45° to 55° N. For part of its extent on Wood Mountain it shows vein material and this material may be the outcrop of the Zopher vein which is well exposed in the Wood Mountain tunnel; however, farther west the breccia reef is poorly exposed and seems to be marked chiefly by a fractured zone from 30 to 60 feet wide, characterized by chloritized granite containing some epidote seams and a few hematite seams. This material may possibly mark the top of the breccia reef, for it is impossible to trace a definite fault fissure through it. Just south of Fourmile Creek, the reefs are rather strong faults and are composed of 8 to 15 feet of sheared and brecciated red granite. These reefs have the same character and general trend as the Fortune reef and probably belong to the same general group. The rather inconspicuous breccia reef on Wood Mountain has apparently influenced the courses of several veins. The Franklin vein takes an abrupt turn where it crosses the breccia reef and several other veins appear to end against it, as shown in figure 2.

Scattered throughout the district there are numerous small breccia reefs of little extent and narrow width. Most of them trend northwestward and dip steeply, but those of a group in the east-central part of the district near the Maxwell reef strike north-northeast and dip steeply westward. A few of these small breccia reefs have had a significant influence on the local distribution of ore.

Vein Fissures

Vein fissures are scattered abundantly throughout most of the district. Nearly all strike northeast and dip steeply to the northwest, but a few strike northwest and there are a few nearly horizontal fissures, such as that occupied by the King vein. There are two main sets of northeast-striking vein fissures, both of which have been productive. A system of north-northeast trend appears to be the earlier and these fissures have been filled with the gold-telluride type of vein material. Most of the productive veins of the district belong to this system. Another system includes veins of east-northeast strike which have been largely filled with pyritic gold or lead-silver ores. East of Emancipation Hill, in the eastern part of the district, there is a group of east-northeast trending vein fissures which appear to be earlier than the north-northeast-trending system, for one of them is cut by a vein of north-northeast trend.

The vein fissures range in length from a few hundred feet to 1¾ miles, and most of the productive veins are more than half a mile long. The width is commonly between 1 and 5 feet, but locally there are zones of fracturing or shearing from 10 to 30 feet wide. The Grand Republic vein forms a zone 40 to 60 feet wide in places.

The displacement on the vein fissures has not been large. In most places it ranges from 2 to 10 feet, but in a few places it is as much as 20 feet. On some of these fissures there have been three or more periods of movement. On most of the veins of both the north-northeast system and the east-northeast system, the southeast wall has moved down and to the southwest, though on some this wall has moved down nearly vertically. On the early east-northeast fissures east of Emancipation Hill, the south wall has moved east nearly horizontally.

Post-ore faulting

In the district there are few if any post-ore faults that cut across the vein fissures; however, along many of the more important veins there have been varying amounts of post-ore movement. For the most part this post-ore movement has amounted to only a few feet, but in a few places, notably on the Twin vein in the northern part of the district, it has been sufficient to lower the grade of ore substantially by breaking it up and distributing it through a wide gougy fissure.

Ore Deposits

Chief Metals

Gold is the chief metal produced in the Gold Hill district, although in most places minor amounts of silver are associated with the gold. In a few of the mines silver has been the most important product, and some lead has been produced with it. Some tungsten ore has been shipped from the Logan mine, in the southwestern part of the district.

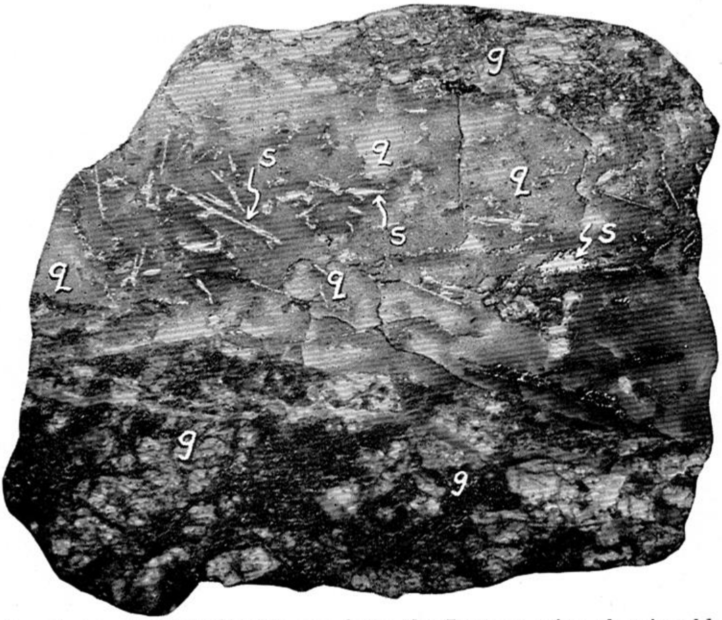
Character of the veins

All the production in the Gold Hill district has come from fissure veins. Most of the veins are of the gold-telluride type, but there are some pyritic gold veins and some silver-lead veins. A few of the silver-lead veins, notably those of the Yellow Pine mine and the Dana lode appear to be related to the breccia-reef period of mineralization and are, therefore, thought to be the earliest ore deposits in the district. Other lead-silver deposits seem to be related to the pyritic-gold veins, which are thought to be slightly later than the gold-telluride ores, because in a few places in the Slide vein, veinlets of typical pyritic gold ore cut horn-quartz seams containing gold-tellurides. It is possible, however, that a few of the pyritic gold veins may be earlier than the gold-telluride veins, as are most of the pyritic gold veins in other parts of the Front Range mineral belt.

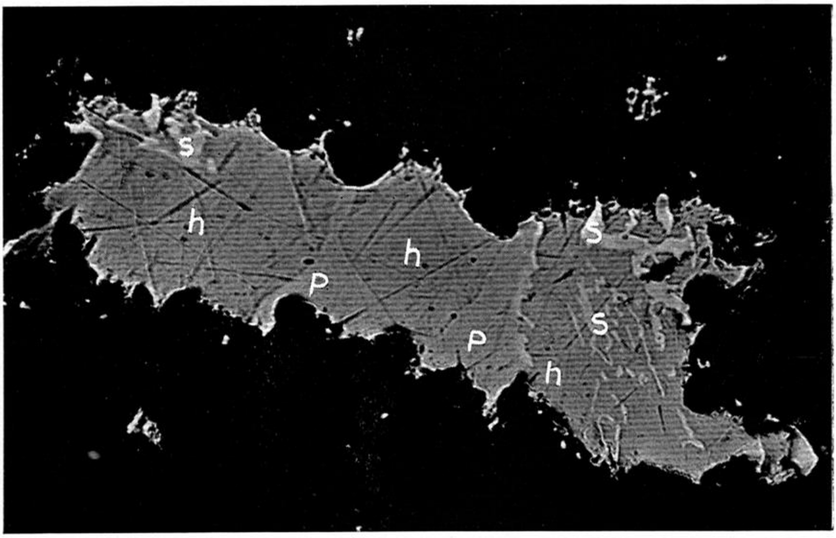
Composition of the ore

Telluride ore.—Gold-tellurides are the most important ore minerals in the district, though free gold is abundant in numerous veins. The most abundant tellurides are petzite and sylvanite (the silver-gold tellurides) but hessite (the silver telluride) is abundant in a few places. Altaite (the lead telluride) and coloradoite (the mercury telluride) are locally associated with the other tellurides in very small amounts. Tetradymite (the bismuth telluride), calaverite (the gold telluride), and native tellurium have been reported by Genth[19] from the Red Cloud mine. In most of the telluride ores two or more of the telluride minerals are microscopically ingrown as shown in figure 3. Free gold is associated with the telluride ores in places, and in some

[19] Genth, F. A., Contributions from the Laboratory of the University of Pennsylvania, No. III, Proc. Amer. Phil. Soc., vol. 14, p. 225, 1874.



A. Specimen of gold telluride ore from the Ingram mine showing bladed crystals of sylvanite (s) in a horn quartz veinlet (q) that is bordered by altered Boulder Creek granite (g). (Photographed by T. S. Lovering.)



B. Photomicrograph of gold telluride ore from the Slide vein showing hessite (h) intergrown with petzite (p) and cut by irregular veinlets of sylvanite (s). Black is quartz.

Figure 3. Photograph and photomicrograph of high grade gold telluride ores.

mines, such as the Logan, Red Cloud, Cold Spring, and Emancipation, it is locally abundant. Rusty gold is found in the oxidized portions of the gold-telluride veins. Fine-grained pyrite is disseminated throughout the telluride veins and very small amounts of galena and sphalerite are associated with the ore.

The chief gangue mineral of the gold-telluride veins is horn-quartz, which grades in places into sugary quartz. In some of the mines ankerite and other carbonates are associated with the telluride ores, but they are later than the telluride minerals. In a few places, notably in some ore from the Slide vein, small amounts of roscoelite are associated closely with free gold and tellurides. The telluride minerals occur in groups of small blades, in small irregular masses, or in tiny veinlets in the horn-quartz as shown in figure 4, and their distribution is very spotty. In places there are small veinlets made up of an intimate intergrowth of tellurides and horn-quartz. Free gold replaces the telluride minerals in places but in others it occurs in separate veinlets.

Pyritic gold ore.—In the pyritic gold veins, pyrite and chalcopyrite are the most abundant ore minerals, but free gold is abundant in some of the veins, notably the veins on Wood Mountain in the southwestern part of the district. In the Klondyke vein, which is the most productive of the pyritic-gold veins, some coarse wire gold has been found near the junction with the Prussian vein; however, in most of the Klondyke ore, the free gold is invisible, but is recovered in the "rag" plant of the Slide mill. The gold seems to be associated with both the chalcopyrite and the pyrite. Small amounts of sphalerite, galena, and gray copper are also commonly associated with the pyritic gold ore.

The chief gangue mineral of the pyritic-gold veins is sugary to glassy quartz, which grades into horn-quartz in places. Ankerite is found in some of the veins and appears to be the latest mineral present.

Silver-lead ore.—The same minerals are present in the silver-lead ore as in the pyritic-gold veins, but in different amounts. Argentiferous gray copper (tennantite) and galena are the chief ore minerals, but sphalerite, chalcopyrite, and pyrite are present in small amounts. Stromeyerite has been described as occurring in the silver-lead ore from the Yellow Pine mine.[20] The chief gangue mineral in the silver-lead ores is sugary to glassy quartz, but ankerite is present in places.

Tungsten ore.—In the tungsten ore in the Logan mine, the ore mineral is ferberite and the chief gangue mineral is a dense horn-quartz.

Grade of ore

The gold-telluride ores are for the most part high grade. In the early days much of the ore shipped in small lots, ranging from a few pounds to several hundred pounds, assayed from 100 to 1,100 ounces of gold to the ton and from 35 to 1,100 ounces of silver to the ton. One shipment in 1900 of 53½ pounds from the Melvina mine assayed 2115.45 ounces of gold to the ton and one of 4½ pounds from the Interocean mine assayed 1747.0 ounces gold and 701 ounces silver to the ton. Many shipments of several tons or more have ranged in grade from 1 to 12 ounces of gold to the ton and from 1 to 60 ounces silver to the ton. Since 1900, much high-grade ore has been mined that was as rich as that found in the early days, but the average grade of telluride ore shipped in ton lots has ranged from about 0.5 to 2 ounces of gold and from 1 to 10 ounces silver to the ton. The average ratio of gold to silver throughout the district is about 1:2, although in some ore it is 1:1; in some shipment records the silver content has not been listed. The free-gold ore mined in the district has had about the same range in grade as the high-grade telluride ore, although a few small pockets are reported to have assayed much higher.

The pyritic gold ore of the district is low-grade and commonly contains from 0.25 to 1.0 ounce gold to the ton.

[20] Headden, H. P., Stromeyerite-Yellow Pine Mine, Boulder County, Colo., Amer. Min., vol. 10, pp. 41-42, 1925.

At the Grand Republic mine, ore having as low a gold content as 0.15 ounce to the ton was mined but formed ore bodies from 20 to 60 feet wide. Small amounts of pyritic gold ore, notably from the Klondyke vein and the Slide footwall vein, have assayed as high as 4 ounces gold to the ton. The silver content of the pyritic gold ores is irregular and has ranged from zero to about the same amount as the gold.

The silver-lead ore shows a wide range in grade. Silver-lead ore from the Yellow Pine mine has assayed from 33 to 1440 ounces of silver to the ton and a few shipments contained from a trace to 0.4 ounce of gold to the ton. Numerous samples taken in the Victoria mine in 1916[21] and 1918[22] have assayed from 5.94 to 218.6 ounces silver to the ton, from 0.12 to 3.08 ounces gold to the ton, from 0.52 to 5.60 percent lead (wet assay), from a trace to 2.50 percent copper (wet assay) and from a trace to 9.00 percent zinc. Tungsten ore taken from the Logan vein has averaged between 5 and 10 percent WO_3.

The most accurate data on the grade of the Gold Hill ores in the early years have been secured from the records of the Boulder Ore Sampling Works[23] and a few representative shipments are given in the following table:

[21]Hoskin, Arthur J., Brief report on the Victoria mine, Dec. 1, 1916, unpublished report.

[22]Alderson, Victor C., and Ziegler, Victor, Report on the Victoria mine, Mar. 28, 1918, unpublished report.

[23]Four record books of the Boulder Ore Sampling Works are on file at the office of the Boulder County Miner and Farmer at Boulder. They cover the periods May 1, 1878, to Jan. 20, 1889, and Dec. 1, 1890, to May 30, 1892. The records of the sampling works at Boulder from 1910 to 1939 are on file in the U. S. Bureau of Mines office in Denver.

Representative shipments of ore from the Gold Hill district to the Boulder Ore Sampling Works, 1878-1892

Date	Mine	Net weight (pounds)	Gold (ounces to the ton)	Silver (ounces to the ton)
Aug. 5, 1878	Slide	147	162.20	1056.0
Sept. 11, 1878	Slide	21,107	12.20	60.0
Dec. 1, 1878	Slide	5,978	3.60	11.0
Aug. 21, 1883	Interocean	7,315	4.90	11.0
Aug. 21, 1883	Interocean	94½	126.00	237.0
Aug. 21, 1883	Interocean	4¼	1747.00	701.0
Nov. 2, 1882	Ingram	45½	1139.00	792.0
Nov. 2, 1882	Ingram	107½	201.00	268.0
Nov. 2, 1882	Ingram	1,575	6.25	15.0
Nov. 17, 1882	Ingram	1,771	3.30	7.0
Mar. 3, 1887	Poorman	3¼	1530.00	302.0
Mar. 3, 1887	Poorman	59½	114.50	68.0
Mar. 3, 1887	Poorman	2,685	6.50	7.5
Nov. 5, 1884	Emancipation	5⅞	713.00	230.0
Nov. 5, 1884	Emancipation	59½	118.00	36.0
Nov. 5, 1884	Emancipation	6,433	4.70	3.0
June 17, 1890	Logan	2½	2169.00	487.0
June 17, 1890	Logan	1,642	5.30	2.5
June 17, 1890	Logan	594	2.20	3.7
June 24, 1883	Yellow Pine	13,857	----------	277.0
June 24, 1883	Yellow Pine	3,916	----------	212.0
June 24, 1883	Yellow Pine	110	----------	115.5

Size and extent of veins

Considering their narrowness and the small amounts of displacement along them, the veins of the Gold Hill district are fairly persistent. Most of the productive veins are more than a half mile in length and a few are more than a mile long. The most persistent veins in the district are the Melvina-Richmond and Horsfal, both of which can be traced continuously for 1¾ miles. Many of the productive veins have been followed to depths ranging from 300 to 600 feet below the surface and the deepest workings are those on the Slide vein, which extend to a depth of 1,080 feet. The Ingram shaft has a vertical depth of 950 feet. In most of the mines, the veins have not pinched out in the bottom levels, but commonly water problems and other operative difficulties have made it unprofitable to explore deeper.

The veins commonly range in width from one to five feet. In places they pinch to only a few inches and locally, chiefly at junctions, a few attain widths ranging from 10 to 30 feet. The widest vein in the district is the Grand Republic, which locally forms a zone 40 to 60 feet wide. Most of the veins are not filled solidly with quartz and ore minerals but are made up of an interlacing network of quartz veinlets from a fraction of an inch to one foot wide in silicified or sericitized wall rock. The ore minerals are chiefly confined to these quartz seams. In the mining of telluride ores it is common practice to sort the high-grade quartz veinlets from the rest of the vein material, which is relatively barren.

Distribution of the Ore

Veins are scattered throughout the Gold Hill district, but nearly all the ore produced has come from the vicinity of the breccia reefs, as shown in figure 4. Most of the production of the district has come from the block of ground between the Hoosier and the Maxwell reefs. In many veins the ore occurred within a few hundred feet of a breccia reef, and it is doubtful if any appreciable production has come from areas 3,000 feet beyond a breccia reef. Perhaps the most strikingly productive zone in the district is the zone about 3,000 feet wide on the northeast side of the Hoosier reef extending from just south of Summerville to northeast of Gold Hill. Another less continuous zone extends northeastward along the Melvina-Richmond and the Sunshine-Grand View-Interocean veins from Melvina Hill to Sunshine. This zone is crossed by a narrow zone along the Fortune reef extending from Summerville eastward to the Emancipation mine northeast of Salina. In addition to these zones there are the small but rich productive blocks at the junctions of the Poorman reef with the Hoosier reef and with the Maxwell reef in the southern part of the district, and the larger block on Wood Mountain west of Wallstreet. Two small productive blocks are also found along the Maxwell reef southeast and northeast of Sunshine. The close

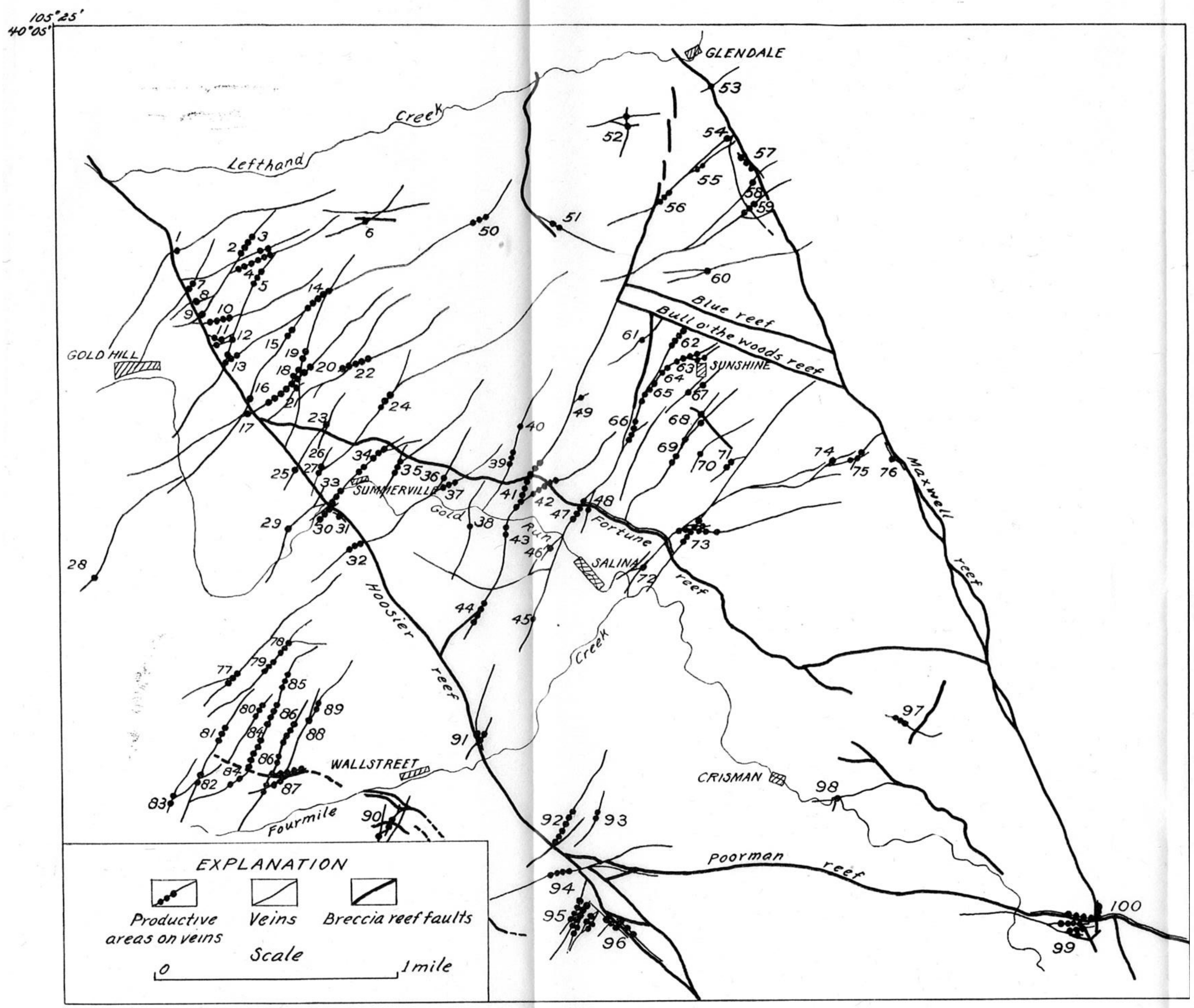


Figure 4. Structure map of the Gold Hill district, Colorado, showing the principal veins and the areas that have been productive.

LIST OF MINES

1. New Discovery
2. Prussian
3. Twin
4. Klondike (correct spelling is Klondyke)
5. Slide
6. Helena
7. Cold Spring and Red Cloud
8. Alturas
9. Gold Ring
10. Alamakee
11. Times
12. Winona
13. White Cloud
14. Horsfal
15. Columbus
16. Who Do
17. Bellvue
18. Cash group
19. Mack
20. St. Joe
21. Ready Cash
22. Black Cloud
23. Atlanta
24. Big Horn
25. King
26. First National Bank
27. Morning Glory
28. Myrtle
29. Tammany
30. Evans
31. Dana
32. Grant
33. Goldsmith Maid
34. Victoria
35. Scotia
36. Valley Forge
37. Belle
38. Golden Eagle
39. Fairfax
40. Minneapolis
41. Richmond
42. Ingram
43. Three Brothers
44. Melvina
45. Critic and Railroad Boy
46. Baron
47. Sunshine
48. Atchison
49. Sussex
50. Snowbound
51. Belle of Memphis
52. Delaware group
53. St.Louis
54. Washington Irving
55. Cleveland
56. Tillie Butzel
57. Sun and Moon
58. Hidden Treasure
59. Nil Desperandum
60. Dolly
61. Gillaspie
62. American
63. Interocean
64. Osceola
65. White Crow
66. Grand View
67. Washburn
68. White Eagle (Archer)
69. Golden Harp
70. Richard
71. Plough Boy
72. Home Sweet Home and Little Johnny
73. Emancipation group
74. Minnie Bell
75. New York-Union
76. Pilot
77. Sakhrat
78. Gold Lode
79. Great Britain
80. Lucky Star
81. Emerson
82. Concord
83. Forest
84. Franklin
85. Gillard
86. Gray Copper
87. Wood Mountain group
88. Last Chance
89. Doss
90. Gladys
91. Tambourine (Patented name is Temborine)
92. Dime
93. Evening Star
94. Grand Republic
95. Logan
96. Yellow Pine
97. King
98. McKnight Placer
99. Poorman group
100. Bell

relation of all these zones and blocks of productive ground to breccia reefs is readily apparent in figure 4 and there seems little doubt that the breccia reefs have exerted the dominant structural control of ore deposition in the district.

Size of ore bodies

The ore bodies of the district are commonly small and most of the very high grade ore comes from small pockets. Figure 5 shows the size and shape of the ore bodies in six of the larger mines in the district. Most of the ore bodies range in length from 100 to 400 feet, in breadth from 50 to 300 feet, and in thickness from 1 to 5 feet.The most persistent oreshoot in the district was in the Slide mine. It extended from the surface down to the 1,000-foot level and its breadth ranged from 60 to 250 feet (see fig. 5). The thickest oreshoot in the district was that in the Grand Republic mine which ranged from 10 to 50 feet. A few other ore bodies in the district have had thicknesses ranging between 5 and 25 feet. High-grade pockets of telluride ore commonly range from 20 to 60 feet in length, 10 to 35 feet in breadth, and 1 to 5 feet in thickness. In several of the mines, the Ingram for one example, several small pockety shoots are grouped together and form a relatively large compound oreshoot.

Persistence of ore with depth

The persistence of ore with depth in the Gold Hill district has been a much discussed, but as yet, unsolved problem. For many years it was commonly believed that most of the ore bodies of the district bottomed between 500 and 600 feet beneath the surface and that the veins themselves either bottomed at similar depth or became barren at greater depth. The outstanding exception was the Slide oreshoot which persisted to a depth of 1,100 feet beneath the surface, but no other vein in the district had been explored to such a depth. Recent development has further served to cast doubt on this old inference if not actually to disprove it.

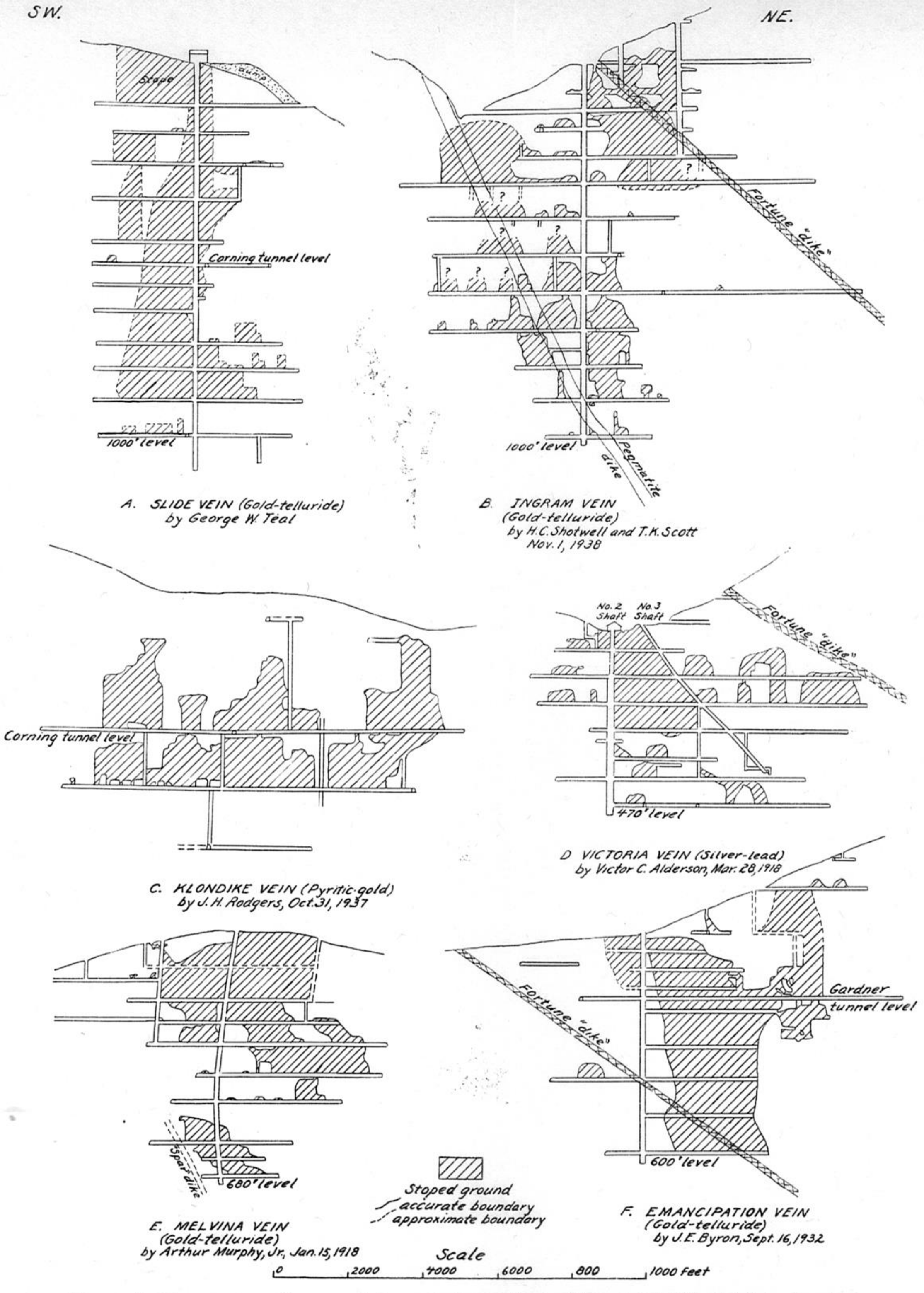


Figure 5. Stope maps of some of the principal mines of the Gold Hill district, showing the general size and shape of the ore bodies.

In October 1936, the Ingram shaft, which was 700 feet deep on the dip of the vein, was unwatered and sunk to greater depth. In sinking from the 700- to the 800-foot level, the company found some of the richest ore that had ever been taken from the mine and between the two levels, 2,022 ounces of gold and about the same amount of silver were mined in 13 months. So encouraging were these results that the shaft was sunk to the 1,000-foot level (930 feet vertically below the surface) where good ore was found, and early in 1939 preparations were being made to sink to the 1,100-foot level.

Ore was also uncovered at greater depth by new development work on the Klondyke vein. In the fall of 1937 the ore had largely been worked out within 515 feet of the surface. Subsequently the Prussian tunnel, which cuts the vein 665 feet below the surface, was cleaned out and drifting on this level uncovered new ore of as good grade as that found in the upper levels. This ore was being blocked out in 1938.

It is true that in several mines, such as the Melvina (550 feet deep), the Emancipation (580 feet deep), and the Interocean (590 feet deep), work has been discontinued at a depth of between 500 and 600 feet, but in nearly all of these mines ore was found in the bottom levels, as shown on the stope maps, and there is nothing to indicate that all the ground below is entirely barren. It seems probable that work was discontinued in these and other mines because of water and other operative difficulties and because of increased costs of further exploration rather than because the ore pinched out at a certain horizon throughout the district. However, in the Cold Spring-Red Cloud mine the ore did pinch out at a depth of 400 feet and although the vein was strong to a depth of 871 feet, very little material of commercial grade was found.[24] In this mine the Cold Spring and Red Cloud veins are on either wall of a porphyry dike. At a depth of 400 feet the dike pinches out and the two veins join in a strong gougy fissure. In numerous mines in the

[24] George Corry, oral communication.

Front Range, a porphyry dike on the wall of the vein has formed a favorable structural condition for the deposition of ore and the ore has pinched out where the dike ended. It therefore seems probable that ore was absent in the lower levels because of unfavorable structural conditions rather than because the ore of the district bottoms at a certain horizon.

Ore has been mined in the Gold Hill district over a vertical range of about 2,500 feet. The highest is that in the Horsfal mine at an altitude of 8,400 feet and the lowest is that in the bottom of the Poorman mine at an altitude of 5,855 feet. Thus in most mines in the district there is a large amount of ground still unexplored above the lowest altitude at which ore has been found.

Therefore, it seems to the writer that there is little evidence to indicate that ores of the district bottom between 500 and 600 feet below the surface. It seems more likely that where ore has bottomed it has been due to a change of local structural conditions. In the larger and more persistent veins of the district there is no reason to suppose that structural conditions favorable to the occurrence of ore will not be found at a considerable depth below the present workings.

Structural control of ore deposits

As already pointed out, nearly all the important ore deposits of the district are in the vicinity of breccia reefs. Fully 90 percent of the production of the district has come from ground within 3,000 feet of the stronger breccia reefs, and in many places the ore bodies are within a few hundred feet of the reefs. It therefore seems probable, as suggested by Lovering,[25] that the fissure zones represented by breccia reef served as deep channels for the circulation of ore-forming solutions. The metallizing fluids apparently rose along

[25]Lovering, T. S., Preliminary map showing the relations of ore deposits to geologic structure in Boulder Co., Colorado: Colorado Sci. Soc. Proc., vol. 13, no. 3, pp. 77-88, 1932.

these more persistent fissures, moved out into the more open but less continuous cross fractures where possible, and deposited ore wherever openings were present. From the distribution of the ores as shown in figure 4, it seems probable that most of the ore-forming solutions rose along the Hoosier reef and then spread out into cross fractures and subsidiary breccia reefs. This movement seems readily apparent in the ore zone on the northeast side of the Hoosier reef, east and northeast of Gold Hill, and in the productive block at the junction of the Hoosier and Poorman reefs. In the ore zone extending northeast from Melvina Hill to Sunshine, it seems likely that the ore-forming solutions moved out from the Hoosier reef along the Richmond and Sunshine breccia reefs and deposited minerals wherever structural conditions were favorable until they were blocked off by the Bull o' the Woods reef just north of Sunshine. From the Richmond and Sunshine reefs, the solutions apparently also moved southeastward along the Fortune reef as far as the Emancipation mine for that part of the Fortune reef has been mineralized by solutions of the vein-forming period. In the ore-bearing block west of Wallstreet in the southwest corner of the district the ore seems related to a breccia reef of low dip that shows no surface connection with the Hoosier reef; however, this reef is a part of a rather persistent group extending southeastward and, as suggested on page 122, it may be the upper part of a breccia reef that is more distinct at depth and connects with the Hoosier reef beneath the surface. The position of the three ore-bearing blocks on the west side of the Maxwell reef suggests that the solutions that formed the ore came from the Maxwell fissure zone but apparently did not move out far from it, however, it can be seen in figure 4 that each of these ore-bearing blocks is connected with the Hoosier reef by extensive vein systems or breccia reefs. It is possible, therefore, that all the ore of the district was deposited from solutions that came up along the Hoosier reef whereas the Maxwell reef merely served to dam the flow of any solutions that reached that far. Most of the other breccia reefs of the district, notably the Poorman, the Bull o' the Woods, and much of the Fortune apparently did not serve as channels for ore-forming solutions but dammed the solutions and provided local structural conditions favorable to the deposition of ore.

The distribution of ore within the vein fissures seems to have been dependent chiefly on local structural conditions that favored the formation of openings, as ore was apparently deposited wherever openings were present and accessible to the ore solution. Some of these structural conditions are illustrated in figure 6. The most important are vein junctions, which can be classified into three types: (1) junctions of productive veins with breccia reefs, (2) junctions of two productive veins, and (3) junctions of productive veins with barren gougy fissures. In the first type, veins have broken across breccia reefs to form relatively open breccia zones in the easily shattered bull quartz or silicified granite of the reef and in the adjacent granite. The largest ore body on the Ingram vein, at the junction with the Fortune reef (see fig. 5), is of this type and the ore bodies in the Cold Spring and Red Cloud mines are apparently of the same type. In the second type, where two fissures cross each other or join, the differential movement on the two fissures is likely to form relatively wide and open fracture zones at or near the junctions highly suitable for ore deposition. This type is illustrated in figures 6A and 6B. As shown in figure 6A, the Slide vein is crossed by the Footwall vein at a large angle and the slide oreshoot extends from this junction northeastward to another cross vein. Numerous small cross veins of the Footwall system also acted to form more open ground between these two main junctions. Ore also extends out along the Footwall vein for some distance from the junction. Figure 6B shows two nearly parallel branches of the Emancipation vein joining to form a relatively wide oreshoot. In the third type of vein junctions, relatively horizontal, tight, gouge-filled fault fissures have served as dams or baffles to the circulating solutions and have tended to cause deposition of ore

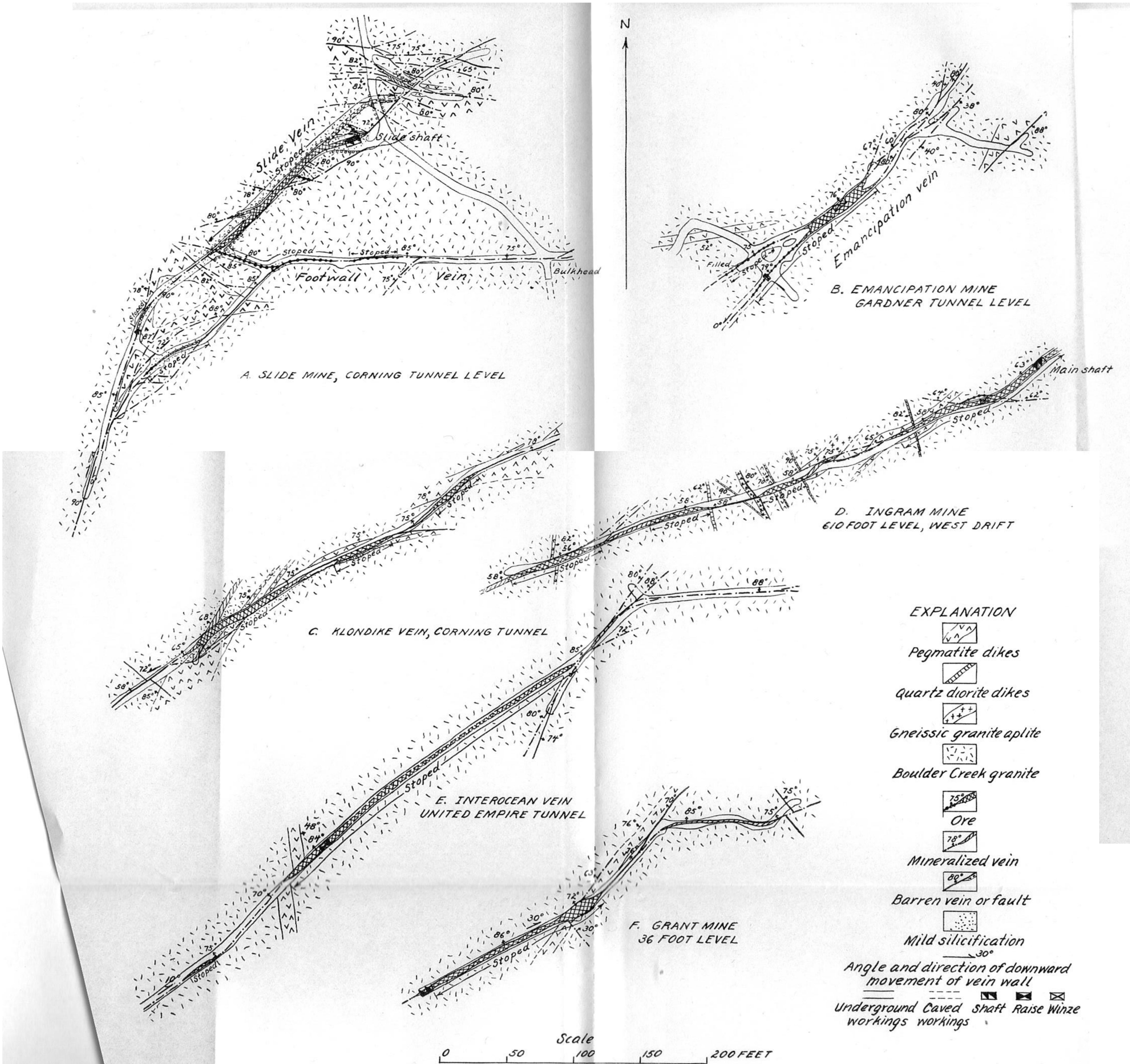


Figure 6. Geologic maps of underground workings in some of the principal mines illustrating structural conditions that control the localization of ore.

A. Ore body localized by the junction of two cross veins.
B. Ore body formed at the junction of two nearly parallel veins.
C. Ore bodies formed at intersections of vein with pegmatite dikes.
D. Ore bodies localized by junction of veins with cross dikes and faults.
E. and F. Ore bodies localized by changes in strike of veins.

immediately below or above the fault. Ore bodies in the Poorman, Yellow Pine and Logan mine are of this type and apparently in some mines the Fortune reef has been effective in this manner.

Other important factors in the localization of ore are the junction of veins with pre-Cambrian dikes of aplite, pegmatite, diorite or gneissic granite aplite, or with Laramide porphyry dikes. In the Slide mine, as shown in figure 6C, the Klondyke vein cuts irregularly through a persistent aplite dike at a small angle and the ore body seems to be largely coextensive with this dike. In the Ingram vein (fig. 6D) some of the ore bodies are bounded on one or both sides by narrow quartz diorite dikes through which the vein cuts nearly at right angles. In the Cold Spring-Red Cloud mine a porphyry dike apparently has influenced the distribution of ore.

A third type of structure favorable to the deposition of ore is that in which there are abrupt changes in the direction of strike or dip of the veins. Movement on the vein tends to form openings on one or the other side of an abrupt bend in the vein, depending on the direction of movement, as illustrated in figures 6E and 6F. Thus, in veins where the hangingwall has moved down the steeper parts of the veins will be open, but where the hangingwall has moved up the less steep parts will be open. Likewise, in veins of northeast trend where the northwest wall has moved northeast the more easterly trending parts of the veins will be open (figs. 6E and 6F), but if the southeast wall has moved northeast the reverse is true. In numerous mines of the district this structural condition apparently has played only a minor part with other structural conditions in controlling the localization of ore, and only in a few places has this type of structure been the controlling factor.

Future possibilities

In view of the large increase in production of the Gold Hill district since 1933, the future of the district seems hopeful. Two properties, the Grand Republic and the Klondyke, were very little explored prior to 1933, but have since become two of the most productive mines in the district. One of the larger mines in the earlier days, the Ingram, has been opened to greater depth and ore as rich as any taken out in early days has been uncovered. These three successes would seem to offer promise to other ventures of careful prospecting.

Future prospecting should be confined to areas within easy access to the ore-forming solutions, that is, within 3,000 feet of the more persistent breccia reefs and on vein systems that connect these reefs. Along the Hoosier reef, the favorable ground seems to be confined to the east side, except in the vicinity of Hoosier Hill, near Summerville, and in the vicinity of the junction with the Poorman reef. Along the Maxwell reef, the favorable ground seems to be confined to a narrow zone on the west side of the reef. In the area between these two breccia reefs, production seems to be largely confined to veins that are connected with the Hoosier reef by an extensive vein system or by a minor breccia reef. In the vicinity of Wood Mountain, in the southwestern corner of the area, the most favorable ground for deposition of ore seems to have been on the northeast side of a small breccia reef.

In exploring favorable areas, search should be made for local structural conditions favorable to the deposition of ore such as junctions of veins with breccia reefs, other veins, barren faults, or igneous dikes, and irregularities in the strike and dip of the veins. There are a number of promising junctions in the district that do not appear to have been adequately explored. Along the Slide vein between the Slide mine and the Hoosier reef there are a number of junctions with other veins that have been explored only by relatively shallow shafts. In view of the fact that the Slide vein is strong and connects with the Hoosier reef, further prospecting on these junctions at greater depth seems justified. Another promising junction is that of the Richmond and Ingram veins. Both are prominent productive veins and the Richmond connects with the Hoosier reef. This junction has been productive near the surface, and, as the Ingram vein has been productive to a depth of 930 feet, exploration of the junction at greater depth would seem worthy of consideration. On the Black Cloud vein between the Black Cloud mine and the Mack vein, there is a junction with a small vein which might justify some prospecting.

If the ore-forming solutions rose from depth along the major breccia reefs, as seems probable from the available evidence, it is reasonable to suppose that the ore deposits in the vicinity of prominent junctions of breccia reefs, such as those of the Hoosier and Poorman and the Maxwell and Poorman, might extend to greater depth than elsewhere in the district. In the vicinity of both these junctions, there has been some of the most productive ground in the district, and exploration at greater depth would seem justified.

In conclusion it should be said that there is no evidence to justify the expectation of finding any larger mines than those already found in the district, but, judging from the increased production of recent years and the existence in the district of numerous structural conditions favorable to ore deposition, as yet little explored, it seems likely that new ore bodies will be uncovered comparable to those mined in the past.

A NICKEL DEPOSIT NEAR GOLD HILL, COLORADO

Recent development in the Copper King mine, near Gold Hill, 8 miles northwest of Boulder, Colo., has opened a nickel deposit in the pre-Cambrian rocks of the Colorado Front Range, the second of its kind known to exist in this region. The deposit occurs in highly metamorphosed sediments of the Idaho Springs formation, one-half mile west of the border of a small batholith of mid-pre-Cambrian granite. A small stock of hornblende diorite, related to the granite, is exposed in the lower workings and numerous irregular pegmatite dikes cut the schists, gneisses, and lime-silicate rocks of the Idaho Springs formation, which have been folded into a tight anticline.

Disseminated intergrowths of pyrite, pyrrhotite, chalcopyrite, pentlandite, and niccolite have replaced amphibole in the more calcic beds of a lime-silicate layer in the Idaho Springs formation. Numerous samples of the primary ore taken by the company yielded from 0.41 to 6 percent nickel, 0.00 to 0.60 percent cobalt, and small amounts of copper. Samples of supergene ore contained from 1.32 to 13.02 percent nickel, 0.22 to 6.22 percent cobalt, and 0.05 to 31.60 percent copper (wet assay). There appear to be several thousand tons of ore in sight that contain from 2 to 5 percent nickel.

The deposit seems to be comparatively small, but the ore-bearing beds are so dislocated by the diorite stock and by pegmatite dikes that it is impossible to project their extensions far beyond the mine workings. The ore is probably genetically related to the pre-Cambrian diorite stock. There are several copper deposits of this general type in other parts of the Front Range but the only other known nickel-bearing deposit lies about 120 miles to the south.