Geology of the Cripple Creek gold-telluride deposit, Colorado: Descriptions and locations of field trip stops

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All coordinates in UTM projection, NAD27 datum for the conterminous US.

Field trip stops will include several stops outside of the Cripple Creek & Victor (CC&V) mining operation (stops 1-6) at which we will view examples of rock types, alteration and mineralization that are located in distal positions in the district. We will then enter the mine and see representative rock types and styles of alteration and mineralization present in the central portions of the district (stops 8-10). Field trip stop locations and access routes are shown relative to district geologic features on figure 1.

Stop 1: Gillette Flats (489410E 4292226N)

This stop is located atop a portion of a regional Eocene-aged erosional surface west of Pikes Peak, and provides a panoramic perspective of the Cripple Creek intrusive/volcanic complex. Prominent conical-shaped hills ring the horizon to the east, south and west; these represent erosional remnants of Oligocene-aged phonolitic intrusive centers that were emplaced as part of the volcanism related to the Cripple Creek gold deposit. Phonolite is the dominant rock type in the Cripple Creek district – these rare igneous rocks are essentially composed of alkali feldspar (sanidine) and feldspathoids, with minor green aegirine-augite pyroxene. When unaltered, these rocks exhibit a dark green-gray color, but become bleached in zones of sulfide-bearing hydrothermal alteration. Few phonolitic rocks in the immediate vicinity of gold mineralization have escaped the effects of alteration in the district. The best examples of fresh rocks can be found in the distal, satellite intrusive complexes that lie outside of the main diatreme complex.

Although relatively uncommon at global scales, phonolitic magmatism does occur frequently in and around rift zones, and the position of the Cripple Creek volcanic complex relative to the Rio Grande rift bears similarity with phonolitic volcanoes in off-axis positions in the East African Rift zone.

Stop 2: Panoramic view of Cripple Creek (485976E 4289856N)

This brief stop is intended to provide a view of the town of Cripple Creek. Note the historic attempts at small bulk-tonnage mining operations to the north. Small amounts of placer production also came from the valley below this stop. Although Cripple Creek represents a world-class gold district, relatively little placer gold has been mined from the area. This is typical of many gold deposits associated with alkaline magmatism, around which placer deposits are commonly under-developed or lacking entirely.

In the road cut opposite of the parking area, contacts between Precambrian rocks and Tertiary diatremal breccias are exposed. This contact is marked by intense hydrothermal alteration, and mineralized veins can be seen in outcrop. We will not take the time to inspect the outcrops as our next stop will provide better exposures of a similar contact on the other side of the diatreme complex.

Stop 3 (485806E 4286770N): Exposures of the diatreme margin in "Squaw Gulch", near the former townsite of Anaconda

Exposed in this area is the margin of the diatreme complex. ***Please be careful of passing traffic at this location!*** At the western end of exposures in this road cut are Precambrian granitoid rocks that exhibit intense K-metasomatism (replacement by hydrothermal K-feldspar) and numerous veins. One especially prominent structural zone in the road cut is occupied by a large quartz vein, and historic diggings can be seen along strike of the vein. This vein is unusually large for veins in the Cripple Creek district, and also contains high base metal values. Veins with high Pb and Zn are common in peripheral and distal portions of the system, although some are seen in the interior of the complex as well.

Moving to the east, you will recognize zones where the granitic rocks become densely fractured and brecciated, and if you look closely, you will recognize numerous intrusions of fine-grained to porphyritic feldspathic rocks which lack igneous quartz crystals. These are phonolitic rocks that appear as irregular masses and dikes, and exhibit the variegated limonitic staining typical of highly altered rocks in the district. Moving further to the east, you will recognize that zones of brecciated granitic rocks give way to masses of heterolithic breccia composed of phonolitic material and xenolithic fragments of the country granitic rocks supported by a rock flour matrix. Also note that multiple contacts between granitoid rocks and Tertiary breccias are seen in these exposures, which illustrates the dynamic nature of the diatreme margin.

Stop 4: Structural features along the Mary McKinney-El Paso vein system (485694E 4285735N)

This will be a brief stop at which we will not leave the vehicles. Along the east side of the road is an exposure of bedrock which exhibits an example of the types of fracture systems which can host mineralization in the district. In looking at the outcrops, you can recognize a NE-trending, subvertical sheeted fracture system that is developed roughly perpendicular to the road cut. The fracture system is developed along the trend of the Mary McKinney-El Paso vein systems (the El Paso headframe can be seen to the west), from which an aggregate of >1.3 million ounces of gold were produced. The sheeted fracture zones that host mineralization in the district can be subtle in their appearance, and often demonstrate little or no offset of the surrounding wall rocks. Commonly, these zones are expressed as parallel fracture sets, in which mineralizing veins may only achieve a few centimeters in width.

Stop 5: Victor Community Center. At this stop we will view a presentation of the three dimensional model of the geology and underground workings in the Cripple Creek district

Over a century of mining has taken place at Cripple Creek, and due to the commonly narrow and anastomosing nature of the high grade vein systems, a complex lattice of underground mine workings were excavated during the historic mining activities. These historic workings present challenges and opportunities for present day mining activities in the district. As surface excavations continue in the district, many underground workings have been exposed, some of which have vertical dimensions of >100 m and represent serious safety concerns. Likewise, because the underground workings were positioned along zones of mineralization, their distributions mimic the key ore controls in the district. Thus, it is essential for the ongoing exploration and mining activities to understand the nature and distribution of those features. Over the past decade, CC&V has made a concerted effort to digitize and geo-register historic maps of the underground workings. This includes the thousands of maps stored on site as well as maps from numerous private collections. A key resource is also the 1965 Open File Report compiled by former USGS geologist Albert Koschmann (Mine maps of the Cripple Creek district, Colorado: U. S.

Geological Survey Open File Report 65-90, 528 map sheets, 18 portfolios), who spent many years working in the Cripple Creek district. Koschmann compiled an impressive array of maps and mine level plans of underground workings in the district, and these provided essential portions of the digitized model. Numerous CC&V geologists and staff members participated in the process of the digitization and creation of the three dimensional models, and many years of work went into constructing the model.

In addition to the underground workings, geologic contacts have also been digitized and interpolated to create the impressive three dimensional geologic model. The digital geologic model is based in the thousands of exploration holes that have been drilled in the Cripple Creek district, as well as information gleaned from the underground mine and level maps in the district.

Stop 6: Independence Headframe (intended lunch stop; 488263E 4284733N)

This stop provides a view of the historic town of Victor, as well as the site of Stratton's famous Independence Mine, one of the first major mines to be constructed in the district. Seen in and around the mine workings in this area are zones of strongly altered Precambrian granitic rocks and Tertiary phonolitic intrusions and breccias positioned along the southern margin of the diatreme complex. By peering down through the steel grates that cover the abandoned mine workings, you can gain an appreciation for the scope and nature of the historic operations. Also seen in this area, particularly down the hill from the Independence Mine are phonolitic dikes that have intruded the Precambrian rocks in a sub-radial pattern (488483E 4284509N). These dikes are bleached, and typically exhibit intense K-silicate (K-feldspar) and fluorite bearing styles of alteration. Considering that the dikes are strongly altered, the relatively weak and under-developed expressions of alteration in the surrounding Precambrian granitoid rocks is particularly notable. These exposures help illustrate the utilization of igneous intrusions as fluid conduits, and how subtle alteration can be in the area.

Stop 7: (optional) Panoramic view of the western side of the Cripple Creek district (486751E 4288163E)

Seen in the foreground is the heap leach operation at the Cresson Mine, the town of Cripple Creek, and the prominent headframe of the El Paso Mine to the southwest. Mount Pisgah forms the prominent conical peak behind Cripple Creek. Seen on the southwestern horizon are the Sangre de Cristo Mountains.

Stop 8: Overlook into deep levels of East Cresson open pit (488460E 4286966N)

Looking SSE across the pit, visible in the opposite highwall are a series of underground mine workings positioned along the Vindicator-Hull City vein system trend. The Vindicator headframe can be seen in the background, and "Big Bull Hill" forms the horizon immediately above the Vindicator Mine. Note the presence of steep-dipping mineralized structures in the highwall (expresses as dark seams of limonitic oxides). In addition to the veins, also visible in the highwall are a group of steep-angled phonolitic dikes, and a prominent phonolite sill. In the Cripple Creek district, phonolites were intruded during several pulses of activity. Large masses of phonolite (commonly with porphyritic textures) were emplaced during the early stages of magmatic activity. In the Altman area, these form the bulk of the mass of volcanic, and comprise much of the rock visible in the highwalls at this stop. Those early stage porphyritic masses of phonolite were intruded by successively more mafic intrusions, culminating with the emplacement of phonotephrite dikes (essentially alkaline basalts). Intrusions of phonotephrite dikes were followed by a renewed pulse of phonolitic activity, which is manifested as the high angle dikes seen in these exposures. Note that the sill has been offset by the vertical dikes, as well as the fracture sets carrying the veining. Following the emplacement of the late stage phonolitic dikes, lamprophyric rocks (not visible in these exposures) were emplaced, followed by the development of gold mineralization and veining.

Accompanying the mineralization event was intense potassic alteration and sulfidation of wall rocks; this alteration gives the originally dark green rocks their current grey color, where pyrite has replaced most or all of the mafic minerals in the rock. In the zones of oxidation, the pyrite has been oxidized to limonite, giving the rocks an orange or bleached color, often with variegated lisegang banding visible on fractured surfaces .

Seen opposite the survey monument to the NNW are a series of sheeted veins developed in phonolitic host rocks. These veins are dominated by limonite, but seams of hydrothermal quartz, amorphous silica, and less common fluorite can be seen in these exposures. These veins are typical of the dimensions of mineralized structures seen in pit exposures.

Stop 9: Deep levels of the main Cresson Pit in the vicinity of the "Bluebird" aphanitic phonolite dike (487839E 4286692N)

The Bluebird dike is a NNW dike the follows a dominant structural trend seen in the district. Two major phases of phonolitic intrusive activity took place in the district, and the Bluebird dike was emplaced during the second episode. As seen in these exposures, the Bluebird dike cuts through both older generations of phonolitic intrusive rocks and volcanic breccias. Intense K-feldspar + pyrite alteration and gold mineralization are developed along the margins of the dike, along with fluorite-bearing sulfide veins. These features suggest that the Bluebird dike served to focus the migration of ore-bearing fluids along its margins.

Veins and alteration are also developed in phonolitic rocks and breccias adjacent to the dike, and samples of fluorite-bearing veins can be collected from fallen rocks that lie on the bench. ***Please do not approach the highwall in these exposures – representative samples can be collected from rocks found on the bench away from the highwall.***

Stop 10: Exposures of Cresson Pipe (lamprophyric breccias; 487446E 4286321N)

The Cresson Pipe, a lamprophyre breccia, represents one of the more notable geologic features in the district. Lamprophyric rocks are the youngest known igneous rocks exposed in the district. Although they constitute only 1-2% of the volume of igneous rocks in the district, mineralized lamprophyres were mined in roughly 1/3 of the mines in the Cripple Creek district.

Lamprophyric rocks derive their name from the greek root "lampros" and "porphyros" which combine to mean "glistening porphyry"; the name was first applied to mafic to ultra-mafic rocks rich in biotite phenocrysts that appear to glisten within the drab, fine-grained mafic groundmass. As commonly applied, the term lamprophyre is used as a field classification to describe mafic to ultramafic rocks with hydrous mafic phenocrysts, and if feldspars are present they are restricted to the groundmass of the rocks.

The Cresson pipe is an elliptical, pipe-shaped body of breccia elongated ENE, with an average diameter of approximately 100 meters. The pipe plunges steeply to the south, tapering and becoming increasingly tabular at depth, and eventually bifurcating into two roots ~600m below the surface. The pipe is composed of heterolithic rock fragments, including a predominance of mafic and ultra-mafic clasts that are supported by a matrix that varies from a fine-grained, crystalline lamprophyric matrix rich in clinopyroxene and analcime (commonly altered to montmorillonite clays and carbonate), to a leucocratic matrix of carbonate-analcime-alkali feldspar±quartz. In portions of the pipe, the leucocratic matrixes contain rounded blebs of dark lamprophyric material. In thin section, the "blebs" are concentrically zoned, and exhibit fine-grained outer rims. These textures suggest that the "blebs" are not mechanically comminuted rock fragments, but were liquid at the time of incorporation into the leucocratic matrixes.

These may reflect processes of liquid-liquid immiscibility, with the leucocratic matrixes representing lowdensity, hydrous phases that were exsolved from lamprophyric melts during crystallization.

The Cresson pipe both cuts and is cut by lamprophyric dikes. Gold mineralization was strongly developed along the margins of the pipe, and appears to form an annulus around the pipe. Roughly 2.5 million onuces of gold were produced from the Cresson Mine, much of which was mined from the stopes along the pipe margins. It is interesting to note that fluorite was common in wall rocks within the annulus of mineralization that surrounds the pipe, but was notably absent from veins the cut into the lamprophyric rocks inside the pipe.

Perhaps the most notorious discovery in the district was made inside the Cresson Mine and is referred to as the "Cresson Vug". This "vug" was a cavity 8 m x 4 m wide and 13 m high that was opened in the Cresson mine in November, 1914. The cavity walls were lined with gold tellurides, quartz, celestite and a white, soft mineral that was probably kaolinite or dickite. By the end of 1914, nearly 20,000 ounces of gold had been removed from the cavity. Good descriptions can be found in Patton and Wolf, 1915; Preliminary report on the Cresson gold strike at Cripple Creek, Colorado: Colorado School of Mines Quarterly, v. 9, p. 1-15 and Smith et al.,1985; The Cresson Vug, Cripple Creek: The Mineralogical Record, v. 16, p. 231-238.

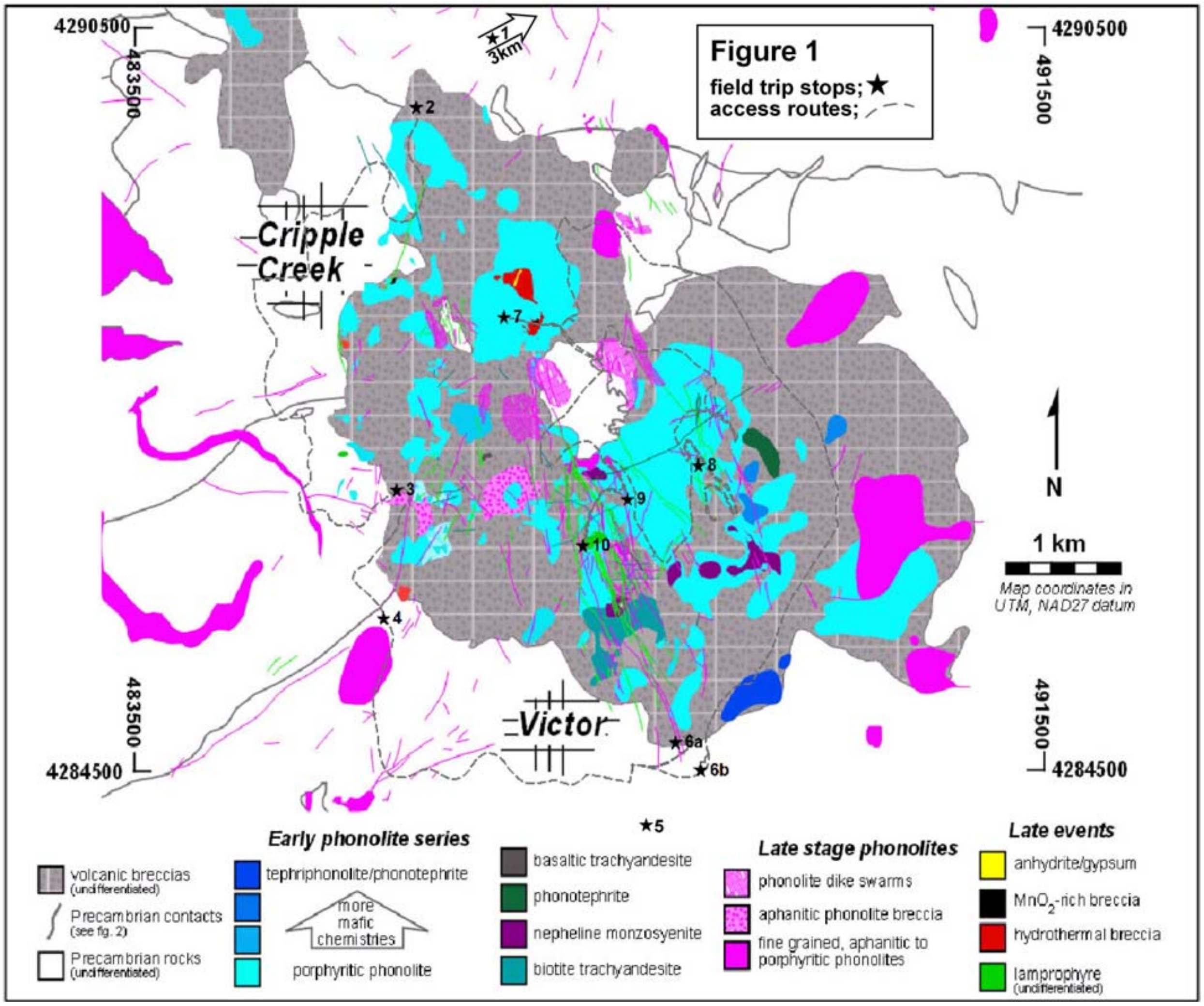
Figure 1
field trip stops; ★
access routes;
4290500
483500
491500
4284500
Cripple Creek
Victor
★2
★3
★4
★5
★6a
★6b
★7
★8
★9
★10
★7 3km
N
1 km
Map coordinates in UTM, NAD27 datum
volcanic breccias (undifferentiated)
Precambrian contacts (see fig. 2)
Precambrian rocks (undifferentiated)
Early phonolite series
tephriphonolite/phonotephrite
more mafic chemistries
porphyritic phonolite
basaltic trachyandesite
phonotephrite
nepheline monzosyenite
biotite trachyandesite
Late stage phonolites
phonolite dike swarms
aphanitic phonolite breccia
fine grained, aphanitic to porphyritic phonolites
Late events
anhydrite/gypsum
MnO2-rich breccia
hydrothermal breccia
lamprophyre (undifferentiated)