Mines, Mountains, and Hot Springs – IMWA 2013 Post-Conference Tour to Silverton, Colorado: August 10–13, 2013

Raymond H. Johnson

U.S. Geological Survey, Denver Federal Center, Denver, Colorado, USA, rhjohnso@usgs.gov

Abstract An itinerary, maps, and details about the IMWA 2013 post-conference tour from Golden, Colorado to Silverton, Colorado on August 10–13, 2013, are provided.

Keywords IMWA 2013, post-conference tour, Silverton

Introduction

A summary of the IMWA 2013 post-conference tour to Silverton, Colorado is provided. This trip will be from August 10–13, 2013. An itinerary, maps, and details about what we will see (along with web links) are provided below. North is toward the top of the page on all maps.

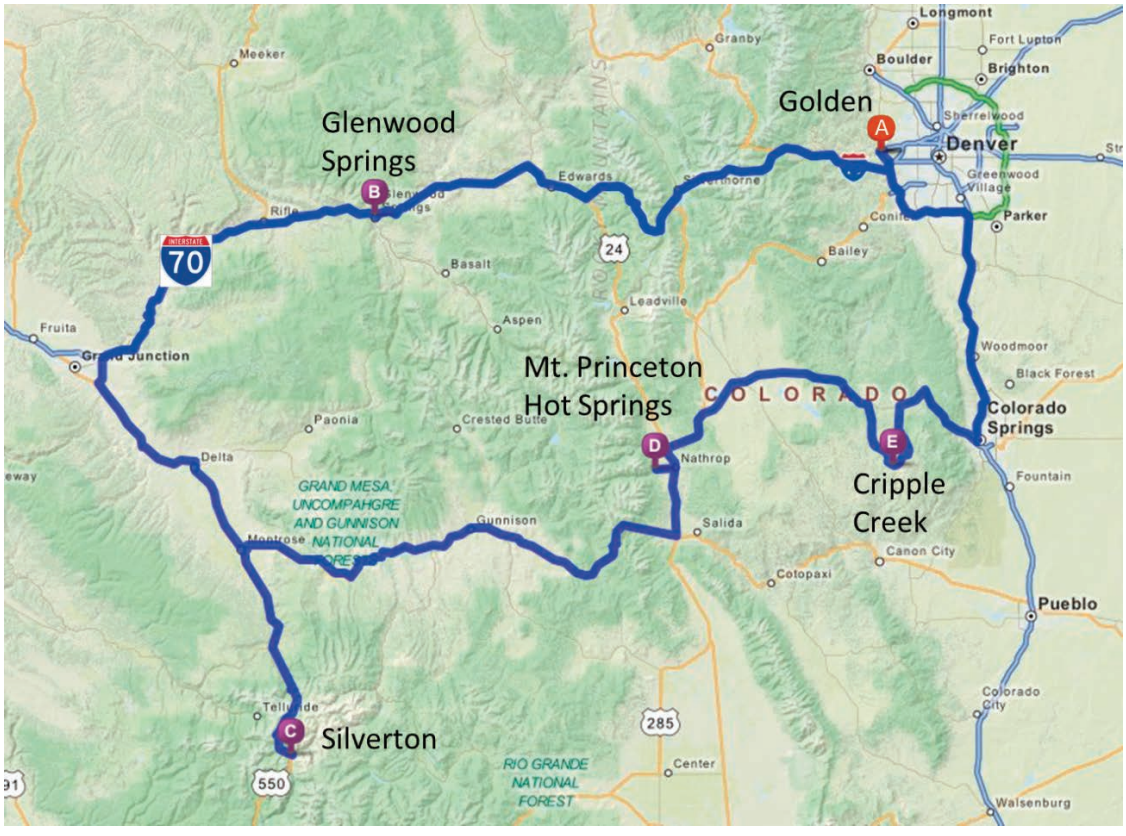

Fig. 1 *Map of IMWA 2013 post-conference field trip route. Golden, Colorado (A) to Glenwood Hot Springs (B) to Silverton (C) to Mount Princeton Hot Springs (D) to Cripple Creek (E) and back to Golden. Road distance from Golden to Silverton is approximately 560 km (350 mi). Map base is from www.mapquest.com.*

Itinerary

Map of full trip route is shown in Fig. 1.

August 10: Golden to Silverton (fig. 1)

07:30 Leave Golden

10:30 – 13:30 Glenwood Hot Springs

18:30 Arrive in Silverton

August 11: Silverton 4 × 4 tour (fig. 2)

08:00 – 17:00 All day in the San Juan Mountains in four-wheel drive, open-top vehicles

August 12: Silverton to Mount Princeton Hot Springs (fig. 3)

08:00 – 10:00 Overlook the Silverton caldera or free time to see the local sights

10:00 – 11:30 Tour of the Mayflower Mill

11:30 – 12:30 Lunch in the local park

12:30 – 17:30 Travel from Silverton to Mt. Princeton Hot Springs

17:30 Arrive at Mount Princeton Hot Springs

August 13: Mount Princeton Hot Springs, Cripple Creek and Victor Gold Mine, and back to Golden (figs. 1, 4)

08:00 – 10:30 Travel from Mt. Princeton Hot Springs to Cripple Creek

10:30 – 15:00 Tour the Cripple Creek area and the Cripple Creek and Victor Gold Mine

15:00 – 18:00 Travel back to Golden

Note: all times are approximate

August 10: Golden to Silverton

On the first day we will travel though the central Colorado Rocky Mountains (fig. 1), taking Interstate 70 over the Continental Divide, past Dillon Reservoir (part of Denver's water supply), and through Glenwood Canyon (http://en.wikipedia.org/wiki/Glenwood_Canyon), which was carved by the Colorado River. We will have an extended lunch stop with time to swim in the Glenwood Hot Springs (www.hotspringspool.com). After Glenwood Springs, we will drive around the north and west sides of Grand Mesa, a 1,300 km^2 (500 square miles) flat topped mountain (3,454 m or 11,332 ft at its peak) capped with volcanic basalt (http://en.wikipedia.org/wiki/Grand_Mesa), before heading south towards Silverton. Hang on to your hats as we drive from Ouray to Silverton along the Million Dollar Highway (http://en.wikipedia.org/wiki/U.S._Route_550) believed to have gotten its name because it cost a million dollars a mile to build in the 1920s. The drop off from the edge of the road to the river below is pretty impressive. If you want a preview, you can take a look at www.youtube.com/watch?v=geLCaRlb3IM.

Throughout the day, we will discuss the geology of Colorado using the guidebook written by Chronic and Williams (2002). At the end of a long day, we will have time to relax in Silverton (http://en.wikipedia.org/wiki/Silverton,_Colorado) where we will be staying at the Grand Imperial Hotel (www.grandimperialhotel.com), which was built in 1882 and has Victorian-style architecture.

August 11: Silverton 4 × 4 tour

A full day touring the San Juan Mountains (fig. 2) in an open-topped four-wheel drive vehicle cannot be beat. This day will have lots of mountain scenery, but also a lot of information about the local geology (Yager and Bove 2002), as this area is rich in metal ores and is the center of the 28-million year old Silverton caldera. We will also visit some of the many abandoned mine sites and discuss the related acid-mine drainage and natural acid-rock drainage issues. In Fig. 2 you can see some of the red iron staining on the mountain sides to the west of Silverton, Cement Creek, and Gladstone.

We will start out from Silverton and go along Cement Creek (fig. 2), which got its name from the naturally cemented creek bottom. Historic mining in the area has degraded the stream water quality even more, resulting in increased metals in the surface water and loss of fish habitat downstream. The U.S. Geological Survey (USGS) has completed a variety of studies in the area, which will be discussed

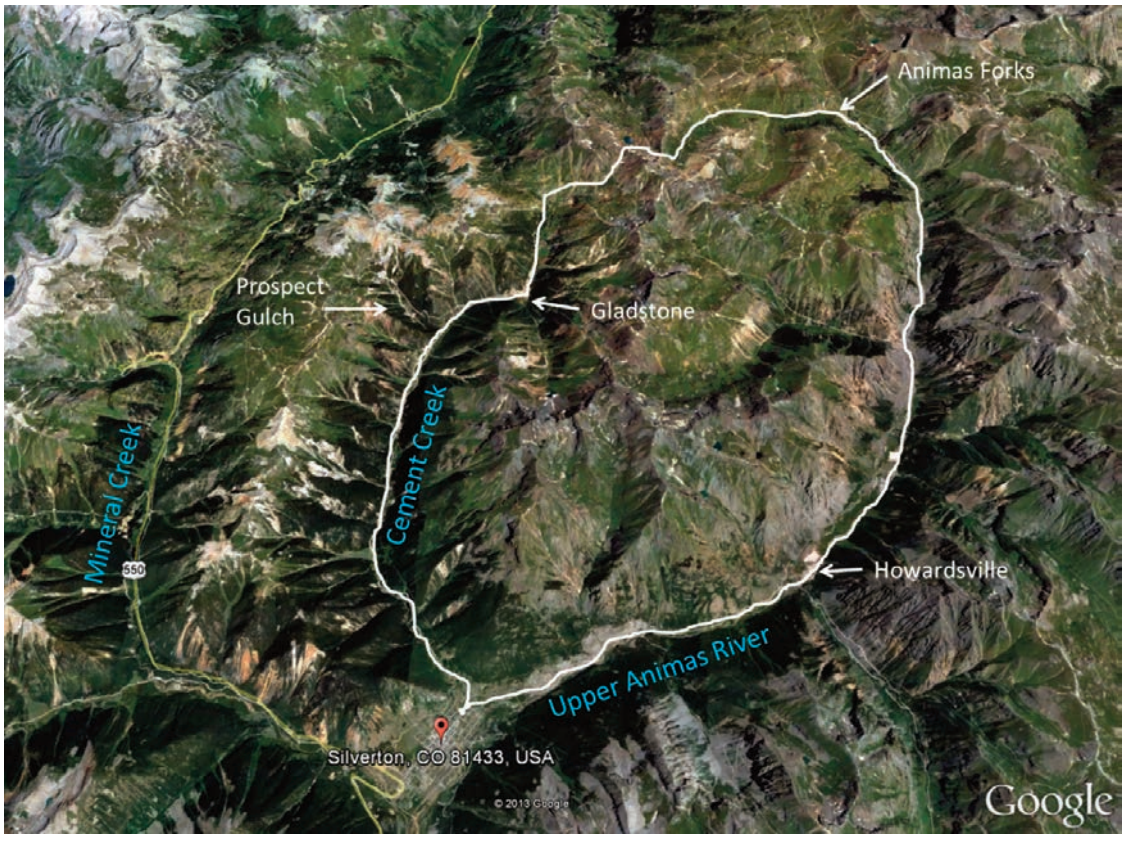

Fig. 2 *Map of 4 × 4 route on from Silverton on August 11 (while line). Map base is from Google Earth.*

throughout the day. This area was part of the USGS abandoned mine land initiative (http://amli.usgs.gov and http://amli.usgs.gov/data/animas) and a series of scientific articles were compiled and published in Church *et al.* (2007). More recent studies have used geographic information systems (GIS) to better understand the rock/water interactions that occur in the area (Yager *et al.* 2008, Yager *et al.* 2013). In addition, the Animas River Stakeholders Group (www.animasriverstakeholdersgroup.org) has been responsible for overseeing abandoned mine reclamation projects and continues to monitor the water quality in the Upper Animas River watershed.

The first stop outside of Silverton along Cement Creek will be a zone of iron-cemented gravel, or ferricrete. This ferricrete was deposited during post-glacial times and is approximately 10,000 years old. It is near the road high above the stream that has since down cut into the valley. The next stop will be Prospect Gulch. Several abandoned mines are located in this small watershed, and it was selected by the USGS for focused studies on understanding the groundwater flow and its influence on the stream water quality (Johnson and Yager 2006, Johnson *et al.* 2007, Johnson 2008). In and around Prospect Gulch, we will visit: (1) some of the groundwater monitoring wells, (2) some natural springs with acid-rock drainage, (3) sites where stream tracers were completed to measure stream flow and groundwater discharge (Wirt *et al.* 2001, Johnson *et al.* 2007), and (4) the abandoned mines, and talk about the reclamation that has been completed, including a full encapsulation of the waste rock from the Lark Mine (completed by the U.S. Bureau of Land Management).

Our next stop will be at Gladstone (fig. 2) and the mouth of the American Tunnel. This tunnel was completed to drain the mines

Fig. 3 *Map of route on August 12 from Silverton (A) to Mount Princeton Hot Springs (B) near Nathrop, Colorado. Road distance is approximately 320 km (200 mi). Map base is from www.mapquest.com.*

above it and was part of the Sunnyside Mine complex (www.mindat.org/Loc-3687.html), which produced over $150 million dollars' worth of metals. It currently has several bulkheads in an attempt to back up the groundwater to pre-mining conditions. However, this bulkheading created new discharges in open mines up the hill (like the Red and Bonita Mine that we will see later in passing). Several stream tracer studies were also completed in this area (Kimball *et al.* 2002, 2007) to better understand the water flow and quality patterns, along with being a valuable tool to assess remedial options (Walton-Day *et al.* 2007, 2012). While the Animas River Stakeholders Group (ARSG) has seen improvements in stream water quality elsewhere, the discharge from in and around the American Tunnel is still a large source of metals draining into Cement Creek. ARSG and several federal entities are currently pursuing treatment options to improve stream water quality in the immediate area.

The trip from Gladstone to Animas Forks (fig. 2) is a rugged four-wheel drive road with amazing mountain scenery. Along the way, we will overlook the Red Mountains just outside of Gladstone, pass some interesting abandoned mines, go over Hurricane Pass, and then drop into the long glacially-carved California Gulch, just before Animas Forks (http://en.wikipedia.org/wiki/Animas_Forks,_Colorado).

Animas Forks is an old mining „ghost" town with many of the old houses still standing. As we come out of the rugged mountains into a broader braided-stream river valley, we will see the abandoned Eureka Mill site and

Fig. 4 *Map of route onAugust 13 from Mount Princeton Hot Springs (A) to Cripple Creek (B). Road distance is approximately 136 km (84 mi). Map base is from www.mapquest.com.*

pass by the Mayflower Mill (fig. 2), with a large tailings impoundment next to it.

August 12: Silverton to Mount Princeton Hot Springs

After a few hours in the morning to enjoy the town of Silverton or going to overlook the edge of the Silverton Caldera, we will be touring the historic Mayflower Mill maintained by the San Juan County Historical Society (www.silvertonhistoricsociety.org). Built in 1929, the Mayflower Mill is one of the last mills in the area that is still standing. On the way out of Silverton, we will follow Mineral Creek next to highway 550 (fig. 2), where a recent stream tracer study was completed by the USGS to determine stream and groundwater flows along with changes in metal loads after recent reclamation activities (Runkel at al. 2009a, b). In the afternoon, we will be on scenic roads through the Colorado Mountains (fig. 3) and again be using Chronic and Williams (2002) to inform us about the geology. Near Gunnison (fig. 3) we will be able to see cliffs of volcanic tuff that formed from the volcanic eruptions of the Silverton caldera 28 million years ago. We will be staying at the Mountain Princeton Hot Springs Resort (www.mtprinceton.com).

August 13: Mount Princeton Hot Springs, Cripple Creek and Victor Gold Mine, and back to Golden

This day will be more travel through the mountains (figs. 1, 4) with much of the day spent touring an open pit gold mine operated by the Cripple Creek and Victor Gold Mining Company (www.ccvgoldmining.com). We will have a chance to visit a regional mine drainage tunnel for the Cripple Creek Mining District, discuss mine water management issues, and will hopefully have some time to visit the historic gold mining town of Cripple Creek (http://en.wikipedia.org/wiki/Cripple_Creek,_Colorado).

Disclaimer

All mention of company names are for informational purposes only and do not constitute any endorsement by the author or the U.S. Geological Survey.

References

Chronic H, Williams, F (2002) Roadside geology of Colorado, 2nd ed. Mountain Press, Missoula, Montana, 399 p

Church SE, von Guerard P, Finger SE, eds. (2007) Integrated investigations of environmental effects of historical mining in the Animas River watershed, San Juan County, Colorado. U.S. Geological Survey Professional Paper 1651, 1,096 p. plus CD-ROM [In two volumes] (http://pubs.usgs.gov/ pp/1651/)

Johnson RH (2008) Geologic controls on metal transport in groundwater within an alpine watershed affected by historical mining (Chapter G) in Verplanck PL, ed., Understanding contaminants associated with mineral deposits. U.S. Geological Survey Circular 1328, 96 p (http://pubs.usgs.gov/ circ/1328/)

Johnson RH, Wirt L, Manning AH, Leib KJ, Fey DL, Yager DB (2007) Geochemistry of surface and groundwater in Cement Creek from Gladstone to Georgia Gulch and in Prospect Gulch, San Juan County, Colorado. U.S. Geological Survey Open-File Report 2007–1004 (http://pubs.usgs.gov/of/ 2007/1004/)

Johnson RH, Yager DB (2006) Completion reports, core logs, and hydrogeologic data from wells and piezometers in Prospect Gulch, San Juan County, Colorado. U.S. Geological Survey Open-File Report 2006–1030 (http://pubs.usgs.gov/of/2006/ 1030/)

Kimball BA, Walton-Day K, Runkel RL (2007) Quantification of metal loading by tracer injection and synoptic sampling, 1996–2000 (Chapter E9), in Church SE, von Guerard P, Finger SE, eds., Integrated Investigations of Environmental Effects of Historical Mining in the Animas River Watershed, San Juan County, Colorado. U.S. Geological Survey Professional Paper 1651, (1):417—495. (http://pubs.usgs.gov/pp/1651/)

Kimball BA, Runkel RL, Walton-Day K, Bencala KE (2002) Assessment of metal loads in watersheds affected by acid mine drainage by using tracer injection and synoptic sampling—Cement Creek, Colorado, USA. Applied Geochemistry 17(9):1183—1207, doi:10.1016/S0883-2927(02)00017-3

Runkel RL, Bencala KE, Kimball BA, Walton-Day K, Verplanck PL (2009a) A comparison of pre- and post-remediation water quality, Mineral Creek, Colorado. Hydrological Processes, 23(23):3319—3333, doi:10.1002/hyp.7427

Runkel RL, Kimball BA, Steiger JI, Walton-Day K (2009b) Geochemical data for upper Mineral Creek, Colorado, under existing ambient conditions and during an experimental pH modification, August 2005. U.S. Geological Survey Data Series 442, 41p (http://pubs.usgs.gov/ds/442/)

Walton-Day K, Paschke SS, Runkel RL, Kimball BA (2007) Using the OTIS solute-transport model to evaluate remediation scenarios in Cement Creek and the Upper Animas River (Chapter E24) in Church SE, von Guerard P, Finger SE, eds., Integrated Investigations of Environmental Effects of Historical Mining in the Animas River Watershed, San Juan County, Colorado. U.S. Geological Survey Professional Paper 1651, (2):973—1028 (http://pubs.usgs.gov/pp/1651/)

Walton-Day K, Runkel, RL, Kimball BA (2012) Using spatially detailed water-quality data and solute-transport modeling to support total maximum daily load development. Journal of the American Water Resources Association (48):950—969, doi:10.1111/j.1752-1688.2012.00662.x

Wirt L, Leib KJ, Melick R, Bove D (2001) Metal loading assessment of a small mountainous sub-basin characterized by acid drainage—Prospect Gulch, upper Animas River watershed, Colorado. U.S. Geological Survey Open-File Report 2001–0258, 36 p (http://pubs.usgs.gov/of/2001/ofr-01-0258/)

Yager DB, Johnson RH, Rockwell BW, Caine JS, Smith KS (2013) A GIS and statistical approach to identify variables that control water quality in hydrothermally altered and mineralized watersheds, Silverton, Colorado, U.S.A. Environmental Earth Sciences, doi:10.1007/s12665-013-2229-y

Yager DB, Johnson RH, Smith BD (2008) Using a geographic information system (GIS) to determine the physical factors that affect water quality in the Western San Juan Mountains, Silverton, Colorado (Chapter M) in Verplanck PL, ed., Understanding contaminants associated with mineral deposits. U.S. Geological Survey Circular 1328, 96 p (http://pubs.usgs.gov/circ/1328/).

Yager DB, Bove DJ (2002) Generalized geologic map of part of the upper Animas River watershed and vicinity, Silverton, Colorado. U.S. Geological Survey Miscellaneous Field Studies Map MF–2377, scale 1:48,000 (http://pubs.usgs.gov/mf/2002/ mf-2377/)