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GEOLOGY AND MINERALIZATION OF THE COOPER HILL MINING DISTRICT, MEDICINE BOW MOUNTAINS, SOUTHEASTERN WYOMING

by

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Abstract

The Cooper Hill mining district, located along the northeastern flank of the Medicine Bow Mountains in southeastern Wyoming, consists of an allochthonous block of amphibolite grade metasedimentary and metavolcanic rock of Proterozoic age. Metamorphic rocks include metalimestone, mica schist, quartzite, metabasalt, amphibolite, and metaconglomerate which are intruded by mafic sills and dikes These rocks have been affected by at least three episodes of deformation.

Mineral deposits include skarns, veins, and placers. Past production included some gold, silver, lead, and copper ore.

Introduction

The Cooper Hill mining district lies along the northeastern edge of the Medicine Bow Mountains in Carbon County of southeastern Wyoming (**Figure 1**). Cooper Hill, a prominent treeless "bald" hill is clearly visible from Interstate 80 in the vicinity of Cooper Cove. The district was an active mining district during the last decade of the nineteenth century and the first decade of the twentieth century. Some gold, silver, copper, and lead was recovered from this district, but the amount of ore is unknown and believed to have been minimal.

Cooper Hill has been interpreted as an allochthonous block of Proterozoic crystalline rock located along the northeastern edge of the Medicine Bow Mountains. Structurally, the Arlington thrust placed ancient Precambrian rock on top of younger Phanerozoic sedimentary rock (King, 1963; Blackstone, 1973).

The rocks comprising Cooper Hill are typical of the miogeosynclinal metasedimentary succession found throughout much of the northern Medicine Bow Mountains and includes quartzite, mica schist, metaconglomerate, metalimestone, and amphibolite. Mineralization is associated with veins, skarns, and placers (Hausel, 1992). Sulfides include chalcopyrite, pyrite, galena, and polybasite (Schoen, 1953).

Acknowledgements

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Location and Access

The Cooper Hill mining district is located along the northeastern edge of the Medicine Bow Mountains in T18N, R78W, about 7 miles southeast of Arlington (**Figure 1**). The district encloses Cooper Hill and the adjacent gold placers in Dutton and Cooper Creeks and is accessible from Interstate 80 at the Cooper Cove Road exit. From the exit, the district is reached by two dirt roads across private property. The northern road leads to Woodedge, and the southern road leads to Morgan. Morgan and Woodedge are villages with a small number of summer cabins.

Mining History

Introduction

Cooper Hill and the surrounding streams lie within what is currently referred to as the Cooper Hill mining district. Historically, the district was flanked by the Herman mining district on the northwest, and the Bald Mountain and Mill Creek districts on the south. The Cooper Hill district has also been referred to as the Cooper Creek mining district, has been included in the Herman mining district (Duncan,1990, p. 180), and has erroneously been referred to as the Bald Mountain district. The Herman district (T19N, R78W) northwest of Cooper Hill, consisted mostly of placer deposits with a few lodes on Foote and Rock Creeks (Laramie Mining and Stock Exchange, 1896, p.12). The Engineering and Mining Journal (EMJ) (1894, v. 57, June 16, p. 567) reported a few scattered lode and placer deposits in the Mill Creek and Bald Mountain districts (T16N, R78W) south of Cooper Hill.

In the early part of 1876, placer gold was discovered on Rock Creek northwest of Cooper Hill near the old Overland Trail. The discovery was made by prospecting loose dirt in the trail. In May, 1877, ditches were constructed to supply water for hydraulic mining operations to the area, but the activity apparently subsided within a few years (Wyoming Industrial Journal,1907, v. 9, no. 4, p. 4).

Many years later in 1897, placer operations began again in the Rock Creek area. By June of 1897, the Overland Gold Mining Company (reported to hold about 11,000 acres of placer ground near Rock Creek) had constructed at least three miles of ditches with 800 feet of flume with iron riffles that led from Foote and Wagon Hound Creeks to Rock Creek. The placer gravel was 4 to 9 feet deep with widely dispersed and granular gold (EMJ, 1897, v. 63, June 5, p. 583).

Later in June, 1897, an additional 500 feet of flume had been added to accommodate the large quantity of gravel being mined at Rockdale (Arlington ?). Two Giants were operating day and night washing 20,000 cubic yards of gravel in a 20 foot face on the east bank of Emigrant Gulch (NW section 24, T19N, R79W). The gravel reportedly averaged $0.75/yd^3 (0.036 oz/yd^3) gold, and additional Giants were planned (EMJ, 1897, v. 63, June 26, p. 673). Samples recently panned by the Geological Survey of Wyoming in gravels along Rock Creek, Wagonhound Creek, and Foote Creek yielded anomalous gold.

Some lode deposits were also development in the region. The Laramie Mining and Stock Exchange (1896) reported considerable work was being done on Threemile Creek a few miles west of Cooper Hill. The ore bodies were described as strong and well defined, carrying gold and silver, and hosted by granite.

At Bald Mountain to the south, it was reported some ore recovered from the 50 foot level of a mine contained $54 (2.6 ounces) in gold, 3 ounces silver, and 4% copper (EMJ, 1895, v. 60, Oct. 5, p. 332). At the head of Mill Creek between Bald Mountain and Cooper Hill, the Laramie Mining and Stock Exchange (1896) reported immense veins. Recent samples panned from Mill Creek by the Geological Survey of Wyoming contained pinhead colors of gold.

Cooper Hill

Placer gold may have been found in Cooper Creek as early as 1854, but whether or not gold was found this early in time can not be accurately assessed. In 1877, the King (40th parallel) Survey reported rumors of gold in Cooper Creek, but no apparent verification was made (Hague and Emmons, 1877). By 1896, placer gold had been discovered in the Cooper Hill district. According to EMJ (1896, v. 62, July 4, p. 15) several thousand acres of placer ground were staked along the North and South Forks of Cooper Creek and on the South Fork (East Fork ?) of Dutton Creek.

The first known report of lode mineralization on Cooper Hill was in the early summer of 1893, when claims were staked following the discovery of gossaniferous outcrops. A short time later, small scale mining began (Duncan, 1990).

Over the next few years, high-grade ore was mined and stockpiled in anticipation of construction of a mill and smelter in the district. In 1896, EMJ (1896, v. 62, Nov 21, p. 495) reported that the Carbon County and Gold Coin Mining Company had contracted for construction of a 10 stamp mill to be built in Denver with concentrating tables, a large boiler and engine, and a 5 ton jacket smelter. In the following year of 1897, a ten stamp mill was delivered and placed at the south end of Cooper Hill, and 300 tons of the stockpiled ore from the Albion and Emma G mines were processed yielding an average of $17.50 per ton (Duncan, 1990). According to Duncan (1990), the smelter was not delivered, thus the base metals (lead and copper) and refractory precious metals of the stockpiled ore could not have been recovered unless the ore had been shipped.

In 1906, Henry C. Beeler, Wyoming State Geologist, visited the Cooper Hill district. His report noted that the Emma G mine produced the richest float in the district, the Albion mine produced the greatest body of gold and galena, the Richmond mine produced the greatest amount of free-milling gold, and the Cooper Hill mine (location unknown) produced the greatest amount of copper in the district (Beeler, 1906). He also mentioned an immense vein of sugar quartz along the west side of Cooper Hill carried free-milling gold which consistently averaged 0.1 to 0.2 opt (ounce per ton) of gold. Beeler also mentioned some ore (undoubtedly some rare and selected specimen grade material) assayed as high as $84,000 per ton.

A detailed study on the geology and mineralization of the Cooper Hill district did not take place until Schoen (1953) characterized Cooper Hill as a folded succession of layered metasedimentary and metaigneous rock which had been subjected to two episodes of mineralization. Later, King (1963) mapped the northeastern Medicine Bow Mountains with emphasis on Cooper Hill and concluded that Schoen's (1953) stratigraphic succession could not be "rigorously demonstrated". In contrast to Schoen's earlier mapping, King's (1963) remapping of Cooper Hill viewed the district as a large block of quartzite cut by amphibolite with scattered floating marble reefs. A later study by Karlstrom and others (1981) incorporated King's mapping into their regional study of the stratigraphy of the Medicine Bow Mountains and Sierra Madre.

This current investigation began with detailed geologic mapping of Cooper Hill at a 1:12,000 scale in the summer of 1991 (**Plate 1**), followed by a historic literature search in the winter of 1992. In conjunction with mapping, samples were collected from most mine dumps and prospects for assay and additional samples were collected for whole rock, hand specimen, thin section, and XRD (x-ray diffraction) studies. Schoen (1953) had the advantage of access to some underground workings which were not accessible during this present study.

Geology

Cooper Hill is an allochthonous block of Precambrian rock that has been interpreted as either a gravity slide originating from the west in the main body of the Medicine Bow Mountains (King, 1963), or as an eastward klippe or salient on the Arlington thrust. The district is underlain by Proterozoic metasedimentary and metaigneous rock deposited in a miogeoclinal basin along the margin of the Wyoming craton (Archean) possibly 1.7 to 2.5 Ga (billion years) ago (Karlstrom and others, 1981). Archean rocks, however, do not crop out at Cooper Hill.

The regional geologic map of the Medicine Bow Mountains shows the northern portion of Cooper Hill to be underlain by Vagner Formation metasedimentary rocks and the southern portion to be underlain by older rocks of the Cascade Quartzite (Karlstrom and others, 1981). Typically, the Vagner Formation consists of diamictite, marble, chlorite-biotite-quartz schist, and quartzite; whereas, the Cascade Quartzite consists of quartz-arenite with quartz and black chert pebble conglomerate. These formations form part of the Deep Lake Group (Proterozoic).

During mapping of Cooper Hill, some inconsistencies with the earlier studies began to evolve. Quartz-pebble conglomerate with quartz and black chert pebbles typical of Cascade Quartzite conglomerate (Paul J. Graff, personal communication, 1991) was found and mapped on the northern half of the hill near the 9,198 foot elevation point (**Plate 1**). If this is Cascade Quartzite conglomerate, it is underlain by metalimestone, mica schist, and quartzite typical of the younger Vagner Formation. This perplexing stratigraphy suggests the lithologies to be overturned. However, it is also possible we are seeing an upper portion of the Vagner Formation that is not preserved in the mountains to the west (R. S. Houston, personal communication, 1992). Since no facing indicators could be found to differentiate top from bottom, formation names were eliminated in favor of lithologic descriptions in this report.

The present mapping study generally agrees with Schoen (1953) rather than King (1963), and interprets the district as a folded succession of Proterozoic metasedimentary and metaigneous rock with a minimum exposed thickness of 800 feet. The stratigraphic succession is dominated by quartzite containing local quartz-pebble conglomerate underlain by metalimestone, mica schist, amphibolite, and quartzite. The steep hill sides are scree covered with few rock exposures. However, there is enough exposure to confidentially confirm much of Schoen's stratigraphic succession.

Structure and metamorphism

With only a few good exposures over a relatively small area, the structural history of Cooper Hill could not be unravelled with any confidence. Precambrian rocks on Cooper Hill appear to be complexly folded and to have been subjected to more than one episode of deformation. Complex folding was also indicated in the metasedimentary succession to the west in the Herman district (King, 1963). The attitude of the lithologic units on Cooper Hill are different from the miogeoclinal metasedimentary rocks to the west in the main body of the Medicine Bow Mountains (Robert S. Houston, personal communication, 1991). The lithologic units on Cooper Hill, have relatively flat dips, whereas in the adjacent uplift, they dip comparatively steeply to the southwest.

Between 2.5 Ga and 1.7 Ga, the sediments and mafic volcanics of Cooper Hill were deposited in a miogeoclinal basin near the margin of the Wyoming craton. These were later lithified and folded into a series of small scale isoclinal folds with northeast-southwest trending axial plane traces.

Refolding produced northwesterly trending open antiforms and synforms. The principal Proterozoic structure on the northern segment of Cooper Hill is a synformal basin cored by quartzite. This synform is separated from a similar quartzite-cored synform in the southern portion of the hill by a fault-bounded horst (?) composed of amphibolite (metabasalt) and capped by an erosional remnant of folded metalimestone. The bedding in the limestone is isoclinally folded and have later been refolded into an open synform. The antiform traces between the synforms have been cut by east-west-trending Laramide faults. The Albion vein near the northwestern flank of the hill apparently predated the refolding event based on the mine map produced by Schoen (1953) which indicates open folds in the vein as well as ore shoots in fold closures.

Regional amphibolite grade metamorphism probably accompanied the initial folding event at Cooper Hill. Schoen (1953, p. 27) more specifically characterized this event as albite-epidote-amphibolite facies metamorphism. During regional metamorphism, the supracrustal succession inherited foliation which is displayed in most rocks in the district. Mica in quartzite and metaconglomerate is foliation parallel, pebbles are stretched in the plane of foliation, mica schists are strongly foliated, and several amphibolites exhibit weak to distinct foliation.

Following regional metamorphism, the rocks of Cooper Hill were intruded by gabbroic and basaltic dikes and sills. Hydrothermal alteration accompanied the intrusion of some of the mafic sills producing localized skarns in metalimestone.

Brittle deformation during the Laramide orogeny resulted in the Medicine Bow Mountains being thrust eastward on the Arlington fault followed by the breaking of the thrust sheet into a series of fault blocks. The eastern flank of the Medicine Bow Mountains (including Cooper Hill), have been placed on Phanerozoic sedimentary rock. This overthrust has been verified by exploration wells drilled for petroleum by Union Pacific Resources and Exxon. The wells spudded northwest and south of Cooper Hill in sections 10 and 11, T17 N, R78W and section 36, T19 N, R79W cut 2,000 to 5,000 feet of Precambrian crystalline rock in the toe of the thrust prior to intersecting overturn Mesaverde sedimentary rock below the thrust sheet (Paul J. Graff, personal communication, 1991).

Cooper Hill projects east of the thrust trace and may either represent a salient on the thrust, or may instead represent a gravity slide with the trace of the thrust located west of Cooper Hill in the Dutton Creek valley. For example, King (1963, 1964) interpreted Cooper Hill as a gravity slide which "*originated from the west during thrusting along the Arlington Thrust*", and Blackstone (1973, Plate 2) mapped the trace of the Arlington thrust 1/4 mile west of Cooper Hill indicating the hill to be a rootless klippe lying on Cretaceous Steele Shale, Mesaverde Formation, and Tertiary Hanna Formation.

Rock Units

Cooper Hill consists of Proterozoic age metamorphic rock covered by a widespread skirt of scree. Quaternary age colluvium and pediment gravels, and Tertiary age Hanna Formation conglomerates occur along the flanks of Cooper Hill (Blackstone, 1973).

Four general rock types were mapped on Cooper Hill during this study. These are amphibolite, quartzite, metalimestone, and mica schist.

Amphibolite

Amphibolite on Cooper Hill includes mafic rock with a variety of textures. All of the mafic rock types examined during this project are assumed to be of igneous origin and can be texturally separated into amphibolite, metagabbro, metabasalt, and chlorite schist. These rocks are fine- to coarse-grained dark grey, green, and black rocks and range from foliated, weakly foliated, and nonfoliated varieties on the megascopic scale.

Petrographic descriptions by King (1963) describe coarse-grained amphibolite to consist of amphibole of variable size with irregular patches of quartz (xenoblastic) and some corroded crystals of plagioclase in the amphibole matrix. Biotite is found as small irregular patches associated with amphibole, rutile, and an opaque mineral. Sphene and epidote are reported in some samples. Fine-grained amphibolite is described as fine-grained to granoblastic consisting of ubiquitious epidote, randomly oriented biotite, and small acicular amphibole set in a matrix of xenoblastic quartz (King, 1963).

Coarse-grained hornblende gneiss (metagabbro) described by Schoen (1953) consisted of 75% hornblende, 15% quartz (with sutured boundaries), 8% magnetite, and 2% chlorite (replacing hornblende). Medium-grained hornblende gneiss (metadiabase) was described as having 62% hornblende, 30% quartz, 5% chlorite, and 3% magnetite. Schoen (1953) also reported metabasalt to exhibit periodic columnar jointing. The presence of columnar joints was not confirmed by the author.

A prominent coarse-grained, foliated metagabbro sill with blasto-subophitic to gneissic texture was sampled from the synformal basin a short distance north of Morgan on top of the hill surrounding the 9,214 foot elevation benchmark (**Plate 1**). This possibly is the same rock described by Schoen above, although it does not contain as much magnetite. Whole rock analysis of this metagabbro (sample CH42-91, **Table 1**) is comparable to a high-iron tholeiitic magma. The rock contains 6.22% MgO, 51.3% SiO_2, 1.51% TiO_2, and has a Ti/V ratio of 15.

Fine-grained amphibolite (metabasalt and mica schist) dikes are found a short distance north of the metagabbro as well as farther north near the 9,798 foot elevation point (Plate 1). These rocks contain abundant chlorite, biotite, and hornblende with plagioclase and minor quartz in blasto-subophitic and schistose rock fabrics.

Fine-grained mafic schist (sample CH3-91, **Table 1**) from the Silver Queen mine area yielded a similar geochemical analysis comparable to the metagabbro. This schist is slightly more MgO-rich (7.06% MgO) than the metagabbro, and falls within the high-magnesian tholeiite field of Jensen (1976). The rock is interpreted to represent a metamorphosed basalt.

A sample of fine-grained amphibolite (metabasalt) collected near the apex of the hill above the Silver Queen mine (CH9-91, **Table 1**) yielded unusually high-MgO whole rock geochemistry. The high-MgO (11.29 weight percent), high chromium (2,500 ppm Cr), and high CaO/Al_2O_3 (1.2) ratio of the rock places it within the basaltic komatiite field of Jensen (1976).

A sample described as metabasalt in the field (CH22-91, **Plate 1**) collected immediately north of Morgan was analyzed for whole rock geochemistry. This rock yielded high magnesium content (12.39% MgO; 14.88% volatile free), very low silica (43.52% SiO_2), and high chromium (1,700 ppm Cr_2O_3) and nickel (387 ppm Ni) values. The MgO, Cr_2O_3, and Ni are too high for a tholeiitic magma, and fall within the compositional field of basaltic komatiite. The CaO/Al_2O_3 ratio of 1.2 is also consistent with basaltic komatiite chemistry, however, the lack of any spinifex or cumulate textures characteristic of komatiite suggests possible affinity for a pyroxenite dike.

The amphibolites examined during this study probably represent pyroxenites, gabbros, basalts, and norites. Similar high-magnesian amphibolites were reported in the Sierra Madre west of the Medicine Bow Mountains by Houston and others (1975). The Sierra Madre amphibolites were classified as gabbros, norites, and pyroxenites based on petrography and geochemistry.

Metalimestone

Relatively thin beds of metalimestone crop out on Cooper Hill. The rock is grey, white, to brown laminated and contorted metamorphosed carbonate or calc schist. Thin quartz-rich layers in the carbonate produce distinct recumbent isoclinal folds. Typically, the rock is massive to recrystallized and has a fine-grained crystalline texture and is reactive to dilute hydrochloric acid. Based on response to hydrochloric acid and its fine-grained to massive texture, the rock is referred to as a metalimestone in this report, although locally it has been upgraded to marble.

In hand specimen, the rock includes abundant calcite, minor quartz, and minor to accessory chlorite and biotite. Schoen (1953) described some samples with nearly equivalent amounts of quartz and calcite. Petrographically, the rock is dominated by calcite with inclusions of quartz and feldspar. Large poikiloblasts of biotite are common, and the abundance of muscovite in some specimens gives the rock a schistose texture, locally (King, 1963).

A sample of metalimestone collected in the NE section 34 (**Plate 1**) yielded 40.49% CaO, 22.71% SiO_2, and 30.11% LOI (sample CH27-91, **Table 1**). The relatively high silica content reflects the presence of quartz and minor amounts of mica.

Quartzite and metaconglomerate

Quartzites crop out over large areas of Cooper Hill. The quartzites are quartz-arenites and micaceous quartzites. The quartz-arenites are massive white to buff granoblastic quartzites with about 5% or less laminated pink feldspar (microcline) accessory plagioclase, minor to trace amounts of mica (muscovite and/or chlorite), and trace to accessory fuchsite and opaques. Micaceous quartzites are light green to brownish foliated quartzites with 70 to 90% quartz, minor feldspar, minor chlorite, and lesser sericite.

Whole rock geochemistry on three quartzite samples (CH17-91, CH24-91, and CH43-91, **Table 1**) yielded 89.47% to 90.79% SiO_2, 0.61% to 2.50% K_2O, 0.18% to 1.70% Na_2O, and 3.10% to 5.26% Al_2O_3. The potassium and alumina contents are reflective of minor amounts of mica and feldspar in the rocks.

Quartzites in the northern portion of Cooper Hill contain thin beds of metaconglomerate. These conglomerates are foliated and consist of abundant stretched, translucent to milky quartz pebbles up to 5 inches in length with uncommon black chert pebbles (the quartz pebbles may be stretched as much as 3 to 4 times in the plane of foliation) in a fine-grained matrix dominated by quartz grains with minor mica and feldspar, and accessory opaque. Fuchsite and sericite occur in minor to accessory amounts. These conglomerates are characteristic of the Cascade conglomerate found elsewhere in the Medicine Bow Mountains. None of the samples collected were radioactive, and were rare earth element poor (samples CH12-91 and CH3-92, **Table 1**), and gold poor. Although one sample (CH34-91, **Table 2**) yielded a weak gold anomaly (see *Economic Geology* section).

The quartzites and conglomerates are interpreted as fluvial and assumed to have been deposited in Proterozoic streams draining from a highland to the north in the Wyoming craton. Similar quartzite and conglomerate elsewhere in the Medicine Bow Mountains have been interpreted as part of a widespread braided drainage that ran to an ancient sea located to the south of the Cheyenne Belt (Karlstrom and others, 1981).

Mica schist

Mica schists are strongly foliated muscovite-chlorite-schists with one or more crenulated cleavages. Porphyroblasts are rare. This unit also includes minor beds of metagreywacke. The schists and metagreywacke represent metamorphosed siltstones, claystones, and sandstones.

In thin section, King (1963) described mica schist to consist of a very fine matrix of quartz with sinuous and bifurcating bands of mica and subparallel bands of quartz with rare plagioclase augen. Muscovite and chlorite are the dominant minerals with subordinate biotite. An ubiquitous opaque mineral in the schists occurs as fine dust-like inclusions and as large elongate grains parallel to foliation.

Poorly preserved porphyroblasts occur in mica schist near the Emma G mine at the south end of Cooper Hill. These grains consist of small grains of quartz and feldspar, and possibly represent alumino-silicate replacements. No primary alumino-silicate porphyroblasts were recognized.

Economic Geology

Mineralization

Cooper Hill has not been developed to any great extent. According to Duncan (1990), Cooper Hill had a short-lived prospecting and mining history between 1893 to 1897, following the economic collapse of the U.S. economy in 1893 set off by the repeal of the Sherman Silver Purchasing Act by Congress. Mining also continued into the early 1900s and possibly some activity also occurred during the Great Depression. In recent years, a few Laramie residents have continued prospecting the district, and essentially all of the accessible mines were recently closed under the State's Federally funded abandoned mine reclamation program.

Ore minerals reported in veins in the district include pyrite (FeS_2), chalcopyrite ($CuFeS_2$), chalcocite (Cu_2S), argentiferous galena [$(Pb,Ag)S$], polybasite [$(Ag,Cu)_{16}Sb_2S_{11}$], and gold (Au) (Schoen, 1953). Secondary ore minerals derived from the oxidation of the primary sulfides include malachite, cerrusite, and limonite. During this study, two forms of limonite [$FeO(OH)$] were recognized. One variety, a reddish-brown to tawny limonite, is typically derived from oxidation of sulfides and can be used as an indicator to gold and sulfide mineralization; whereas a second variety, a sugary, yellow-orange limonite after siderite is of no apparent economic value. Lode mineralization includes veins and skarns.

Skarns: Skarns were identified at some sites on Cooper Hill (Hausel and others, 1992) (Plate 1). The skarns occur in metalimestone in contact with mafic schist (amphibolite), and range from one foot to more than 100 feet thick. One of the more extensive skarns was mapped north of the Silver King prospect in the extreme southeastern corner of section 27. Skarns are undoubtedly more widespread than mapped simply because portions of the metalimestone are buried by colluvium and scree on the steep hill sides.

Most skarns on Cooper Hill were prospected in the past. Other than shallow prospect pits, no tunnels were driven in skarn. Typically, the skarns are erratic and contain some pyrite, chalcopyrite, and magnetite. Because of the presence of magnetite, the skarns would be susceptible to magnetic prospecting where they continue under colluvium.

Skarn samples were examined in hand specimen. Megascopically, the skarns are varied and include: (1) dark green to black garnet (XRD pattern best fits goldmanite and hydrogrossular), epidote, actinolite, chlorite, calcite, limonite, ± magnetite hornfels; (2) epidote, pyrite, calcite, quartz hornfels; (3) magnetite hornfels; (4) calcite, epidote, actinolite, pyrite, magnetite marble; (5) actinolite, calcite, quartz, chlorite, ± chalcopyrite hornfels; (6) tremolite, quartz, calcite marble; and (7) calcite, light yellow-green garnet (identified as uvarovite by XRD), magnetite hornfels.

Skarn exposed in a prospect pit (known as the Silver King) in the saddle of the hill above the Silver Queen mine shows clear association to amphibolite (metabasalt). The prospect cut exposes a narrow amphibolite dike intruding metalimestone that is replaced by skarn along both margins of the dike. A short distance from the dike, the skarn grades into metalimestone. All other skarns found in the district also lie in contact with amphibolite. Skarn samples collected for assay are weakly anomalous in silver, gold, and copper.

<u>Veins</u>: More than one vein type occurs in the district. At the portal of the Albion mine along the western flank of Cooper Hill, the vein consists of pyrite-sericite-limonite-calcite wallrock alteration in metalimestone (calc-schist) enclosing fractured and frayed pyritiferous milky quartz. The calc schist is stained by limonite and contains abundant cubic limonite pseudomorphs after pyrite(?) over the exposed width of the outcrop. The vein cuts across lithologies into an underlying footwall quartzite where it is a relatively well defined quartz vein with galena. Later stage silicification is evident where small fractures in some quartz are partially rehealed by minor translucent quartz and jasper often accompanied by galena.

Additionally, some classical well-defined, quartz vein deposits occur in the district that are either conformable or crosscutting to foliation and bedding. According to Schoen (1953), the crosscutting veins are typically barren. Another type of vein found at the Richmond mine, is a strike-trending (conformable), limonite-stained, several-foot-wide, quartz breccia vein with open vugs filled with radiating actinolite prisms, pyrite, and chlorite.

Mines and occurrences

None of the mines or prospect pits located on Cooper Hill were developed to any great extent, and unfortunately only the workings of one mine were accessible during this study. This is unfortunate in that only mine dump samples could be collected. It is the author's experience that mine mineralization can be somewhat characterized from the ore from some mine dumps, although in some cases, mine dump samples will not always be indicative of the mineralization within the mines.

During mapping, most mine and prospect pit dumps were sampled on Cooper Hill. In many cases, the names of the mines and pits were unknown. Stream sediment samples were also collected in the North Fork of Cooper Creek and Cooper Creek to test for placer gold.

<u>Albion mine</u> (W/2 section 27, T18N, R78W): The Albion mine workings were inaccessible during this study since the portals had recently been reclaimed. Therefore, it was necessary to rely on the available literature to visualize the mine workings.

The Albion mine was developed by two adits driven in on a near horizontal vein near the contact between altered hanging wall metalimestone (calc schist) and footwall quartzite (**Figure 2**).

The portals were cut into a frayed quartz vein hosted by the altered, limonite-stained, calc schist. Twenty to 30 feet into the tunnel, the vein cut across lithologies into a footwall quartzite. Where hosted by calc schist, the vein carried disseminated pyrite, chalcopyrite, chalcocite, and bornite; where hosted by quartzite, the vein carried argentiferous galena and was well defined (Schoen, 1953). A short distance from the end of the tunnel (mine face), the vein abruptly changed attitude from near horizontal to an 80° dip (EMJ, 1896, v. 61, Jan. 11, p. 47).

Two ore shoots were intersected about 70 and 100 feet from the mine portals (see heavy dashed lines on **Figure 2**). The shoots are localized where the vein rolls from an easterly to a southerly dip (Schoen, 1953). According to EMJ (1896, Sept. 12, p. 255), the No.1 tunnel was 270 feet long and the No.2 tunnel was 185 feet long. This agrees well with Schoen's (1953) map.

At the northern portal (No. 2 tunnel), the vein consists of a relatively narrow, frayed quartz veinlets (<6 inches wide) enclosed by a broad zone of altered, limonite-stained, calc schist with abundant cubic limonite pseudomorphs after pyrite(?) over the width of the exposed outcrop. At this point, the footwall quartzite is buried.

Based on Schoen's (1953) study, the adit was driven 80 feet east in calc schist and cut across the dipping contact of the schist before continuing another 85 feet east in the footwall quartzite. From here, the tunnel turns southeast another 40 feet down an incline where the mine tunnel terminates in quartzite. Near the mine portal, the vein is 2 feet thick. Further in the tunnel, it pinches to 2 to 18 inches but again swells to 2 feet thick near the face of the incline. A winze was sunk at the face, but was full of water at the time of Schoen's investigation.

The southern portal (No. 1 tunnel) is presently covered by quartzite scree that buries the calc schist and vein. According to Schoen (1953), the vein is 2 to 5 feet thick a short distance into the southern portal. Further into the hillside, the vein cuts across lithologies into the lower quartzite. At about 40 feet into the tunnel, the schist-quartzite contact was intersected and the tunnel continued another 160 feet east into the footwall quartzite before terminating in quartzite. At about 100 feet from the portal, a 50 foot crosscut was driven south. The face of the crosscut is also in quartzite. Schoen (1953) reports the primary vein disappeared below the mine workings near the face of the main tunnel, and that the workings continued to follow another galena-bearing vein to the face.

Samples of the vein and altered calc schist were collected from the outcrop at the northern portal during this study; galena-bearing quartz was collected from the dump since it is not exposed at the portal. The pyritiferous quartz collected at the portal is weakly anomalous in gold and silver (samples CH40-91 and CH52-91, **Table 2**), as is the calc schist wallrock (sample CH51-91, **Table 2**). Samples of galena-bearing quartz were relatively well mineralized and assayed 0.62 and 1.12% Pb, 0.05 and 0.22 opt Au, and 2.83 and 1.66 opt Ag (samples CH39-91 and CH50-91, **Table 2**). Schoen's (1953) sample of galena-bearing quartz from the second roll (ore shoot) in the mine yielded 0.83% Pb, 0.7 opt Au, and 2.2 opt Ag.

Assays reported in historic documents are much higher than the samples reported by Schoen (1953) or in **Table 2**. The discrepancy is either due to the assaying of selected ore for the historic reports, or due to exaggeration by the early reports. For example, the EMJ (1895, v. 60, Oct. 19, p. 380) reported a narrow pay steak in the Albion mine that assayed 350 ounces of silver, 9 ounces of gold, and 40% lead.

An 1895 mill run of ore from the Albion mine yielded $101 worth of metals, and from the adjacent Smuggler (No. 2 adit ?) mine $69 (EMJ, 1895, v. 60, Oct. 19, p. 380). The Smuggler Gold Mining and Milling Company reported a carload of argentiferous galena had a value of $18.40 per ton (EMJ, 1897, v. 63, Jan. 9, p. 51).

Clara B (Morgan) prospect: SE section 34, T17N, R78W. A shallow prospect pit on the Clara B claim on the south-sloping hill side north of the village of Morgan, exposed a narrow quartz vein with common limonite boxworks after pyrite. The sample from the vein assayed >10 ppm Au and 1.4 ppm Ag (sample CH23-91, **Table 2**). The sample was reassayed yielding 0.53 opt Au.

Cooper Creek adit: SW section 3, T17N, R78W. Locally known as the Sawmill Creek adit. A short adit was driven in on a N5°W trending, milky quartz vein in chlorite schist. The vein is about 5 to 6 feet wide at the portal.

The tunnel followed the vein 140 feet to the southeast, and terminated in the quartz (**Figure 3**). A select sample of quartz from the mine dump (CH2-92, **Table 2**) yielded no detectable gold or silver. A sample of quartz (CH1-92) collected from the eastern mine rib in a open fold closure also contained no detectable gold or silver. A third sample (CH5-92) of boxwork quartz with some chalcopyrite collected 20 feet from the mine face yielded >2% Cu, 71 ppb Au, 1.9 ppm Ag, and 128 ppm Pb. This was the only place in the mine where mineralization was observed.

Copper Queen mine (Rip Van Winkle tunnel, Silver Queen mine): S/2 S/2 section 27, T18N, R78W. Located about 400 feet below the Rip Van Winkel adit on the Wyoming claim (**Plate 1**). Duncan (1990, p. 193) indicates this to be the Rip Van Winkle tunnel, however, Schoen (1953, p. 7, Figure 2) published a photograph apparently of the same mine and labeled it as the old Copper Queen mine renamed the Silver Queen mine. The workings were inaccessible, and the adit was driven in quartzite scree. Based on the rock types found on the mine dump, the tunnel intersected amphibolite somewhere near the mine face. Very little evidence of mineralization could be found on the dump other than a few specimens of quartz with minor limonite after siderite.

Croesus tunnel: The Croesus claim was reported to be on a large vein of silicious gold, copper, and silver ore that averaged $27 per ton. The EMJ (1896, Sept. 12, p. 255) reported the ore body to be 18 feet wide and to carry gold and copper pyrites averaging $8 in gold (0.4 opt) and 14% Cu. The mine was located on the east side of Cooper Hill about a half mile from the Albion (EMJ, 1897, May 22, p. 523). In 1902, the Mining Reporter (1902, June 12, p. 565) reported the tunnel was 1,236 feet long, and that ore from one of the drifts assayed as high as $44 (2.1 opt) in gold. The ore was also reported to be an excellent smelting flux (Laramie Mining and Stock Exchange, 1896)

The only mines that might fit this description are in section 35 at sample locality CH 26-91 and 1/4 mile directly south (Plate 1). However, no evidence of an 18 foot wide ore body was found on the surface, nor was there much evidence of mineralization on the mine dumps.

Emma G. Mine: Located at the southern end of Cooper Hill above the village of Morgan in the N/2 NE section 34, T.18N., R.78W. In 1894, a strike was made at the Emma G mine during the driving of a 135 foot tunnel which cut a 20 foot wide vein 60 feet below the surface (EMJ, 1894, v. 57, March 17, p. 257). A shaft was later sunk to 60 feet and the tunnel was extended to 300 feet. The ore was reported to carry $12 per ton (0.58 opt) gold, and to be free milling (EMJ, 1896, v. 62, Sept. 12, p. 255).

The Emma G mine consists of three different portals. A shaft with an adit was driven in metalimestone and amphibolite, and an inclined shaft (**Figure 4**) cut into mica schist and intersected a vein a short distance to the north (Plate 1).

According to Schoen (1953), the ribs of the incline(?) are in porphyroblastic biotite schist. These porphyroblasts were described as granulated quartz developed during regional metamorphism (Schoen, 1953, p. 28). A brief field examination of these metacrysts (?) showed them to be quartz-mica augen. Possibly, they are the alteration products of alumino-silicates. Schoen further described the vein as a thick, barren, milky quartz breccia vein conformable to foliation. At 15 feet from the bottom of the shaft, the vein is reportedly 15 feet thick. Fault gouge was intersected at the bottom of the shaft (Schoen, 1953).

The southern shaft was sunk on the contact between metalimestone and amphibolite. No evidence of mineralization was found on the dump. Possibly, this was an exploration shaft in search of skarn, or was dug to explore gossaniferous metalimestone. The limonite here is after carbonate (siderite) rather than after sulfide. One sample of limonite-stained quartz from the mine dump assayed only 0.089 ppm (parts per million) Au and 1.0 ppm Ag (sample CH21-91, **Table 2**).

<u>Little Ella-Senator Stewart Mine:</u> SW section 16 and NW section 21, T18N, R78W. The mine was reported in the EMJ (1897, May 22, p. 523) to lie 2 miles north of Cooper Hill on the north branch (West Fork?) of Dutton Creek. However, an earlier report located the mine 3 miles north of the Richmond mine (EMJ, 1895, v. 60, Oct 19, p. 380). County courthouse records indicate the Senator Stewart claim was staked in sections 16 and 21, which would place it along the West Fork (E. Neilsen, personal communication, 1992).

The Little Ella mine included 700 feet of development work with two shafts of 70 feet deep each (EMJ,1897, May 22, p. 523). The Little Ella shaft was later sunk to a depth of at least 100 feet and connected to the Senator Stewart shaft by a 150 foot tunnel (EMJ, 1896, v. 61, April 11, p. 359).

The main vein cut by the drifts was reported to be 9 to 12 feet wide with gold- and copper-bearing sulfides in quartz (EMJ,1897, May 22, p. 523). However, the vein cut by the 100 foot level was interpreted to be 50 feet wide (EMJ, 1896, v. 61, June 13, p. 575). The vein was reported to average $23 per ton (1.1 opt) (EMJ, 1896, v. 61, April 11, p. 359) with pay streaks running from $40 to $50 (2 to 2.4 opt) in gold (EMJ, v. 60, p. 380, Oct 19, 1895; Laramie Mining and Stock Exchange, 1896). Some select ore from the mine was reported by Knight (1893) to have assayed 32.17 opt Au, 4 to 10 opt Ag, and 10 to 12 % Cu.

<u>Little Johnnie:</u> Location unknown. The Cooper Hill Deep Mining Company reported plans to run a 1,300 foot tunnel into Cooper Hill from the Little Johnnie claim (EMJ, 1896, Sept. 12, v. 62, p. 255). It was later reported that the company was working on a group of claims north of the Rip Van Winkle, and a tunnel had been started at the base of the hill to penetrate to the center, a distance of 1,400 feet (EMJ, 1897, May 22, p. 523).

<u>North Star Mine:</u> Location unknown (see Rip Van Winkle adit). The Laramie Mining and Stock Exchange (1896) reported the North Star to consist of three claims located on a blowout of quartz on the apex of the hill (based on this description, this probably is the Richmond mine?). The formation was described as quartz and black granite (amphibolite?). Across the gulch from the same group, a peculiar black quartz was reported to carry from $8 to $19 in free gold.

Richmond Mine: Located in the NE section 27, T18N, R78W, along the crest of Cooper Hill. According to Beeler (1906), the Richmond mine produced the largest amount of free-milling gold of the Cooper Hill mines. The Richmond mine was developed by a 40 foot deep shaft with a 94 foot drift (Laramie Mining and Stock Exchange, 1896) which intersected a vein reported to have free milling gold at a depth of 20 feet (EMJ, 1894, v. 58, Sept. 22, p. 280). Mill runs of ore from the mine were reported to average nearly $20 per ton gold (approximately 1.0 opt) (EMJ, 1895, v. 60, Oct. 19, p. 380).

The Richmond shaft was sunk in a quartz breccia vein in a fine-grained hornblendic amphibolite (metabasalt). The vein lies near the bottom of the amphibolite outcrop near the contact of the host amphibolite with underlying quartzite. The vein disappears a short distance southeast and southwest under colluvium and does not reappear indicating the vein to be very limited in strike length.

The vein is more than 20 feet thick at the Richmond shaft and consists of fractured, iron-stained quartz with angular clasts of amphibolite country rock. The quartz is pitted with open vugs filled with well-developed radiating actinolite prisms on a fine-grained mass of chlorite, actinolite, and calcite. Uncommon sulfides occur as chalcopyrite and chalcocite blebs with small (1mm) pyritohedrons and octahedral pyrite grains. Minor stains of malachite occur on some fracture surfaces in the quartz.

Three samples were collected from the Richmond mine for assay by the Geological Survey of Wyoming (samples CH14-91, CH35-91, and CH36-91, **Table 2**). Two samples of boxwork quartz contained 0.012 and 0.041 ppm Au, <0.1 to 0.2 ppm Ag, and traces of lead, zinc, and copper. One 20 foot composite chip sample chipped across the vein width assayed only 0.08 ppm Au (0.002 opt), 1.2 ppm Ag (0.035 opt), 0.07% Cu, 11 ppm Pb, and 50 ppm Zn.

Rip Van Winkle adit: S/2 S/2 section 27, T18N, R78W. Two photographs in Duncan's (1990, p. 192) book indicate this mine near the crest of the hill is the Rip Van Winkle shaft. This is supported by the description in the Laramie Mining and Stock Exchange (1896) which reported the Rip Van Winkle and North Star claims to occupy the apex of the mountain.

The available historic reports conflict as to the amount of development in the mine. For instance, the Rip Van Winkle adit was reported to be driven in the hill side 750 feet by 1906, and to have cut several minor leads. The first lead was intersected 200 feet further in the tunnel than expected, and a sample from this vein reportedly assayed $650 in gold (31 opt) (Wyoming Industrial Journal, 1906, v. 7, no. 12, May, p. 20). Beyond the 500 foot point, the whole breast of the tunnel reportedly panned in gold (Wyoming Industrial Journal, 1905, v. 6, no. 12, May, p. 7).

In another report, the mine was described to consist of two 25 foot deep shafts (no evidence of the shafts were found in 1991) with a 250 foot tunnel and a 100 foot tunnel (Wyoming Industrial Journal, 1906, v. 8, no. 2, July, p. 8-9). In 1908, another lead intersected in the mine carried $6 (0.3 opt) to the ton (Wyoming Industrial Journal, 1908, v. 10, no. 1, June, p. 22).

The portal of the adit assumed to be the Rip Van Winkle, was cut in amphibolite and the tunnel intersected mica schist and metagreywacke a short distance into the hill side. Only a few fragments of quartz were found on the mine dump in 1991 and these contained uncommon limonite boxworks after siderite. One sample of the limonite-stained quartz (sample CH11-91, **Table 2**) yielded only 0.006 ppm Au and <0.2 ppm Ag.

Silver King prospect: N/2 NE section 34, T18N, R78W. This is a small prospect pit dug in skarn in the saddle of Cooper Hill on the Silver King claim (**Figure 5, Plate 1**). The open cut exposes a narrow mafic sill in metalimestone. The metalimestone adjacent to the sill is altered to skarn producing a epidote-calcite-actinolite skarn with some chalcopyrite. A narrow quartz vein exposed in this pit carries some chalcopyrite, chalcocite, and minor malachite.

Five samples collected from the dump in 1991 were poorly mineralized. The maximum assay was of cupriferous quartz which yielded 0.187 ppm Au, 0.8 ppm Ag, and 0.065% Cu (sample CH5-91, **Table 2**).

Silver Queen adit: N/2 N/2 section 34, T18N, R78W. The location of this mine suggests it to be on the Silver Queen claim (**Figure 5**), although it is possible the mine lies on either the Sol or Charlie claims. The mine portal is located about 1,200 feet southeast of the Copper Queen mine and was sealed by a locked wooden door. Thus it was inaccessible when visited in 1991.

The adit was driven into amphibolite. Mine dump material consists of chloritized mafic schist and amphibolite. A few samples of quartz and silicified amphibolite were collected from the dump that contained secondary chlorite, sericite, and biotite with minor sulfides. Ore minerals included chalcopyrite, cuprite, malachite, chrysocolla, and limonite after sulfides. Samples collected from the mine dump included a sample of limonite after siderite which assayed <0.005 ppm Au, 0.6 ppm Ag, and 23 ppm Ga (sample CH1-91, **Table 2**). A sample of limonite-stained mafic rock (sample CH2-91) assayed 0.034 ppm Au, 0.3 ppm Ag, and 30 ppm Ga. Chalcopyrite-bearing schist (sample CH25-91) assayed 0.046 ppm Au, 0.7 ppm Ag, and 0.35% Cu, and cupriferous quartz (sample CH7-91) yielded >10 ppm Au, <0.2 ppm Ag, and 2.27% Cu. The sample was reassayed yielding 0.16 opt Au.

Quartz pebble conglomerate: W/2 E/2 section 27, T18N, R78W. Quartz pebble conglomerate crops out as thin beds at a couple of different localities at the crest of the hill. At sample location CH12-91, three samples were collected for analysis. This quartz pebble conglomerate contained milky quartz and uncommon black chert pebbles in a quartz matrix with some fuchsitic mica and hematite pseudomorphs after magnetite(?) or pyrite(?). None of the samples were radioactive. One of the three samples contained detectable gold of 0.04 ppm Au (sample CH34-91, **Table 2**).

Samples of quartz pebble conglomerate collected a short distance southwest of Cooper Hill were poorly mineralized. CH3-92 (**Table 1**), a quartz pebble conglomerate with accessory fuchsite, and disseminated limonite was collected from a prospect pit in the NE section 3, T17N, R78W. The sample yielded no precious metal or rare earth element anomalies. Sample CH4-92 (**Table 2**) was collected from a prospect pit nearby in the NE NE section 4, T17N, R78W. This sample was milky quartz with boxworks hosted by diabase adjacent to quartz pebble conglomerate. The assay indicated no unusual gold or silver values.

Placers: Placer gold was discovered in the district by 1896. According to EMJ (1896, v. 62, July 4, p. 15) several thousand acres of placer ground were located along North and South Forks of Cooper Creek and the South Fork of Dutton Creek. It was reported that the gravel contained from \$0.50 to \$0.75/yd3 (0.02 to 0.04 oz/yd^3) (EMJ, 1896, v. 62, July 4, p. 15).

Samples collected by the Geological Survey of Wyoming confirmed the presence of anomalous gold in Cooper Creek (Hausel and others, 1992). Every panned sample collected from Cooper Creek was anomalous and contained visible gold. Dutton Creek was not sampled.

Summary

The Cooper Hill mining district produced minor amounts of lead, silver, gold, and copper ore near the turn of the century. Mineral deposits in the district include skarns and veins in Proterozoic age rocks, and gold in Quaternary placers.

The historic literature describes several impressive ore deposits that were not apparent during the 1991 mapping project. Unfortunately, none of the mine workings were accessible during 1991 making it difficult to properly assess the early reports. The early assays reported in the historic literature in many cases are probably exaggerations, assays of selected ore, and assays of supergene enriched ore, and are not consistent with the samples collected by Schoen (1953) and Hausel and others (1992). This is not unusual, but it leaves the geologist with the problem of sorting out what is fact and what is fiction.

When a district receives recognition for specimen grade ore, as Cooper Hill may have because of Beeler's (1906) report, many of the mine dumps become thoroughly picked over by specimen collectors through time. Possibly this has happened to Cooper Hill, and sampling on the surface and from the mine dumps may not do the district justice. Because of this problem, it would be highly recommended to anyone exploring Cooper Hill, to reopen the historic mines and sample and map the mines in detail. For the historic literature (unless it is all fiction which is highly unlikely) does suggest this area to have some interesting mineralization.

It has been erroneously suggested by some historians that the Cooper Hill district may require deep exploration to find an extension of some of the ore deposits. This proposal is in direct conflict with the geological facts for the following reasons: (1) Cooper Hill is a rootless block of Precambrian rock overlying relatively undeformed Cretaceous sedimentary rocks located at relatively shallow depths. 'Deep' vertical mining would ultimately enter the underlying Cretaceous and Tertiary sedimentary rock units (possibly only 800 to 1,000 feet below the highest point of Cooper Hill) which are geologically too young to host extensions of Precambrian mineralization. (2) The rock attitudes on Cooper Hill are relatively flat lying and most mineral deposits examined appear to be stratabound or stratiform. Thus exploration seeking the continuation of mineralization exposed at the surface would logically have to follow the attitude of the rock units. And if King's (1963) thesis is correct that Cooper Hill is a gravity slide, then exploration for the source terrane could be beneficial and lead to the discovery of similar deposits to the west.

After reviewing the geochemical data produced during this study, one is drawn to the conclusion that the greatest potential may be the source of the gold found in the streams and stream banks. Although the source is unknown, it appears to be widespread.

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Table 1. Trace element and whole rock analyses of selected rocks from the Cooper Hill district (analyses by Bondar-Clegg).

Oxide (%)	CH3-91	CH9-91	CH12-91	CH17-91	CH22-91	CH24-91	CH27-91	CH42-91	CH43-91	CH3-92
SiO2	50.42	50.53	--	89.63	43.52	90.79	22.71	51.30	89.47	--
TiO2	0.60	0.55	--	0.11	0.51	0.04	0.12	1.51	0.08	--
Al2O3	15.82	10.07	--	4.11	7.32	3.10	3.79	14.31	5.26	--
Fe2O3	10.90	10.34	--	0.85	10.24	0.33	1.27	13.47	0.57	--
CaO	7.91	11.59	--	0.12	9.11	0.04	40.49	10.01	0.10	--
MgO	7.06	11.29	--	0.34	12.39	0.09	0.89	6.22	0.23	--
MnO	0.13	0.17	--	<0.01	0.15	<0.01	0.11	0.21	<0.01	--
Na2O	2.94	1.50	--	1.70	<0.01	0.18	1.29	2.21	0.43	--
K2O	1.36	0.64	--	0.61	<0.10	2.15	0.91	0.11	2.50	--
P2O5	0.03	0.03	--	0.04	<0.01	0.02	0.04	0.09	0.05	--
LOI	2.46	1.14	--	0.69	16.59	0.43	30.11	1.01	0.54	--
Total	99.63	97.85	--	98.20	98.83	97.17	101.73	100.45	99.23	--
CaO/Al2O3	0.5	1.2	--	1.2	--	--	--	0.7	--	--
Ti/V	35	60	--	15	--	--	--	15	--	--
BaO (%)	0.012	0.012	--	0.005	0.001	0.024	0.012	0.005	0.028	--
Cr2O3 (%)	0.05	0.25	0.12	0.04	0.17	0.04	0.03	0.02	0.02	--
S (%)	<0.02	0.02	--	<0.02	<0.03	<0.02	<0.02	<0.02	<0.02	--
Ni (ppm)	114	63	--	--	387	--	--	33	--	--
V (ppm)	101	55	--	--	201	--	--	574	--	--
La (ppm)	--	6.9	5.0	--	--	--	--	--	--	13
Ce(ppm)	--	11	10	--	--	--	--	--	--	25
Pr (ppm)	--	<6	<4	--	--	--	--	--	--	--
Nd (ppm)	--	7	5	--	--	--	--	--	--	10
Sm (ppm)	--	1.60	1.40	--	--	--	--	--	--	5.2
Eu (ppm)	--	0.5	0.6	--	--	--	--	--	--	1.5
Gd (ppm)	--	<5	4	--	--	--	--	--	--	--
Tb (ppm)	--	<0.5	0.6	--	--	--	--	--	--	3
Dy (ppm)	--	1.9	3.6	--	--	--	--	--	--	--
Ho (ppm)	--	0.5	0.7	--	--	--	--	--	--	--
Er (ppm)	--	<5	2	--	--	--	--	--	--	--
Tm (ppm)	--	<0.5	<0.5	--	--	--	--	--	--	<10
Yb (ppm)	--	1.1	1.4	--	--	--	--	--	--	7
Lu (ppm)	--	0.15	0.19	--	--	--	--	--	--	0.8
Sc (ppm)	--	--	--	--	--	--	--	--	--	1.5
Au (ppb)	--	--	<5	--	--	--	--	<5	<5	6
Ag (ppm)	--	--	<0.1	--	--	--	--	0.1	<0.1	<0.1
Cu (ppm)	--	--	29	--	--	--	--	--	--	--
Sn (ppm)	--	--	8	--	--	--	--	--	--	--
W (ppm)	--	--	<2.0	--	--	--	--	--	--	--
Pd (ppb)	--	--	--	--	--	--	--	17	--	--
Pt (ppb)	--	--	--	--	--	--	--	21	--	--

Sample CH3-91, mafic schist; CH9-91, metabasalt; CH12-91, quartz pebble conglomerate; CH17-91, quartzite; CH22-91, metabasalt; CH24-9, quartzite; CH27-91, metalimestone; CH42-91, metabasalt; CH43-91, quartzite with minor sericite and fuchite; CH3-92, quartz pebble conglomerate (see Plate 1 for sample locations).

Table 2. Geochemical analyses of mineralized rock samples from the Cooper Hill district. Refer to Plate 1 for sample locations. Analyses by Bondar-Clegg. (Dashes imply not analyzed).

Sample #	Description	Au (ppm)	Ag (ppm)	Cu (%)	Pb (ppm)	Zn (ppm)	Ga (ppm)	Cr (ppm)	Ni (ppm)	W (ppm)	Sn (ppm)	Ti (ppm)	Pt [ppb]	Pd [ppb]	Y [ppm]	Mn [ppm]	As [ppm]	Sb [ppm]	Hg [ppm]
CH1-91	Limonite after siderite from Silver Queen mine dump.	< 0.005	0.6	--	--	--	23	--	--	--	--	--	--	--	--	--	--	--	--
CH2-91	Limonite after sulfides in chloritized mafic rock, Silver Queen dump.	0.034	0.3	--	--	--	30	500	264	--	--	--	--	--	--	--	--	--	--
CH4-91	Marble from prospect pit (N/2 NE/4 sec. 34).	< 0.005	1.6	--	22	5	--	--	--	--	--	--	--	--	--	--	--	--	--
CH5-91	Cupriferous quartz in metalimestone from prospect pit (NW/4 NE/4 sec. 34).	0.187	0.8	0.065	10	--	--	400	--	--	--	--	--	--	--	--	--	--	--
CH7-91	Cupriferous quartz from Silver Queen mine dump.	>10.0	< 0.2	2.27	< 2	12	--	--	--	--	--	--	--	--	--	--	--	--	--
CH8-91	Pyrite-actinolite-epidote-garnet hornfels (N/2 N/2 NE/4 sec. 34).	< 0.005	< 0.2	0.014	7	1	--	--	--	--	--	--	--	--	--	--	--	--	--
CH11-91	Milky quartz with limonite boxworks after siderite from Rip Van Winkel mine.	0.006	< 0.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CH13-91	Massive limonite and hematite in quartz vein (E/2 sec. 27).	0.240	< 0.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CH14-91	Boxwork-filled quartz from Richmond mine dump	0.041	0.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CH15-91	Limonite boxworks from mine dump along East Fork Dutton Creek (NE/4 NW/4 sec. 27).	0.013	< 0.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CH16-91	Limonite boxworks after siderite in quartz from mine dump	0.037	0.8	0.08	56	46	--	700	--	--	--	--	--	--	--	--	--	--	--
CH18-91	Limonite- and hematite-stained quartz pebble conglomerate (NW/4 SE/4 sec. 27).	< 0.005	< 0.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CH19-91	Milky quartz breccia with massive limonite after siderite (E/2 NE/4 sec. 34)	< 0.005	0.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CH20-91	Milky quartz in mafic schist selvage in quartzite, with minor limonite after sulfide.	0.022	< 0.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CH21-91	Limonite-stained quartz from Emma G mine dump.	0.089	1.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CH23-91	Limonite boxworks after sulfides in quartz from Clara B prospect.	>10.0	1.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CH25-91	Limonite-stained chalcopyrite-bearing schist from Silver Queen dump.	0.046	0.7	0.35	< 2	20	--	--	--	--	--	--	--	--	--	--	--	--	--
CH26-91	Milky quartz breccia vein from mine dump (W/2 NW/4 sec. 35).	< 0.005	0.5	--	--	--	--	--	--	---	--	--	--	--	--	--	--	--	--
CH28-91	Limonite-stained skarn (S/2 SE/4 sec. 27).	0.012	< 0.2	0.04	34	21	44	--	--	< 2.0	31	--	--	--	--	--	--	--	--
CH30-91	Limonite boxworks from skarn.	0.170	< 0.2	0.09	< 2	10	--	--	--	--	--	--	--	--	--	9	363	2.4	0.101
CH31-91	Limonite boxworks from skarn (SE/4 SE/4 sec. 27).	< 0.05	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CH32-91	Limonite-stained, grey-black quartz (SE/4 sec. 27).	0.190	< 1.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CH34-91	Quartz pebble conglomerate with hematite pseudomorphs after magnetite (?) or pyrite (?).	0.040	< 0.2	--	--	--	--	--	--	< 2.0	< 5	< 50	--	--	--	--	--	--	--
CH35-91	Select sample of quartz from ore sack at Richmond mine.	0.012	< 0.1	0.10	25	63	--	--	--	--	--	--	--	--	--	--	--	--	--
CH36-91	Twenty-foot composite chip sample across Richmond breccia vein.	0.080	1.2	0.07	11	50	--	--	--	--	--	--	--	--	--	--	--	--	--
CH38-91	Limonite boxworks in quartz from mine dump (E/2 sec. 27).	0.160	1.8	--	72	48	--	--	--	--	--	--	--	--	--	--	--	--	--
CH39-91	Grab sample of galena-bearing quartz, Albion mine (W/2 sec. 27).	7.5	56.9	0.04	11,242	2.6	--	--	--	--	--	--	--	--	--	--	--	--	--
CH40-91	Boxwork quartz from Albion mine.	<0.05	1.4	0.03	134	45.5	--	--	--	--	--	--	--	--	--	--	--	--	--
CH41-91	Epidote-calcite-actiolite-sulfide-skarn (N/2 NE sec.34)	0.108	0.6	1.88	14	19	-	-	--	5	--	--	4	11	--	--	--	--	--
CH45-91	Weak skarn from prospect pit (NW/4 NE/4 sec. 34).	<0.05	3.5	0.003	60	15.8	--	--	--	--	--	--	--	--	--	--	--	--	--
CH46-91	Skarn from pit.	<0.05	2.5	0.004	31	7.3	--	--	--	--	--	--	--	--	--	--	--	--	--
CH50-91	Galena-bearing quartz form Albion mine dump.	1.7	97.2	--	6,193	< 0.005	--	--	--	--	--	--	--	--	--	--	--	--	--
CH51-91	Decalcified pyritiferous metalimestone from Albion mine.	0.6	1.0	0.003	93	36.7	--	--	--	--	--	--	--	--	--	--	--	--	--
CH52-91	Boxwork quartz with pyrite from Albion mine.	0.2	<0.1	0.003	12	12.7	--	--	--	--	--	--	--	--	--	--	--	--	--
H1-92	Chip of quartz from rib, Sawmill Creek adit.	<0.005	<0.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
H2-92	Selected samples of quartz from dump.	<0.005	<0.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
H4-92	Milky quartz with boxworks.	0.005	<0.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
H5-92	Selected sample from rib, Sawmill Creek adit.	0.071	1.9	>2.0	128	55	--	--	--	--	--	--	--	--	--	--	--	--	--

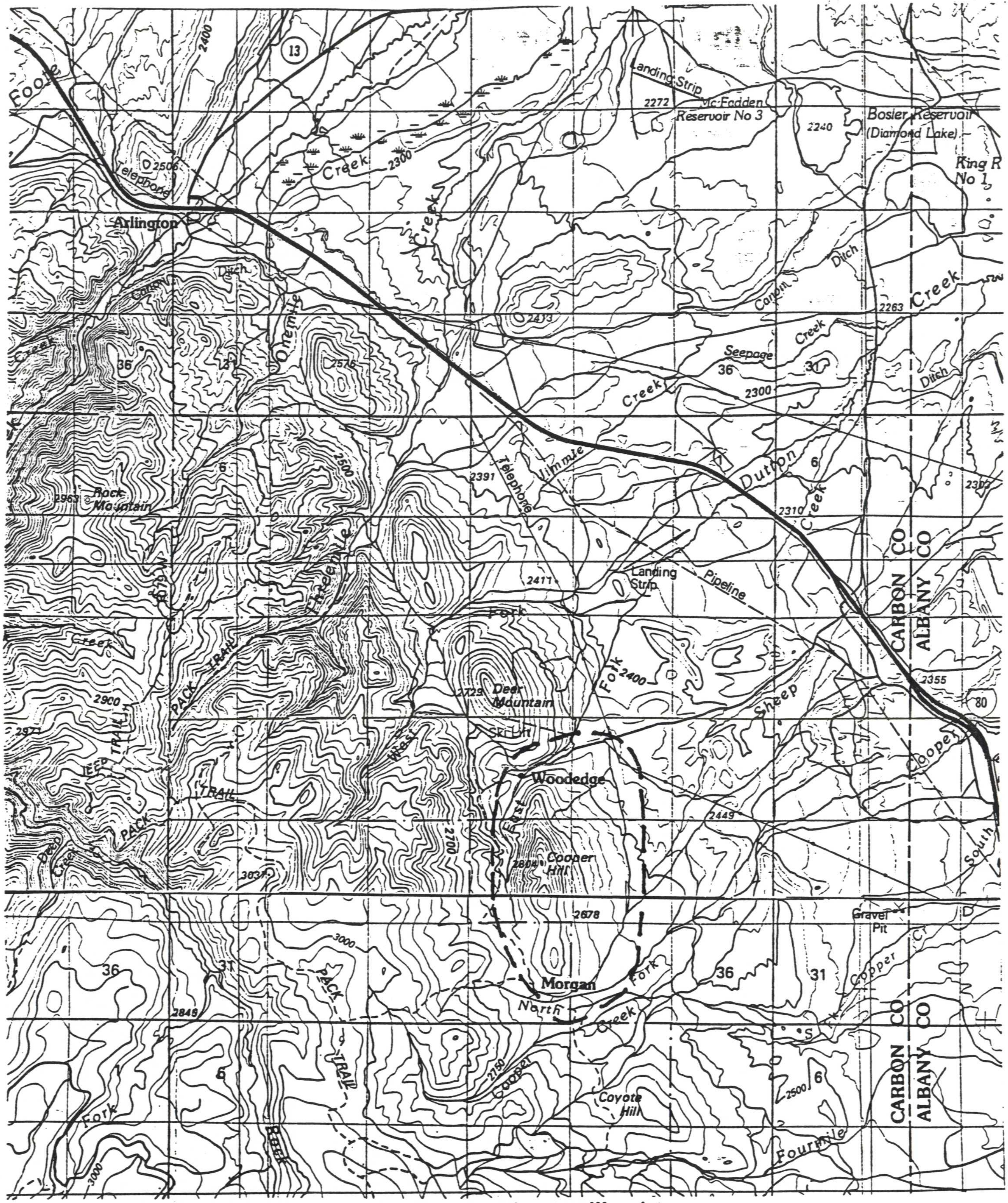


Figure 1. Cooper Hill lies south of I-80 in T.18N., R.78W., of southeastern Wyoming.

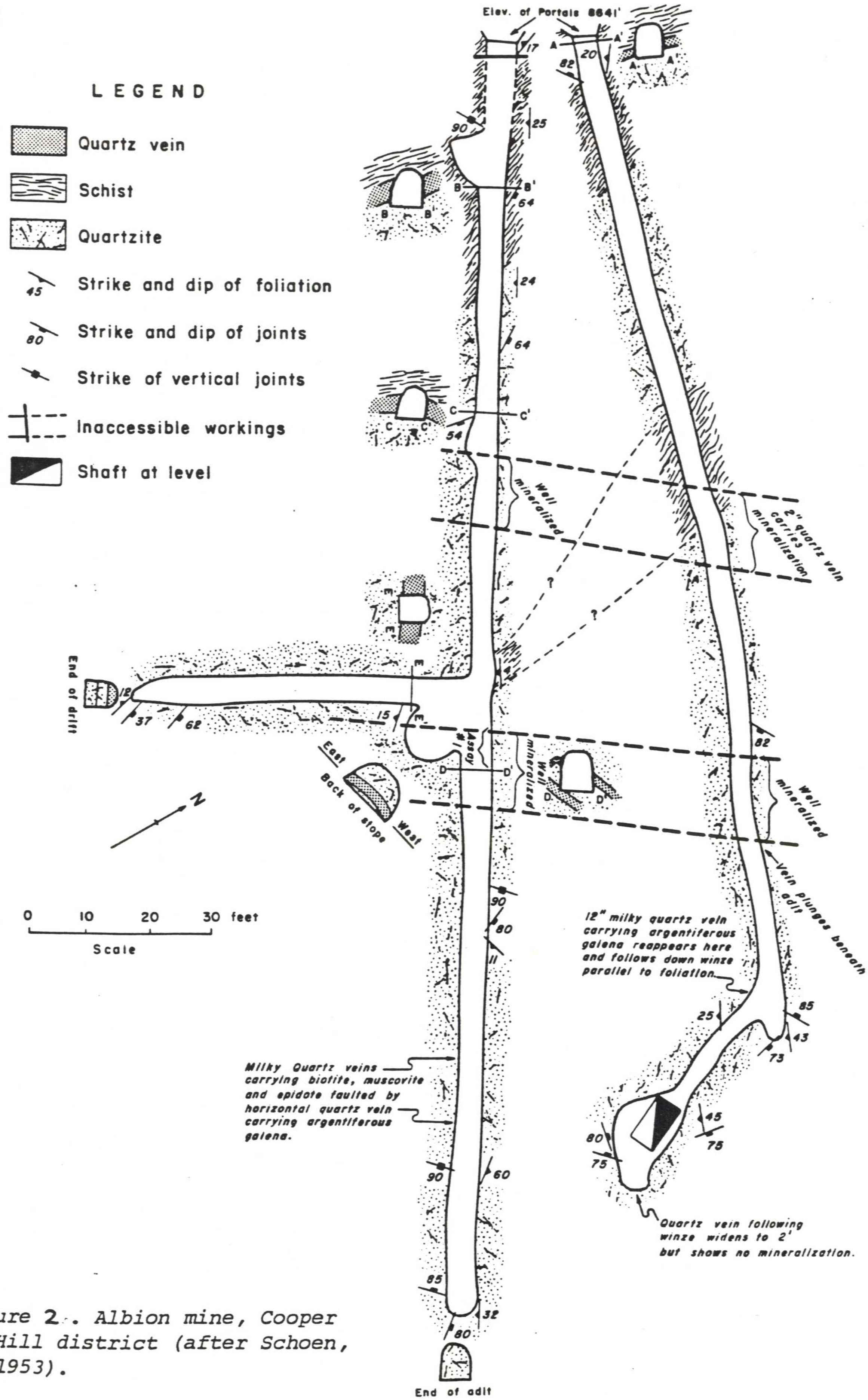
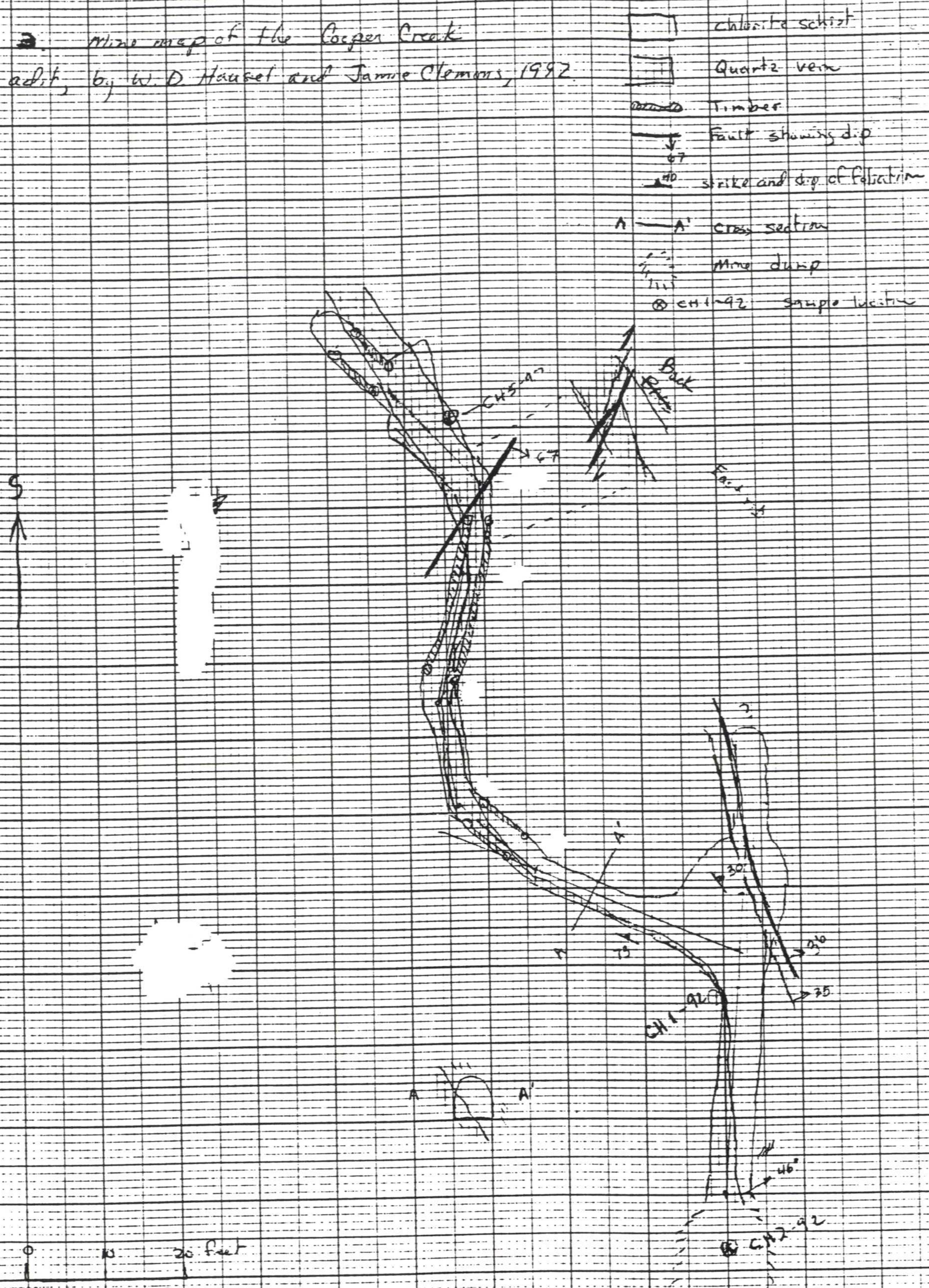


Figure 2. Albion mine, Cooper Hill district (after Schoen, 1953).

Figure 2: Mine map of the Cooper Creek adit, by W.D. Hausel and Jamie Clemons, 1992



MAP OF INCLINED SHAFT
EMMA G CLAIM
COOPER HILL DISTRICT
CARBON CO., WYOMING

To accompany report by R. Schoen, Aug., 1953
Scale 1 in. = 10 ft.

LEGEND

- Quartz vein
- Fault showing dip, and bearing and plunge of slickensides, and relative motion.
- Gneiss
- Schist
- Strike and dip of foliation

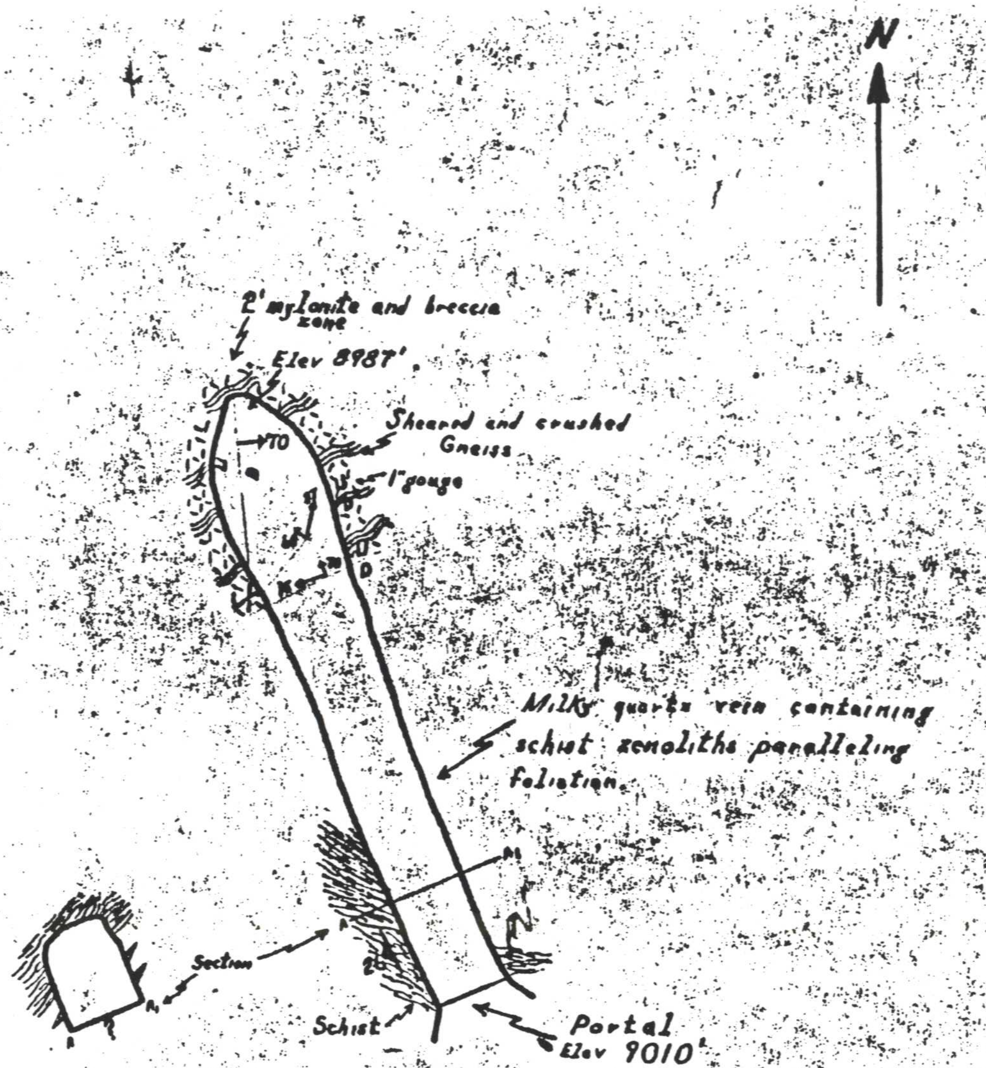


Figure 4

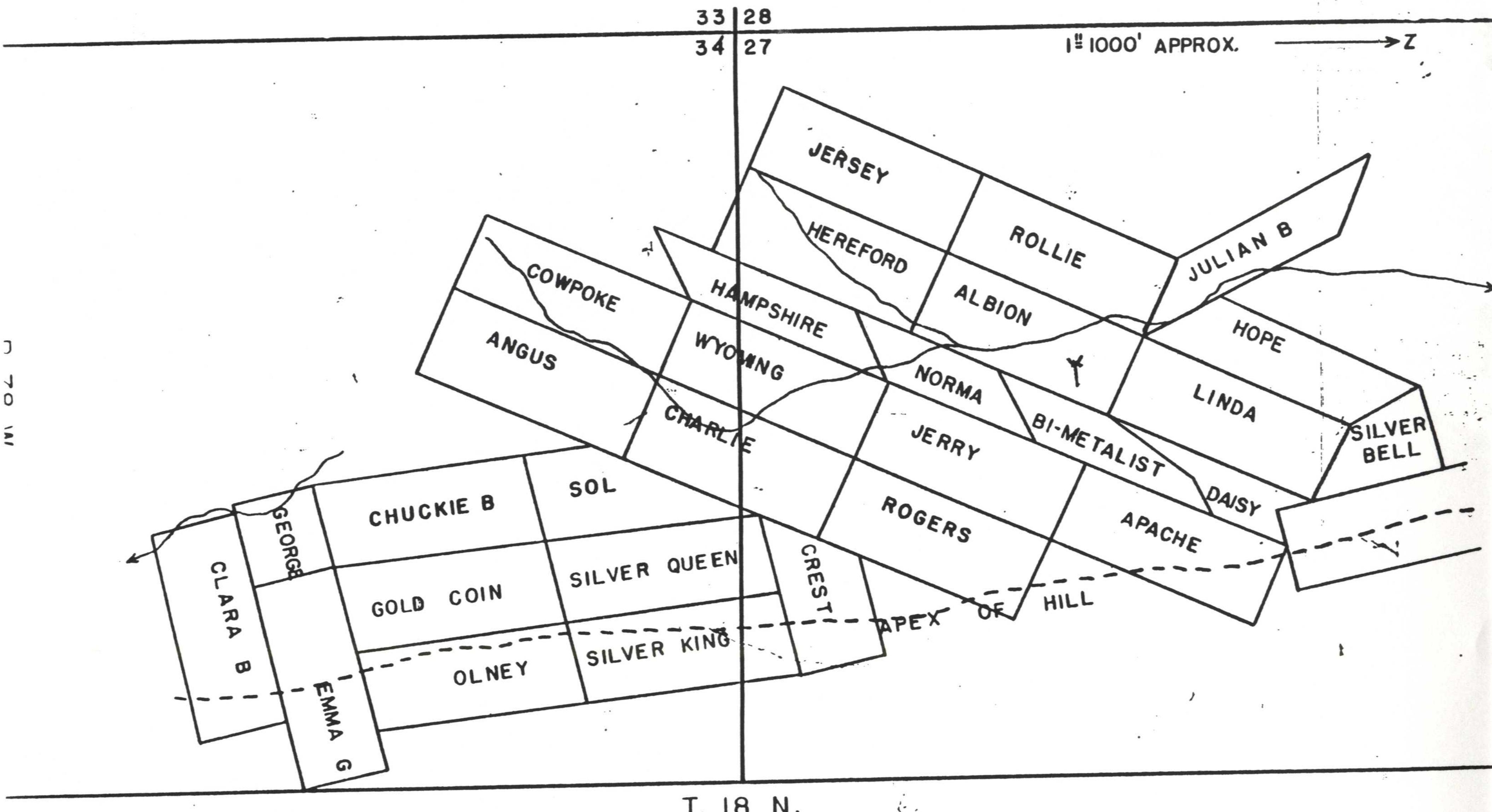
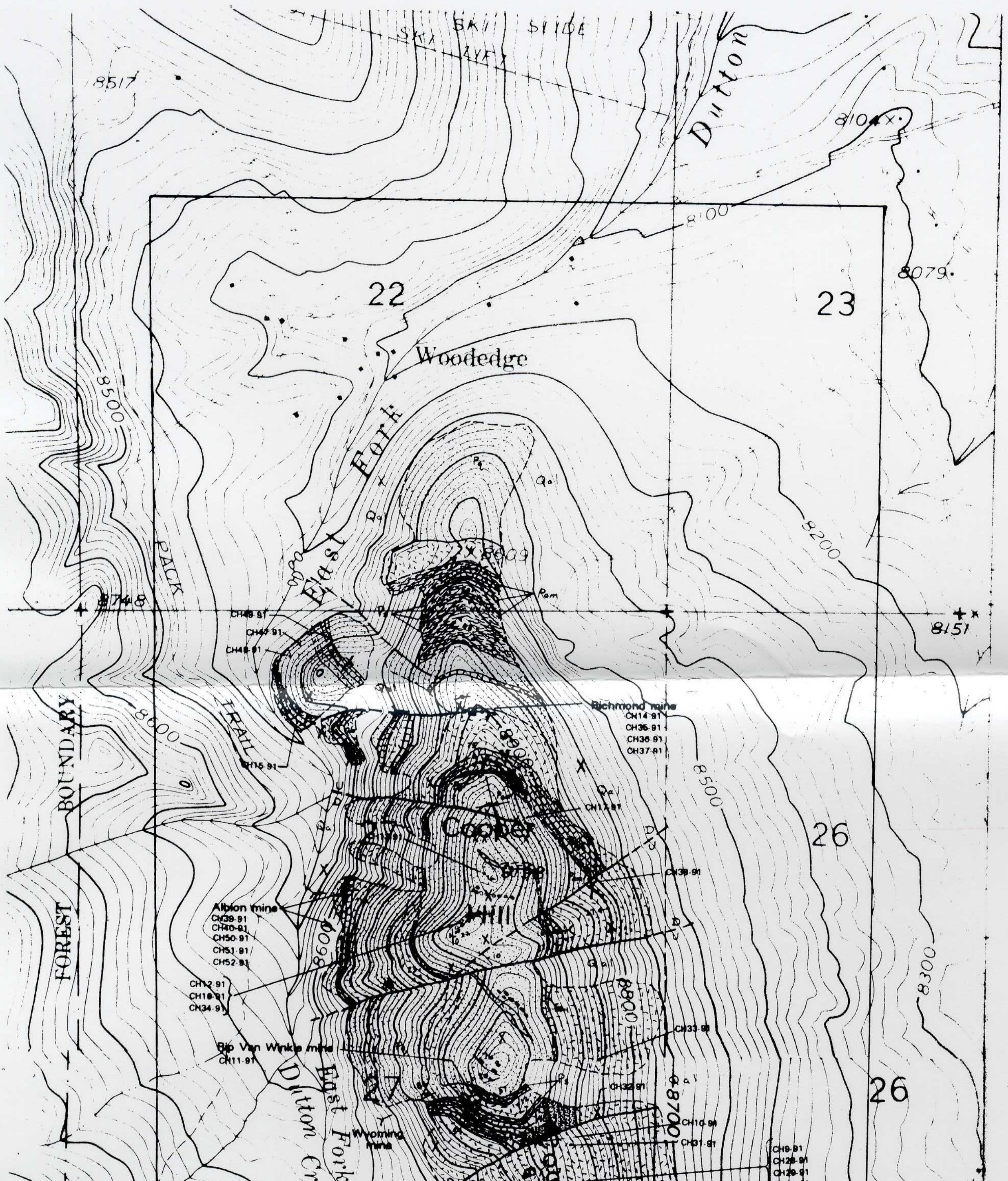

33 | 28
34 | 27
1" 1000' APPROX.
N
JERSEY
ROLLIE
JULIAN B
HEREFORD
ALBION
HOPE
COWPOKE
HAMPSHIRE
ANGUS
WYOMING
NORMA
LINDA
CHARLIE
JERRY
BI-METALIST
SILVER BELL
DAISY
APACHE
ROGERS
CHUCKIE B
SOL
GEORGE
CLARA B
GOLD COIN
SILVER QUEEN
CREST
SILVER KING
OLNEY
EMMA G
APEX OF HILL
T. 18 N.

Figure 5.

PLATE 1



GEOLOGIC MAP OF THE COOPER HILL MINING DISTRICT, WYOMING

by

W. Dan Hausel
1992

EXPLANATION

Qal — **Quaternary undivided**. Includes scree and talus covered slopes and stream aluvium.

PROTEROZOIC

Pam — **Amphibolite, metagabbro, and metabasalt**. Fine-, medium-, and coarse-grained mafic, metaigneous rocks with schistose, blasto-ophitic, and blasto-subophitic textures.

Pq — **Quartzite**. Pink, cream, to greenish, fine-to medium-grained quartzite and schistose micaceous quartzite with minor muscovite, chlorite, and orthoclase and trace fuchsite. Locally, beds of stretched-pebble metaconglomerate occur with milky quartz pebbles and minor black chert pebbles.

Ps — **Mica schist**. Chlorite and biotite schists and phyllites.

Pml — **Metalimestone**. White metalimestone and fine-grained marble.

MAP SYMBOLS

MINES & PROSPECTS

shaft

adit

prospect pit

VEINS & ALTERATION

30 — dipping quartz vein

unexplored gossan

skarn

BEDDING & FOLIATION

35 — dipping beds

30 — dipping foliation

FAULTS & JOINTS

U / D — fault showing relative movement. U = up, D = down-thrown side

35 — dipping joints

LARGE SCALE FOLDS

plunging antiform

synform

MINOR FOLDS

plunging isoclinal fold

plunging open fold

30 — plunging open fold with dipping fold plane

MISCELLANEOUS

metaconglomerate bed

spring

CH 2 91 — sample site

0 — 1/4 — 1/2 Mile

scale

N MN 17 1/2