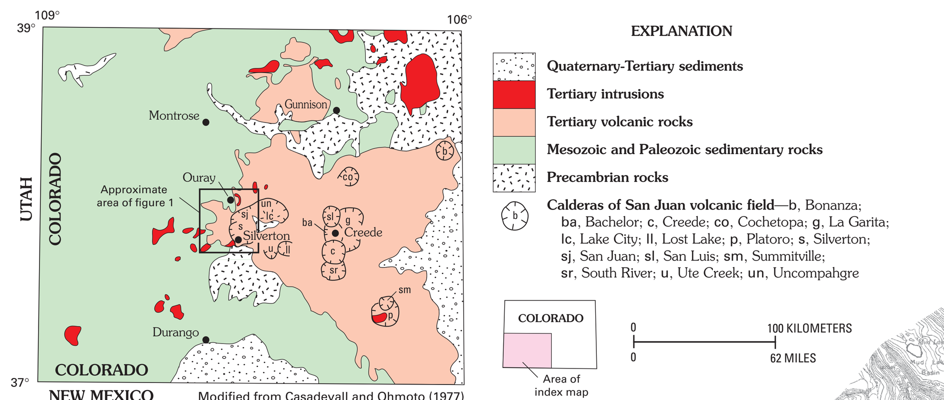


Figure 1. Generalized regional geologic map of part of the Animas River watershed and surrounding regions. Major tributaries to the Animas River are shown in addition to the major Tertiary volcano-tectonic structures related to the Silverton and San Juan calderas. Figure is modified from Casadevall and Ohmoto (1977).

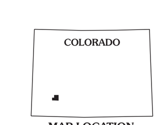


REGIONAL INDEX MAP

Base from U.S. Geological Survey, 1:24,000,
Handies Peak, Howardsville, Ironton,
Ophir, Silverton (1955).
Projection: Universal Transverse Mercator, zone 13.
10,000-foot grid based on Colorado
coordinate system, south zone.
1927 North American datum

SCALE 1:48 000

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929



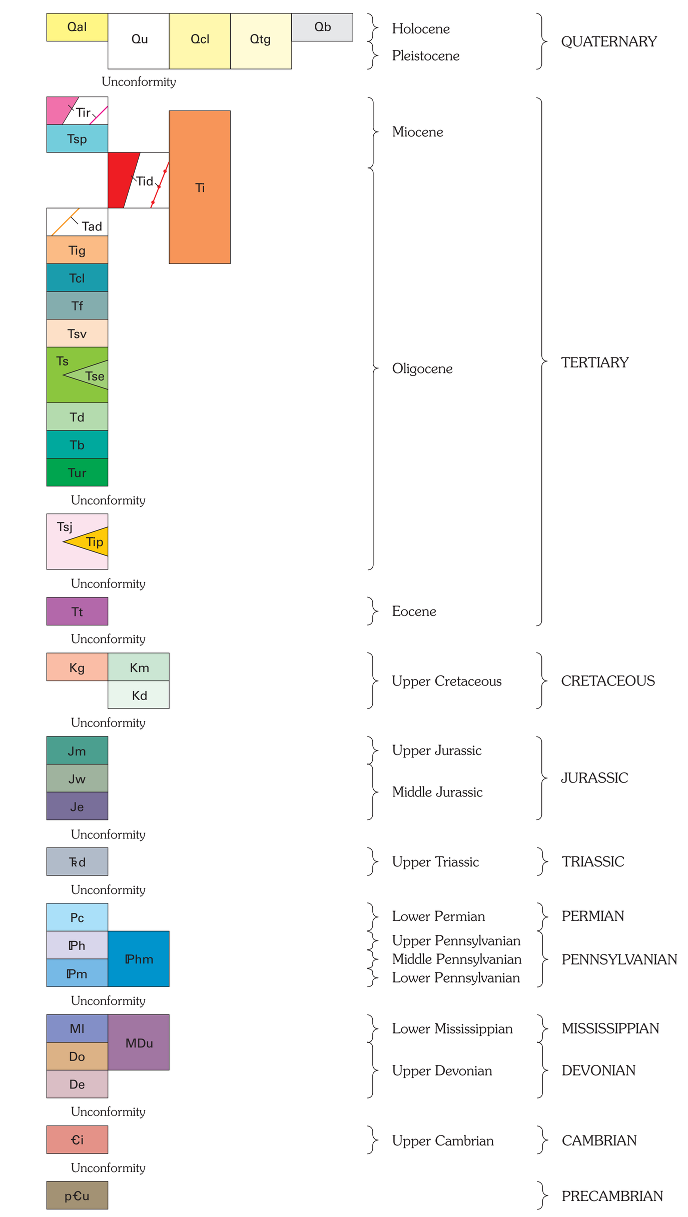
MAP LOCATION

Geology compiled by Yager and Bove, 1996–1999.
See index map at right for mapping data sources used in compilation

GENERALIZED GEOLOGIC MAP OF PART OF THE ANIMAS RIVER WATERSHED AND VICINITY, SILVERTON, COLORADO

Compiled by
Douglas B. Yager and Dana J. Bove
2007

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

QUATERNARY SURFICIAL DEPOSITS

TERTIARY IGNEOUS AND VOLCANICLASTIC ROCKS

PRE-TERTIARY ROCKS

INTRODUCTION

GEOLOGIC SETTING OF THE ANIMAS RIVER WATERSHED STUDY AREA

PHYSIOGRAPHIC SETTING

GEOLOGIC SETTING

MAP COMPILATION APPROACH

Most map data were transferred to stable base materials and scanned or digitized. Digital map data were converted into ARC/INFO and projected to the Universal Transverse Mercator (UTM) geographic projection (zone 13). This is the projection used for other cartographic base information available for the Animas River watershed, AML project. The compilation scale was 1:24,000; sufficient data were generally available from existing geologic maps to maintain continuity in map units and structural features across map boundaries. Parts of the Howardsville and the Silverton 7 1/2' quadrangles were not mapped in as much detail as the remainder of the map area. Thus, certain units and structural features and veins are not displayed in as much detail as is evident in other areas.

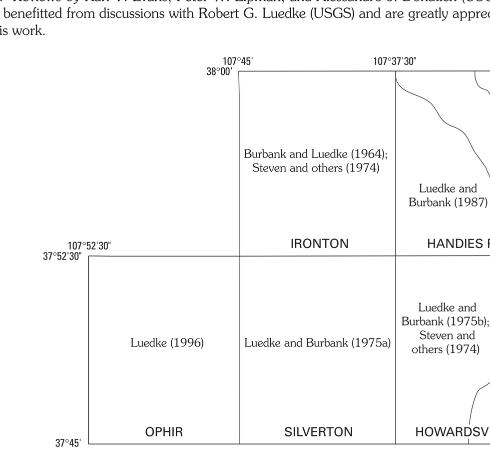
Units within the Silverton Volcanics, such as the Burns and Henson Members and the pyroxene andesite member (Lipman, 1976), were not mapped separately for this compilation due to the lack of corresponding data for parts of the Howardsville and Silverton 7 1/2' quadrangles. Quaternary units were generalized for the purposes of this compilation. Detailed 1:24,000-scale surficial geology is available for the Animas River from Durango to Silverton and for its major tributaries in the Animas River watershed study area (Blair and others, 2002). Not all veins were compiled from existing maps. Vein orientation and vein density are generalized throughout the map area.

REFERENCES CITED

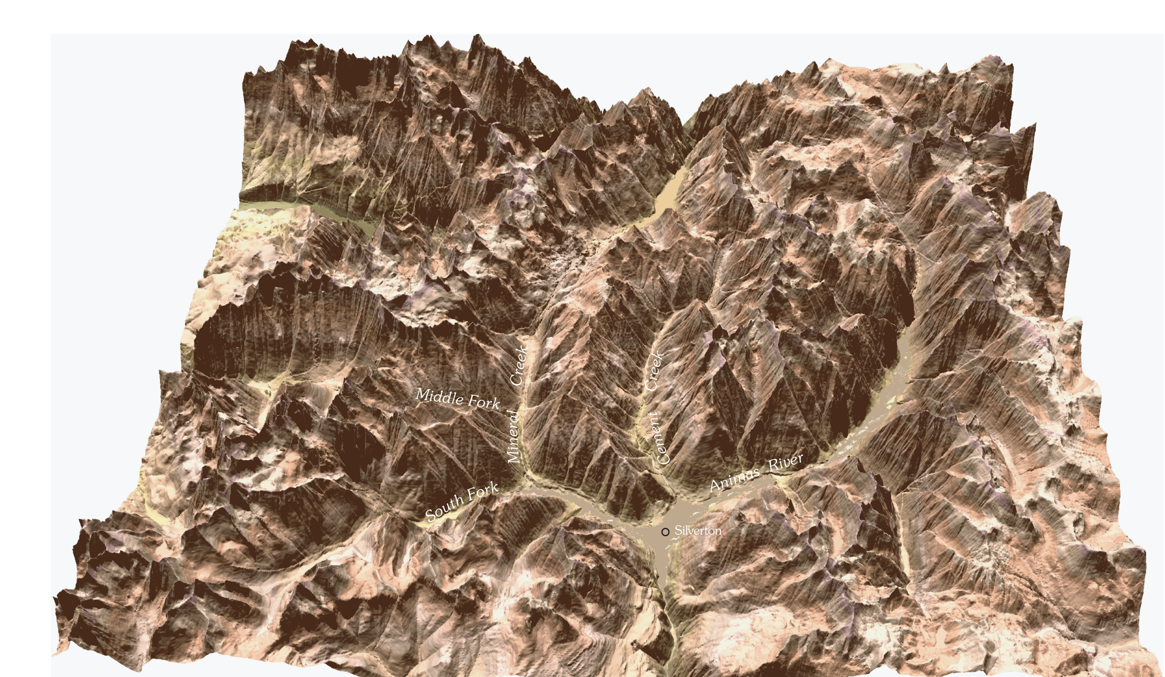
Bailey, R.G., 1995, Description of the ecoregions of the United States: United States Department of Agriculture Miscellaneous Publication 1391, 108 p.
Blair, R.W., Jr., Yager, D.B., and Church, S.E., 2002, Surficial geologic maps along the riparian zone of the Animas River and its headwater tributaries, Silverton to Durango, Colorado, with upper Animas River watershed gradient profiles: U.S. Geological Survey Digital Data Series 071, one CD-ROM.
Bove, D.J., Hon, Ken, Budding, K.E., Slack, J.F., Snee, L.W., and Yeoman, R.A., 2001, Geochronology and geology of late Oligocene through Miocene volcanism and mineralization in the western San Juan Mountains, Colorado: U.S. Geological Survey Professional Paper 1642, 30 p.
Bove, D.J., Mast, M.A., Wright, W.G., Verplanck, P.L., Meeker, G.P., and Yager, D.B., 2000, Geologic control on acidic and metal-rich waters in the southeast Red Mountain Area, near Silverton, Colorado, *in* ICARD 2000; Proceedings of the Fifth International Conference on Acid Rock Drainage, Volume 1: Society for Mining, Metallurgy, and Exploration, p. 523–533.
Burbank, W.S., and Luedke, R.G., 1964, Geology of the Ironton quadrangle, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ–291, scale 1:24,000.
Buxton, H.T., Nimick, D.A., von Guerard, Paul, Church, S.E., Frazier, Ann, Gray, J.R., Lipin, B.R., Marsh, S.P., Woodward, Daniel, Kimball, Briant, Finger, Susan, Ischinger, Lee, Fordham, J.C., Power, M.S., Bunk, Christine, and Jones, J.W., 1997, A science-based, watershed strategy to support effective remediation of abandoned mine lands: Fourth International Conference on Acid Rock Drainage, Vancouver, B.C., Canada, v. 4, p. 1869–1880.
Casadevall, T.J., and Ohmoto, Hiroshi, 1977, Sunnyside mine, Eureka mining district, San Juan County, Colorado; Geochemistry of gold and base metal ore deposition in a volcanic environment: Economic Geology, v. 72, p. 1285–1320.
Cross, Whitman, Howe, Ernest, and Ransome, F.L., 1905, Description of the Silverton quadrangle, Colorado: U.S. Geological Survey Geological Atlas, Folio 120, 34 p. [text], 3 maps.
Daly, Christopher, Neilson, R.P., and Phillips, D.L., 1994, A statistical model for mapping climatological precipitation over mountainous terrain: Journal of Applied Meteorology, v. 33, p. 140–158.
Desborough, G.A., and Yager, D.B., 2000, Acid neutralizing potential of igneous bedrocks in the Animas River headwaters, San Juan County, Colorado: U.S. Geological Survey Open-File Report 00–165, 14 p.
Gilzean, M.N., 1984, Nature of a deep hydrothermal system, Red Mountain district, Colorado: Berkeley, Calif., University of California M.S. thesis, 104 p.
Hon, Ken, and Mehnert, H.H., 1983, Compilation of revised ages of volcanic units in the San Juan Mountains, Colorado—Recalculated K-Ar determinations using IUGS constants: U.S. Geological Survey Open-File Report 83–668, 19 p.
Jackson, S.E., Harmon, R.S., Lux, D., Rice, C.M., and Ringrose, C.M., 1980, Isotopic geochemistry and chronology of porphyry-style mineralization near Ophir, San Juan Mountains, Colorado: Geological Society of America Abstracts with Programs, v. 12, p. 454.
Lanphere, M.A., and Baadsgaard, Halfdan, 1997, The Fish Canyon Tuff, a standard for geochronology: Eos, v. 78, p. 326.
Lipman, P.W., 1976, Geologic map of the Lake City caldera area, western San Juan Mountains, southwestern Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I–962, scale 1:48,000.
Lipman, P.W., Fisher, F.S., Mehnert, H.H., Naeser, C.W., Luedke, R.G., and Steven, T.A., 1976, Multiple ages of mid-Tertiary mineralization and alteration in the western San Juan Mountains, Colorado: Economic Geology, v. 71, p. 571–588.
Lipman, P.W., Steven, T.A., Luedke, R.G., and Burbank, W.S., 1973, Revised volcanic history of the San Juan, Uncompahgre, Silverton and Lake City calderas in the western San Juan Mountains, Colorado: U.S. Geological Survey Journal of Research, v. 1, p. 627–642.
Luedke, R.G., 1996, Geologic map of the Ophir quadrangle, San Juan, Hinsdale, and Ouray Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ–1760, scale 1:24,000.
Luedke, R.G., and Burbank, W.S., 1963, Tertiary volcanic stratigraphy in the western San Juan Mountains, Colorado, *in* Short papers in geology and hydrology: U.S. Geological Survey Professional Paper 475–C, p. C39–C44.
Luedke, R.G., and Burbank, W.S., 1975a, Preliminary geologic map of the Silverton quadrangle, Colorado: U.S. Geological Survey Open-File Report 75–433, scale 1:20,000.
Luedke, R.G., and Burbank, W.S., 1975b, Preliminary geologic map of the Howardsville quadrangle, Colorado: U.S. Geological Survey Open-File Report 75–432, scale 1:20,000.
Luedke, R.G., and Burbank, W.S., 1987, Geologic map of the Handies Peak quadrangle, San Juan, Hinsdale, and Ouray Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ–1595, scale 1:24,000.
Ransome, F.L., 1901, A report on the economic geology of the Silverton quadrangle: U.S. Geological Survey Bulletin 182, 265 p.
Ringrose, C.R., 1982, Geology, geochemistry, and stable isotope studies of a porphyry-style hydrothermal system, west Silverton district, San Juan Mountains, Colorado: Aberdeen, Scotland, University of Aberdeen Ph.D. dissertation, 257 p.
Sloan, R.E., and Skowronski, C.A., 1975, The Rainbow Route, an illustrated history of the Silverton Northern Railroad and the Silverton, Gladstone and Northerly Railroad: Denver, Colo., Sundance Publications, 416 p.
Steven, T.A., Hon, Ken, and Lanphere, M.A., 1995, Neogene geomorphic evolution of the central San Juan Mountains near Creede, Colorado, 1995: U.S. Geological Survey Miscellaneous Investigations Series Map I–2504, scale 1:100,000.
Steven, T.A., Lipman, P.W., Hail, W.J., Jr., Barker, Fred, and Luedke, R.G., 1974, Geologic map of the Durango quadrangle, southwestern Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I–764, scale 1:250,000.
Varnes, D.J., 1963, Geology and ore deposits of the south Silverton mining area, San Juan County, Colorado: U.S. Geological Survey Professional Paper 378–A, 56 p.
Yager, D.B., Mast, M.A., Verplanck, P.L., Bove, D.J., Wright, W.G., and Hageman, P.L., 2000, Natural versus mining-related water quality degradation to tributaries draining Mount Moly, Silverton, Colorado, *in* ICARD 2000; Proceedings of the Fifth International Conference on Acid Rock Drainage, Volume 1: Society for Mining, Metallurgy, and Exploration, p. 535–547.

ACKNOWLEDGMENTS

The authors wish to thank Thomas J. Casadevall (USGS) and Karen Budding (formerly USGS) for their contributions regarding the geochronology and paleomagnetic characteristics of the units mapped previously as the Gilpin Peak Tuff (Burbank and Luedke, 1964). Their work along with newly acquired isotopic dates on these units (Bove and others, 2001) permitted determination of the ages and caldera-related sources of these units. Reviews by Karl V. Evans, Peter W. Lipman, and Alessandro J. Donatich (USGS) are appreciated. We have benefitted from discussions with Robert G. Luedke (USGS) and are greatly appreciative of his early review of this work.



INDEX MAP SHOWING 7 1/2' TOPOGRAPHIC QUADRANGLES AND AREAS OF MAPPING RESPONSIBILITY USED FOR THIS GEOLOGIC COMPILATION



ARC/INFO hillshaded perspective relief model indicates the rugged relief of the upper Animas River watershed, Abandoned Mine Lands study area. View is to the north from an altitude of 30,000 ft, with a sun azimuth of 50°; no vertical exaggeration was used. Cropping of the image at its edges combined with the viewing perspective parameters used results in a slightly exaggerated appearance of the topography. Data sources include 10 m digital elevation models available from the U.S. Geological Survey.