GEOLOGICAL SURVEY CIRCULAR 213

PRELIMINARY REPORT ON THE JO REYNOLDS AREA LAWSON-DUMONT DISTRICT CLEAR CREEK COUNTY COLORADO

By J. E. Harrison and B. F. Leonard

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PRELIMINARY REPORT ON THE JO REYNOLDS AREA
LAWSON-DUMONT DISTRICT, CLEAR CREEK COUNTY, COLORADO

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ABSTRACT

Pitchblende occurs in the deposit of the Jo Reynolds area, which was primarily a lead-zinc-silver ore body. The reported production in 1919 of 8 tons of high-grade uranium ore, presumably from the lowest workings of the mine, is still unconfirmed but has a fair degree of credibility. The deposit consists of 3 (possibly 4) veins, but the ore was concentrated principally along the no. 2 vein. The no. 2 vein is localized along a fault, which is independent of the pre-Cambrian structures in the bedrock. The age of the mineralization is inferred to be Tertiary.

The deposits of the Jo Reynolds area appear to contain an ore shoot, which has a trend of N. 17° E., a plunge of 60° NE., and a rake of 70° NE. Localization of the ore body in a shoot, or possibly shoots, is attributed either to intersection of the main shear with a transverse set of joints or the movement along a curved fault surface.

INTRODUCTION

Location of the area

The Jo Reynolds area, as designated here, includes the Jo Reynolds and American Sisters groups of claims. The area is in Clear Creek County, Colo., about three-fourths of a mile south of the town of Lawson (fig. 1). The coordinates given on the map (pl. 1) were established by triangulation from a Bureau of Reclamation triangulation net. The coordinate system of the Bureau of Reclamation has its origin at Douglas Mountain, about 0.75 mile southeast of Empire, Colo. For convenience, the Bureau of Reclamation coordinates (0,0) for Douglas Mountain were transformed to (100,000 N, 100,000 E). The general surface geology of the area has been described by Spurr, Garrey, and Ball (1908), Bastin and Hill (1917), and Lovering and Goddard (1950, pl. 2).

Purpose and scope of study

The Jo Reynolds group of claims was mined extensively for lead, zinc, and silver from 1877 through 1907. Since 1907 the claims have been worked only intermittently, the last operation having been about 1946. Pitchblende in the Jo Reynolds mine has been reported in newspapers, in publications of the U. S. Geological Survey, in unpublished reports of the Union Mines Development Corp., and orally. The most significant of these accounts states that 8 tons of high-grade uranium ore (pitchblende) was shipped from the mine in 1919.

Because of the potential importance of the area it was selected for detailed study, together with other areas in the Lawson-Dumont district. This report

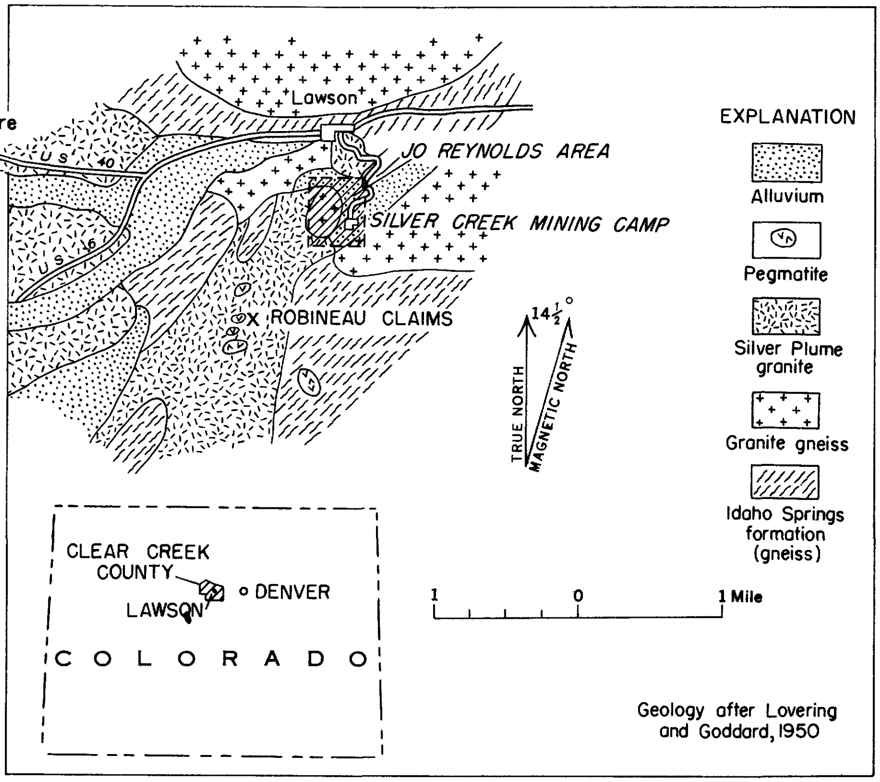


Figure 1. --Index map of the Jo Reynolds area, Lawson-Dumont District, Clear Creek County, Colo.

is based upon surface mapping done during September and October 1951. The work was on behalf of the U. S. Atomic Energy Commission. Harrison is responsible for the geologic mapping and for the preparation of most of the report; Leonard is largely responsible for the section on economic geology.

Mine workings

The Jo Reynolds mine consists of a surface stope above the Daily tunnel, drifts and extensive stopes along 10 levels, the Elida tunnel which forms the 11th level, and a sublevel below the Elida tunnel (pl. 2). These workings extend through a vertical distance of about 900 ft. At the time of the examination, November 1951, the Daily tunnel was caved at the portal, the Moore shaft to the surface stope was caved, no. 6 shaft to the 4th level was not safe, and the Elida tunnel had recently caved at a point 745 ft from the portal.

ROCK UNITS

The mapped area consists predominantly of igneous rocks, some of which have been metamorphosed, and metasedimentary rocks. The bedrock is mostly pre-Cambrian in age (pl. 1). The metasedimentary rocks have been invaded and migmatized by quartz diorite, gneissic granite, Silver Plume granite, and finally pegmatite. One large bostonite dike of Tertiary age cuts the pre-Cambrian rocks. The eastern part of the area mapped is covered mostly by Quaternary glacial debris and alluvium.

Field relations of the pre-Cambrian rock units suggest the following age sequence: Idaho Springs formation (consisting of biotite-quartz-plagioclase gneiss, granodiorite gneiss, and migmatite), quartz diorite, gneissic granite, Silver Plume granite, pegmatite.

Idaho Springs formation

Biotite-quartz-plagioclase gneiss. --Three distinct units of the Idaho Springs formation (as defined by Lovering and Goddard, 1950, pp. 19-20) are recognizable in the Jo Reynolds area. One unit is a fine- to medium-grained biotite-quartz-plagioclase gneiss that ranges in composition from a highly quartzose rock to a biotite schist locally containing sillimanite. The gneiss is migmatitic due to introduction of white granitic material along the foliation. Where the white granitic material forms over 40 percent of the rock, the rock has been mapped as migmatite on plate 1.

The biotite-quartz-plagioclase gneiss has well-developed foliation due to a mineral layering. Alinement of biotite flakes forms a strong lineation in the gneiss. In places fracture cleavage is common and is revealed by thin layers of recrystallized(?) quartz along fractures.

The biotite-quartz-plagioclase gneiss grades into granodiorite gneiss, and both of these rock types occur as inclusions in quartz diorite.

Granodiorite gneiss. --The granodiorite gneiss is a brownish-gray porphyroblastic gneiss whose main constituents are plagioclase, biotite, and quartz. Small feldspar porphyroblasts give a distinctive "knotty" appearance to the rock in outcrop.

The gneiss has a weak foliation produced by small subrounded feldspar porphyroblasts in planar arrangement. Lineation due to mineral alinement is commonly lacking.

The granodiorite gneiss is cut by small white granitic layers similar to those forming migmatite in the biotite-quartz-plagioclase gneiss.

Migmatite. --Several stages of migmatization are indicated by the field relations of the rock units in the Jo Reynolds area. The bulk of the migmatite appears to belong to an early stage that was formed by the introduction of white granitic material into biotite-quartz-plagioclase gneiss and granodiorite gneiss. Small veins of granitic material were introduced principally along foliation of these older gneisses, though locally the veins transect the foliation. Further migmatization occurred with the emplacement of the later granitic rocks (quartz diorite, gneissic granite, Silver Plume granite, and pegmatite). The migmatite has been assigned to the Idaho Springs formation with the realization that this migmatite actually is a combination of older metasedimentary rocks of the Idaho Springs formation with later introduced material of younger pre-Cambrian age.

Quartz diorite

Two small irregular bodies of quartz diorite are present in the southwestern part of the mapped area (pl. 1). The quartz diorite is principally a coarse-grained, massive rock consisting of biotite, hornblende, and plagioclase, with noticeable amounts of quartz. Locally a metamorphosed quartz diorite facies has been developed by shearing and recrystallization of the quartz diorite.

Foliation, apparently due to local shearing of the quartz diorite, is present in the metamorphosed quartz diorite facies. The foliation direction is immediately related to the direction of the shearing.

Locally, the quartz diorite is cut by stringers of gneissic granite and occurs as inclusions in Silver Plume granite.

Gneissic granite

The gneissic granite is a white medium-grained foliated rock that consists essentially of potash feldspar, plagioclase, and quartz. It contains as much as 30 percent of schist inclusions. Locally a coarse-grained pegmatitic facies occurs as irregular masses in the granite.

The gneissic structure of the granite is given by subparallel alinement of thin wisps of biotite schist and 1- to 2-in. layers of biotite-quartz-plagioclase gneiss, which range from a few inches to 4 ft in length. In places a weak mineral layering is present in the parts of the granite containing inclusions of schist, gneiss, or both of these rocks. The degree of gneissic structure present in this granite depends principally upon the abundance of inclusions--the more inclusions present, the better the gneissic structure. More inclusions are present in the granite near its contact with migmatite or biotite-quartz-plagioclase gneiss than in the central part of the granite. Gneissic granite grades into migmatite and biotite-quartz-plagioclase gneiss. The gneissic granite apparently has inherited its foliation from the older rocks. Gneissic granite is cut by veins of Silver Plume granite and pink pegmatite.

Silver Plume granite

A gray to pink, fine- to coarse-grained biotite granite is exposed in approximately 40 percent of the outcrop area shown on plate 1. The granite consists of potash feldspar, plagioclase, quartz, and biotite and is similar in mineralogy, texture, and color to Silver Plume granite at the type locality of Silver Plume, Colo. For this reason the writers refer to it as the Silver Plume granite. Most of this granite in the Jo Reynolds area belongs to the medium-grained facies; a few outcrops of the fine- and coarse-grained facies occur around and within the larger medium-grained masses.

All facies of Silver Plume granite have a weak foliation. Subparallel tabular potash feldspar crystals in planar arrangement give foliation to the medium- and coarse-grained facies; alinement of biotite flakes forms the foliation in the fine-grained facies.

The Silver Plume granite contains inclusions of quartz diorite and rocks of the Idaho Springs formation. Veins of Silver Plume granite cut through gneissic granite. Silver Plume granite is cut by veins and dikes of pink pegmatite.

Pegmatite

Dikes or veins of pink granite pegmatite occur in most of the outcrops of this area. Most of the dikes, however, are too small to be shown on plate 1. Small pegmatite masses are found along most contacts between Silver Plume granite and older rocks. The pegmatite consists of perthitic microcline, plagioclase, and quartz with small amounts of biotite and muscovite. Locally the dikes contain magnetite, which may form as much as 35 percent of a 2-ft square section of an outcrop.

Pink pegmatite veins and dikes cut all other pre-Cambrian rocks. A close field association between the pink pegmatite and Silver Plume granite suggests that the pegmatite may be a late phase of Silver Plume granite.

Bostonite dike

A bostonite dike crops out in the extreme northern part of the mapped area and extends several hundred feet northward beyond the limit of the map (pl. 1). The southward extension of the dike is covered by a thick deposit of glacial debris. Excellent exposures of the dike occur in the road cut and in several of the prospect pits.

The dike is essentially a fine-grained light-lavender rock, which is locally porphyritic. The porphyritic parts of the dike may have a dozen small phenocrysts per square foot. Trachytic texture is well developed in the dike and is made visible to the naked eye by weathering. Chilled margins are present. Alteration along fractures has bleached parts of the dike to light buff.

The bostonite dike cuts pre-Cambrian rocks. Similar bostonite dikes in other parts of the Front Range are considered by Lovering and Goddard (1950, p. 47) to be early Tertiary in age.

Glacial debris and alluvium

Much of the area mapped north of coordinate 102,000N (pl. 1) is covered by Quaternary glacial debris deposited by alpine-type glaciers, which moved easterly down Clear Creek valley.

The eastern part of the area mapped along Silver Creek is covered by alluvium.

STRUCTURE

Principal structural features

Two fold systems have been formed in the pre-Cambrian bedrock of the mapped area (fig. 2). The principal fold system is indicated by the major structural feature in this area--a syncline plunging 20° to 80° in a general direction of N. 60° E. A second fold system intersects the major fold system at an angle of about 30°. Traces of the axial planes of the secondary fold system trend about N.30° E. on the northwest flank of the major syncline. Bending of fold axes in a horizontal plane is reflected by bends in the trace of the axial planes (fig. 2); bending in a vertical plane is suggested by a wide range in plunge of lineations that are parallel to axes of folds (pl. 1).

Traces of two normal faults are shown on plate 1 and figure 2. The faults are not directly related to planar and linear structures of the pre-Cambrian bedrock. The faults, though in places subparallel to major fold axes in the bedrock, elsewhere transect these axes. Lovering and Goddard (1950) consider the faulting in the Lawson-Dumont district to be early Tertiary in age.

Folds

The folds in the area are outlined by gneissic structures, which have been previously described with each rock unit. The mapped area contains a series of upright and very slightly overturned synclinal and anticlinal folds a few hundred feet across. The folds generally plunge 20° to 80° NE. The flanks of the larger folds of both fold systems have been crumpled into small rolls and warps, in places several feet across. The small warps plunge down the flanks of the larger folds and have their axes approximately normal to the axes of the larger folds. Crinkles and drag folds are present on both of these fold systems, and other linear features are developed in the rocks through streaking and mineral alinement.

Faults

The faults in this area are normal faults trending N. 65° E. The faults are indicated on the map (pl. 1) by the veins that occupy them. Surface exposures of the faults are easily recognized because of the presence of siderite, sphalerite, and hematite along them.

Two faults are exposed on the surface: the main Jo Reynolds fault (occupied by the Jo Reynolds no. 2 vein), which strikes N. 60° -80° E. and dips 58° -82° NW., and a minor subparallel fault 150 ft southeast of it. Each fault has a 20- to 30-ft sheared zone adjacent to it.

The Jo Reynolds fault and the minor fault southeast of it are curved surfaces and in general take the form of flat cymoid curves.[1] Associated fractures and shingle structures in outcrops indicate that the southeast blocks have moved up and to the southwest relative to the northwest blocks. Underground mapping of the accessible part of the Elida tunnel (fig. 3) confirms this apparent movement along the Jo Reynolds fault and suggests that the apparent horizontal offset is 20 to 30 ft.

At least two other faults are reported in this area but are not shown on the map--one contains the Jo Reynolds no. 1 vein, the other is presumed to follow the general line of the American Sisters group of dumps. Bastin and Hill (1917, p. 339) give the general trend of the American Sisters vein (fault) as parallel to the Jo Reynolds main vein (fault).

Joints

Joints are well developed in all the pre-Cambrian and Tertiary rocks exposed in the area mapped. The most prominent joints strike N. 65° E. and dip 80° NW. and are approximately parallel to the Jo Reynolds fault. Less prominent are joints that strike approximately N. 35° W. and dip steeply to the northeast or northwest.

ECONOMIC GEOLOGY

The Jo Reynolds no. 2 vein, or main vein, is exposed at the surface in 12 places over a strike length of several hundred feet. The same(?) vein crops out in the saddle on the prominent rock knob N. 46° E., 1,250 ft, from the portal of the Daily tunnel. The no. 2 vein, where exposed, strikes N. 60°-80 E. and dips 58°-82° NW., generally flattening from southwest to northeast along the strike. Although only the most prominent vein is shown on the maps (pl. 1 and fig. 2), several exposures show minor parallel fractures in a 20- to 30-ft zone around the main vein. The main vein and parallel fractures contain sphalerite, siderite, and local hematite. From the plan of the drifts, it is inferred that the no. 2 vein has an average strike of N. 63° E. and dip of 67° NW.

The no. 3 vein crops out in four places. It strikes N. 55°-68° E.; it dips 55°-70° NW. opposite the places where the no. 2 vein dips 75°-82° NW. Underground, the no. 3 vein appears to strike N. 80° E.; its dip is not known.

The no. 1 vein is not exposed, and the no. 4 "lode," as mentioned by Morton,[2] cannot now be identified.

[1]A cymoid curve is a reverse curve in which a line swerves from its course and then swings back again, resuming a direction parallel to its former course but not in line with it (McKinstry, 1948, p. 315).

[2]Morton, R. B., Vertical longitudinal section of Jo Reynolds mine (loaned by C. L. Harrington) and notebook page (photostat loaned by J. W. Shireman), 1905.

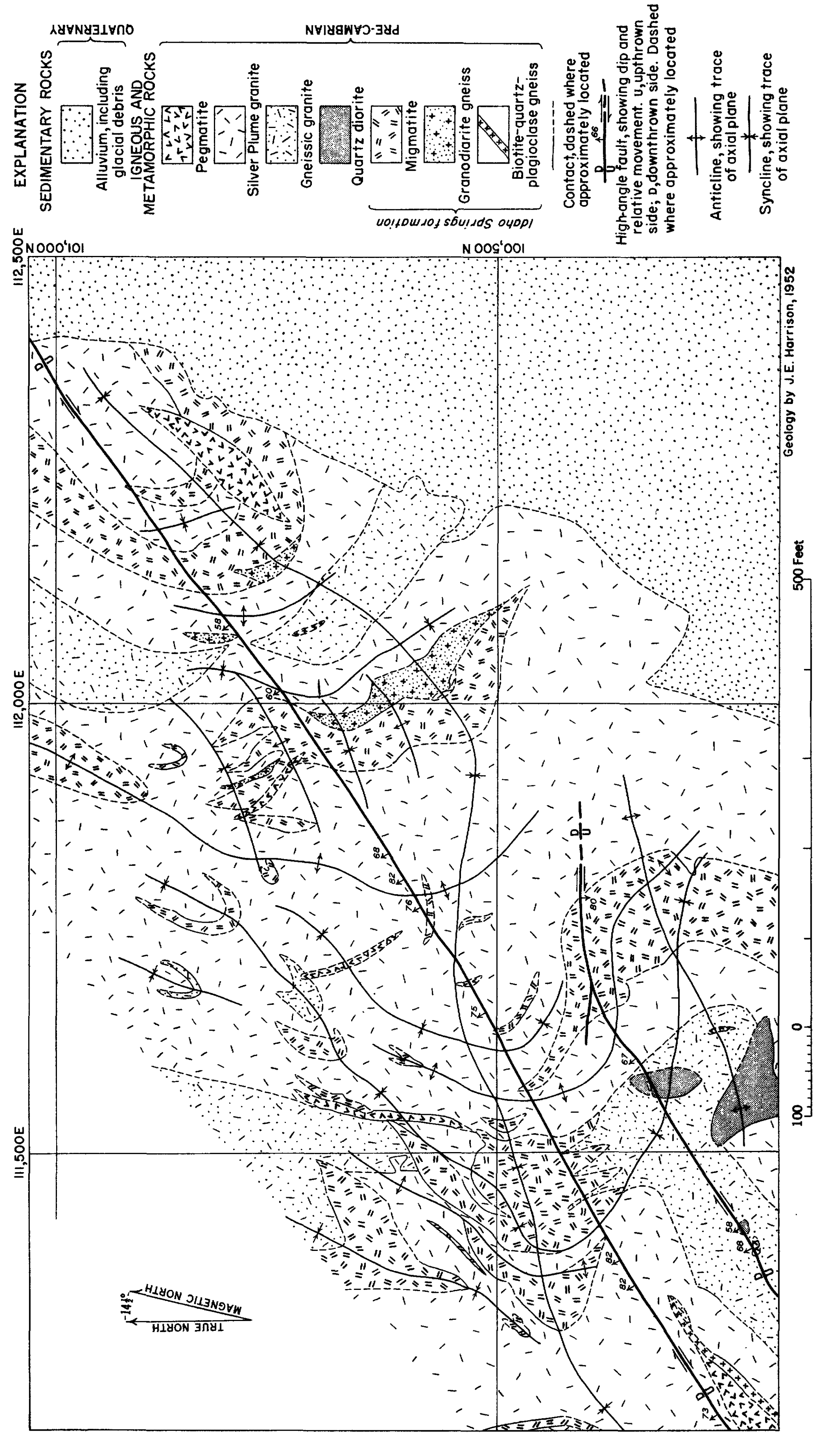
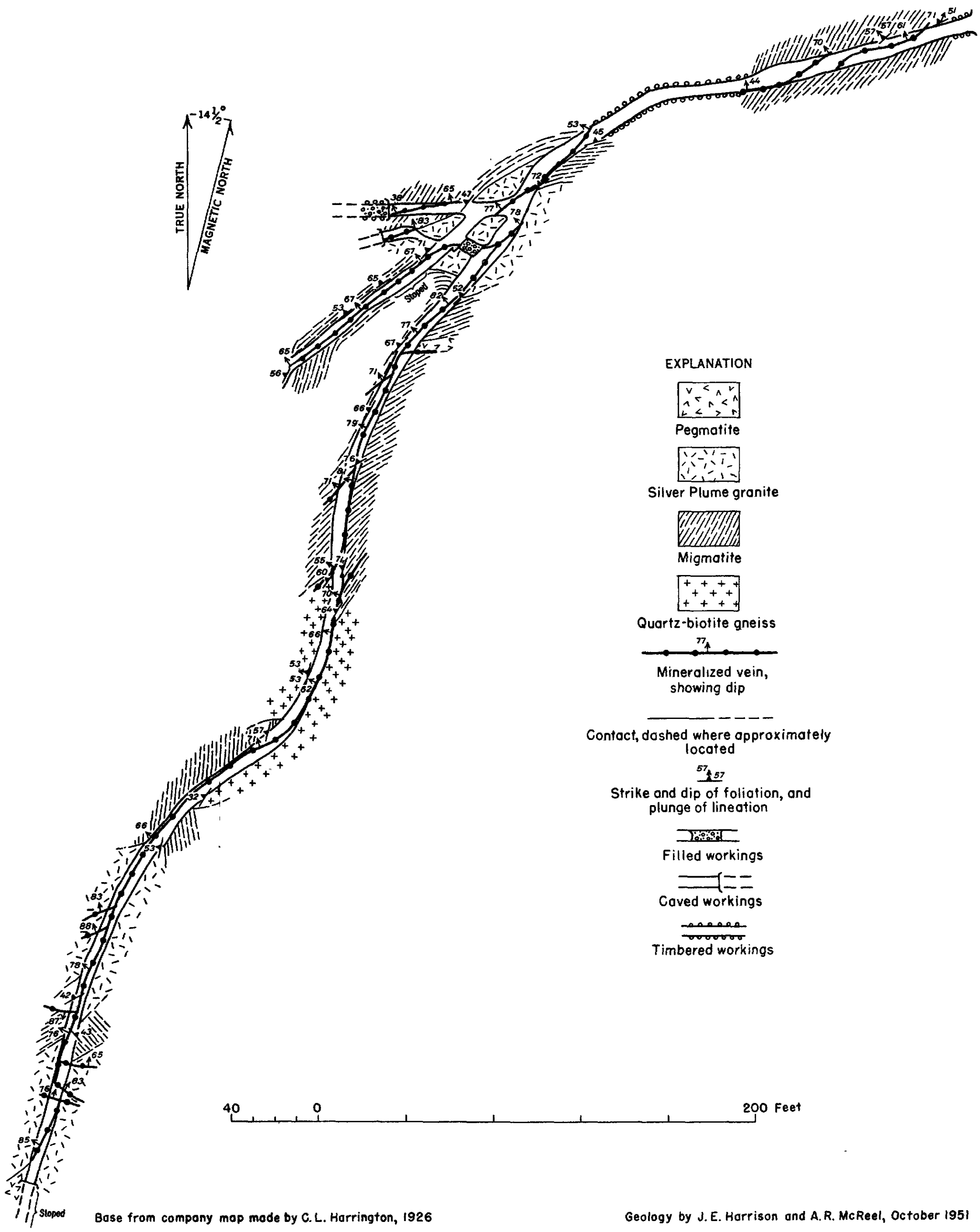


Figure 2. --Inferred geologic and structure map of part of the Jo Reynolds area, Lawson-Dumont district, Clear Creek County, Colo.



Base from company map made by C. L. Harrington, 1926

Geology by J. E. Harrison and A. R. McReel, October 1951

Figure 3. --Geologic map of the northeast part of Elida tunnel, Jo Reynolds mine.

Bastin and Hill (1917, p. 340) give the mineralogy of the vein as follows:

> "The vein is similar in mineral characters to the neighboring American Sisters vein. The primary metallic minerals are galena, sphalerite, pyrite, chalcopyrite, and gray copper; and the secondary minerals polybasite, pearceite, proustite, argentite (original?), native silver, chalcopyrite, and galena."

Bastin and Hill (1917, p. 124) examined polished surfaces of pitchblende ore from the Jo Reynolds mine. They concluded that deposition of the pitchblende was early and was followed by deposition of the sulfides.

Though a radiometric survey of the dumps in the area failed to show significant anomalies (King, 1951, p. 6), outcrops of the veins show anomalous radioactivity on the order of two times background on the 0.2 mr/hr scale of a Geiger counter.

The only mine workings accessible at the time of the mapping were 745 ft of the Elida tunnel. This part of the tunnel (fig. 3), together with the short drifts near its portal, shows several minor shear zones with oxidized sulfides but no detectable concentrations of radioactive material. A cave 745 ft from the portal blocks access to the main Jo Reynolds vein and the area from which pitchblende has been reported.

Occurrences of pitchblende and anomalous radioactivity in the Jo Reynolds area

Eight occurrences of pitchblende have been reported at this deposit. In addition, Guillotte (1944, p. 13) reports the presence of torbernite in the Jo Reynolds mine.

The eight occurrences are tabulated below, beginning with the upper workings.

1. A pocket of pitchblende at a point on the 100-ft level.[3] The 100-ft level might be either level 3 or level 4 (pl. 2, B).
2. Abeel crosscut to no. 4 lode, and 100-ft and 200-ft levels from Herrick shaft--places not further identifiable.[4]
3. "Quite a large pocket" of uranium ore encountered in 1886 on the second or third level (Georgetown Courier, February 28, 1914).
4. Pitchblende high in radium from an 18-in. vein--location in the mine unspecified (Denver Post, November 10, 1914; Rocky Mountain News, November 11, 1914; --? Herald, with Idaho Springs, November 10 dateline).
5. Tunnel level (Elida?), near the bottom of the old shaft, about 1,000 ft below the surface (Bastin and Hill, 1917, p. 124).
6. Sooty pitchblende(?), Elida tunnel, 100-150 ft southwest of the main shaft (King, 1951, p. 6). This might be virtually the same occurrence as that noted by Bastin and Hill (1917, p. 124).
7. A 76-ft raise in 1 to 3 percent ore more than 3 ft wide; raise made from the tunnel (Elida?) level (Georgetown Courier, January 12, 1916).
8. Eight tons of pitchblende--location unknown but inferred to have been in the lowest workings of

[3]Morton, R. B., photostat of notebook, 1885.
[4]Op. cit.

the Jo Reynolds mine (King, 1951, p. 2)[5]. Most of the current significance of the Jo Reynolds property is based on this reported production of high-grade ore. Because of the importance of such a deposit and the divergence of opinion on its credibility, the matter is discussed below.

Guillotte (1944, p. 6) states that in 1919 the Jo Reynolds mine produced 8 tons of pitchblende that assayed 72 percent U_3O_8. The ore was sold in France by R. B. Morton, owner in 1919, for $80,000. Both statements were contributed to Guillotte in 1944 by the owner, E. H. Geary (now deceased) of Denver, and reportedly confirmed by Mrs. Morton. Guillotte, apparently finding it impossible to authenticate the information, felt that the production data for the Jo Reynolds mine might be erroneous.

King (1951) found no significant quantities of uranium ore in the Elida tunnel but concluded, after re-evaluating all the available information, that the ore body reported to have yielded 8 tons of high-grade ore was probably cut in the lowest workings of the mine.

Anomalous radioactivity in the vein exposed in the Elida tunnel has been reported by King (1951, p. 6) in the ground 100 to 200 ft southwest of the main shaft. Local areas in the first 745 ft of the Elida tunnel show very slight anomalous radioactivity.

Other anomalous radioactivity near the area

King and Granger (1950) report the occurrence of torbernite at the Robineau claims about three-fourths of a mile southwest of the portal of the Daily tunnel. This group of claims was located by triangulation and their position plotted with reference to the Daily tunnel portal. The Jo Reynolds no. 2 vein, when projected, passes about 1,200 ft north of the Robineau claims. The Nabob vein, which is reported to be essentially parallel to the Jo Reynolds and American Sisters veins, had the correct geographic position and attitude to project through the Robineau claims. The question of whether or not it does can be settled only by detailed study, however.

Shoot structure

The writers believe that the lead-zinc-silver ore body in the Jo Reynolds mine had a pronounced shoot structure. This raking ore shoot with a possible maximum height[6] of about 500 ft is shown on the vertical longitudinal projection (pl. 2, B). The original stope section bore tonnage and grade estimates for all the unstoped ground. These estimates were an extrapolation of data from adjacent stoped areas, so that Morton clearly reckoned--on that stope section, at least--that the ore body was a uniform tabular deposit. However, the writers doubt that an ore body then mined for more than 30 yr would have been stoped obliquely down the vein unless that was truly the most favorable ground.

[5]There is some uncertainty about the date of driving the sublevel below the Elida level. Part of the sublevel is more than 30 yr old; part of it may be 15–20 yr old. The term "lowest workings" as used by King is deliberately noncommittal (King, oral communication). It refers to the Elida level and workings immediately above and below that level.

[6]The height of an ore shoot is its dimension perpendicular to the long axis of the shoot, measured in the plane of the shoot. "Height" is sometimes called "breadth."

The "apparent rake" of the ore shoot in the vertical longitudinal section is 45°-65° NE. (probably close to 60° NE). This inclination is approximately equivalent to the true plunge of the shoot. The trend, or direction of elongation of the shoot, is close to N. 17° E. The true rake, measured in the plane of the vein, is about 70° NE.

The structural control for the now unobservable ore shoot is, of course, a matter of conjecture. However, the meager structural information that is available suggests two explanations for localization of an ore body along the direction N. 17° E., 60° NE.

1. A plan map of the Elida tunnel loaned by C. L. Harrington[7] shows the strike and dip of the main mineralized fractures in the tunnel and adjoining workings. A schematic plot of these fractures and their relation to the trend of the ore shoot is shown in figure 4. The main vein (*A*) appears to have the attitude N. 65° E., 65° NW. Two essentially symmetrically arranged mineralized fracture surfaces (*B* and *C*) have attitudes of N. 88° E., 65° NW., and N. 46° E., 71° NW., respectively. A transverse joint (*D*) strikes N. 35° W., and dips 65° NE. The traces (lines of intersection) *AD*, *BD*, and *CD* lie within a few degrees of N. 17° E., 60° NE. The trace *AC* has a similar plunge but trends roughly north, instead of north-northeast. A statistical study of joints in outcrops in the Jo Reynolds area shows maxima for surfaces having attitudes of N. 65° E., 80° NW., and N. 35° W., steep NE. and SW. These data agree well with Harrington's plot of mineralized fractures on the Elida level. Perhaps we may cautiously infer, then, that the structure of the ore body was controlled by the intersection of a main fracture zone with a transverse set of joints(?); surfaces symmetrical about the main zone may also have exerted considerable control.

[7]Harrington, C. L., Maps of Jo Reynolds property, including plan of Elida tunnel and vertical longitudinal (stope) section prepared by R. B. Morton.

In the fracture pattern of the area the transverse set of joints bears the relation of a tension fracture to the main faults. Everhart and Wright (1951) and Buffam (1951) have recently suggested that pitchblende occurs in tension fractures that are commonly minor fractures associated with large-scale structures. The writers do not wish to imply that they believe that pitchblende necessarily should, or should not, be found on the transverse joints of the Jo Reynolds mine. However, the hypothesis should be borne in mind when further study of the deposit is undertaken.

2. Data from surface geologic mapping show that the Jo Reynolds no. 2 vein is on a somewhat curving surface. The apparent movement along this curved surface has been discussed under the topic of faults. The data are too few to define the directions or amounts of relative movement with precision, but they suggest movement roughly along the NNE. direction at a high angle, with consequent horizontal displacement of 20 to 30 ft. This movement would serve to develop openings along the curved shear surface favorable for the deposition of ore in a shoot.

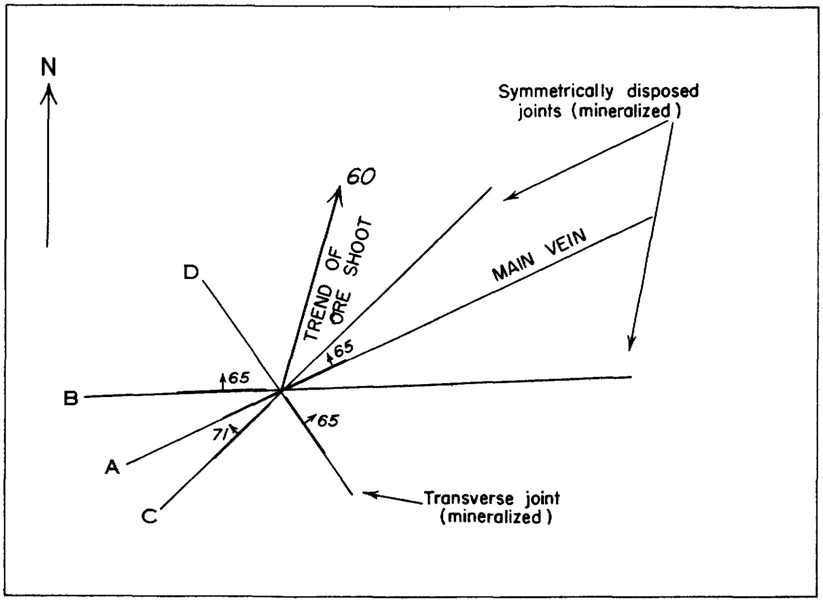


Figure 4. --Schematic plot of fracture surfaces and trend of ore shoot, Elida tunnel level, Jo Reynolds mine.

A multiple shoot structure may be present in the Jo Reynolds mine. Slight variations in strike and dip along the high-angle fault, such as appear on the surface map, could serve to develop a series of openings favorable for the formation of ore shoots. At least three veins have been mined on the Jo Reynolds property, and the intersection of each of the veins with a transverse set of joints could also serve to localize ore in shoots.

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