son and Elkton shafts, the Elkton or Raven basaltic dike, which extends in steplike fashion from the granite to the Raven workings, the productive veins, and the postmineral Thompson fault or "dead vein," which approximately follows the breccia-granite contact. The contact dips vertically to 80° S. Where exposed on and above level 7 it curves sharply from an easterly to a southerly course for about 200 feet and there resumes its easterly course. (See fig. 8.) The granite thus forms a blunt projection or plunger that was evidently a controlling factor during the compression that preceded the basaltic intrusion and vein formation. The phonolite "flats" on levels 6 and 7 were much fractured and so well mineralized that they were largely mined as ore. Their downward continuations were evidently not exposed during the earlier surveys, and workings beneath the "flats" were inaccessible to us. The only other exposures of phonolite are steeply dipping dikes of north-northwest trend in the northern, less productive part of the mine.

The principal mineralized fissures (fig. 44) include (1) the Walter fissure, of north-northwest to north trend and of nearly vertical to steep easterly dip, which extends from the southeastern part of the mine to the northernmost workings; (2) a steplike fissure zone of east-northeast trend and steep westerly dip that closely follows the basaltic dike, extending from the vicinity of the granite contact and joining the Walter vein near the shaft; (3) a cross fissure that trends eastward in the southern part of the mine and dips about 50° N., crossing the shaft at level 15; (4) the Henley fissure, which parallels the Walter vein, beginning near the junction of the cross vein and the north-northeast zone, and extending north-northwest for 500 feet or more; (5) a network of fractures in granite close to the contact and connecting with the cross fissure and the north-northeast zone.

The fractures in granite were doubtless opened or reopened during the explosive eruptions that produced the breccia; the cross fissure may be attributed to the upward-thrusting force of explosions during later stages, after the breccia had become well consolidated and invaded by the phonolite

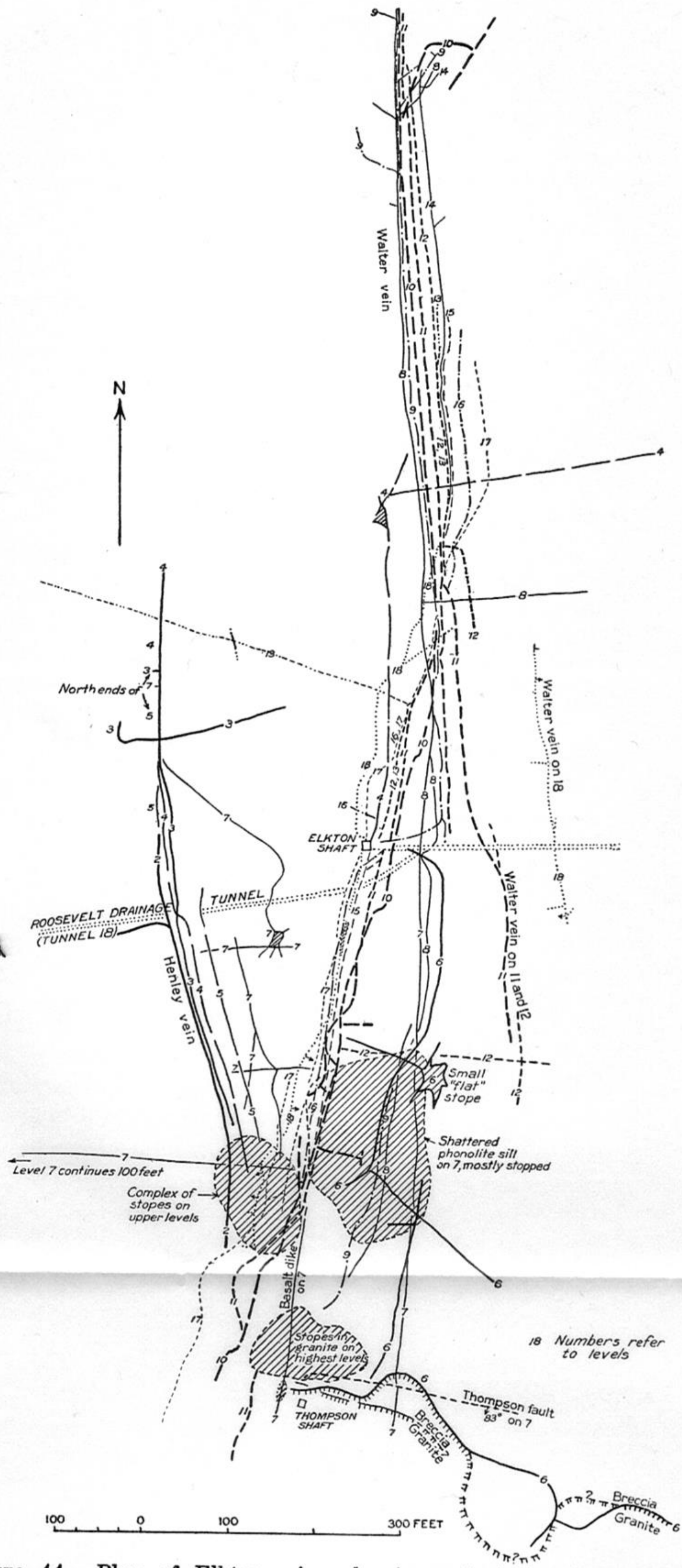

Figure 44.—Plan of Elkton mine showing principal veins, irregular productive areas in southern, upper workings, breccia-granite contact on levels 6 and 7, and Thompson fault or "dead vein" on level 7. Compiled from company's mine maps.

masses. Its relation to the north-northwest and north-northeast fissures was not disclosed in the accessible workings. The positions of the fissures that trend north-northwest and north-northeast from the granite plunger indicate a mild compression and shearing from the south that tended to move the western part of the ground northward with respect to the eastern part. The north-northwesterly fissures were formed as relatively tight shear planes, and those of the steplike north-northeasterly zone as complementary tension fissures. The basalt was intruded along this open north-northeasterly zone and continued northward along the Walter vein until it could deflect again along another north-northeasterly fissure in the northernmost part of the mine. A mild renewal of the shearing movement then occurred and was accompanied or closely followed by a slight settling of the eastern walls of the veins. The upper, more nearly vertical parts of the Walter and Henley veins (fig. 45) were thus opened, while the lower parts, which had a more easterly dip, became closed. The movement released the wedge-shaped block whose west side is bounded by the north-northeasterly fissure zone and increased the openings along that zone, as well as along the adjoining part of the cross fissure and the shattered granite. The earliest mineral deposition took place along these more open fissures. The mineralizing solutions probably rose near the granite contact, as mineralization there was most intense. The shattered granite was at first leached and converted into a honeycombed mass of quartz and adularia. Small amounts of these two minerals were also deposited in the breccia, phonolite, and basalt but were mainly concealed by the dense mixture of first-stage fluorspar and quartz. Renewed settling ensued, during which the dense fluorite and quartz in some places became sheared and crushed to a tight gouge and in others became opened and accessible to the later solutions that introduced the gold. The most open ground for the introduction of gold obviously included the honey-combed granite, in which ore bodies similar to those in the upper levels of the Granite (Ajax) mine were formed, and the broken ground along the junctions of the cross fissure with the phonolite "flats" and the almost vertical parts of the north-northeast fissure zone. Ore, according to Kissell, was deposited in the vicinity of this cross fissure from about level 6 down to level 17. It continued northward for 1,200 feet or more along the Walter fissure as far down as level 11. Below this level the vein evidently had a steplike interruption (fig. 45), and little or no ore was found along it except near the shaft, where the junction of the north-northeast and cross fissures afforded openings.

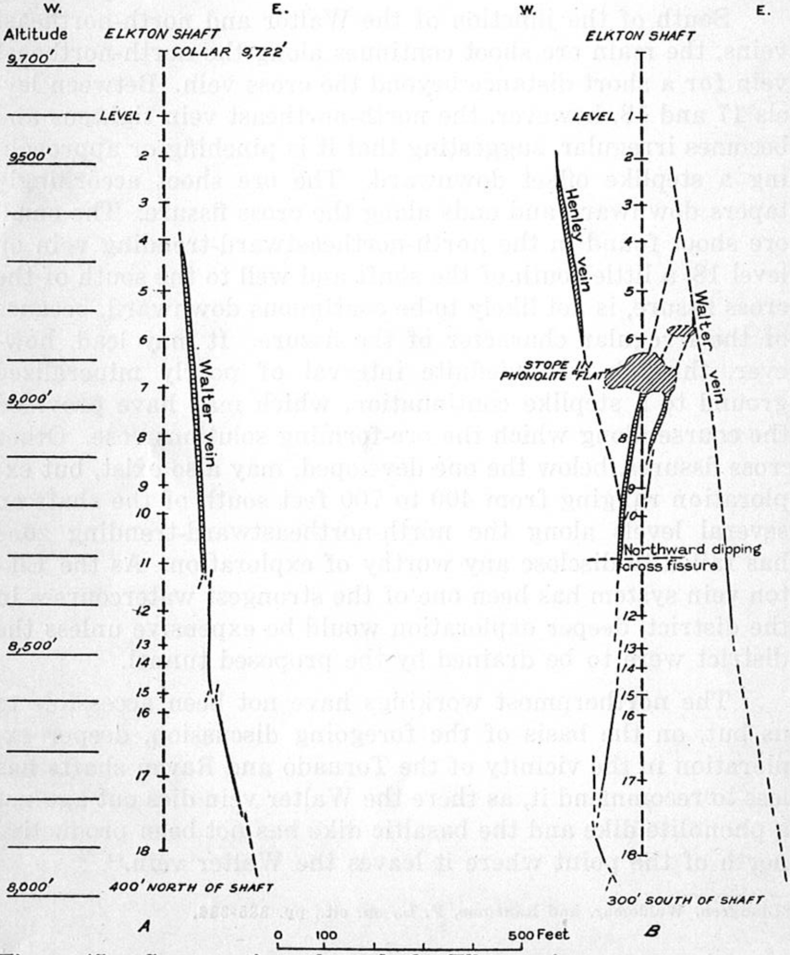

Figure 45.—Cross sections through the Elkton mine.

The Walter vein on levels 12, 13, and 14 is also nearly vertical, but the tight ground at the deflection below level 11 may have prevented the solutions from entering it. The Walter vein below level 14 has a pronounced easterly dip and is barren except for a few insignificant ore bodies at junctions with minor cross fractures. Similarly, ore deposition in the Henley vein was evidently confined to the upper, steeply dipping part above level 5, as downward exploration of this vein stopped at level 7.

South of the junction of the Walter and north-northeast veins, the main ore shoot continues along the north-northeast vein for a short distance beyond the cross vein. Between levels 17 and 18, however, the north-northeast vein tightens and becomes irregular, suggesting that it is pinching or approaching a steplike offset downward. The ore shoot accordingly tapers downward and ends along the cross fissure. The small ore shoot found in the north-northeastward-trending vein on level 18, a little south of the shaft and well to the south of the cross fissure, is not likely to be continuous downward, because of the irregular character of the fissure. It may lead, however, through an indefinite interval of poorly mineralized ground to a steplike continuation, which may have provided the course along which the ore-forming solutions rose. Other cross fissures, below the one developed, may also exist, but exploration ranging from 400 to 700 feet south of the shaft on several levels along the north-northeastward-trending zone has failed to disclose any worthy of exploration. As the Elkton vein system has been one of the strongest watercourses in the district, deeper exploration would be expensive unless the district were to be drained by the proposed tunnel.

The northernmost workings have not been accessible to us but, on the basis of the foregoing discussion, deeper exploration in the vicinity of the Tornado and Raven shafts has less to recommend it, as there the Walter vein dies out against a phonolite dike and the basaltic dike has not been productive north of the point where it leaves the Walter vein.[61]

[61]Lindgren, Waldemar, and Ransome, F. L., op. cit., pp. 335-336.

Still farther north, at the summit of Raven Hill, the presence of several dikes of phonolite and basaltic rock may suggest that ore deposition has also taken place on a considerable scale. There has been no opportunity for us to study the mines of this area. According to Lindgren and Ransome,[62] the phonolite dikes and sills are irregular and have no significant relations to ore. The basaltic dikes are small and commonly trend a little east of north, and ore has been mined at shallow depths along or near two of them—the North Star dike, just north of the Doctor-Jackpot line, and the Ingham dike, between the Ingham and Gregory shafts. This ore appears more closely connected with the large Doctor-Jackpot ore shoots, to the west, than with those of the Elkton mine, to the south.

The Joe Dandy mine, in which an interesting discovery has recently been reported, is one of a small group of shallow mines about midway between the Ingham workings and the Moose ore zone. This group has not been accessible to us and, like certain other groups, is so isolated from the principal ore zones that any conjectures regarding the size and continuity of its ore bodies would be purely speculative. A study of its workings should lead toward an inference as to whether it is related to a local, hitherto unrecognized source of ore or has been supplied by solutions derived from subcraters to the southwest or southeast. Other mines that are similarly isolated from the principal vein zones of the district have been productive at shallow depths, and their further development should apparently be guided by a close structural study that would throw light on the courses followed by ore-forming solutions and therefore, on the general pitch and alinement of ore shoots.

Mary McKinney Group

The Mary McKinney group as here defined includes the Mary McKinney mine and adjacent workings to the north and south, also the Doctor-Jackpot and adjacent mines. These mines are in the southwest corner of the crater and in general

[62]Lindgren, Waldemar, and Ransome, F. L., op. cit., pp. 317, 320.

alignment with the El Paso master shear zone, which extends for half a mile or more to the south-southwest in granite. The only workings accessible to us were the shallow workings in the Moffat or Ophelia tunnel, north of the Mary McKinney mine, which have been studied by Koschmann. The geologic description that follows, therefore, is based largely on Professional Paper 54 (pp. 314-330). Data on the Mary McKinney mine are also based on annual chapters on Colorado in Mineral Resources of the United States, and on information supplied by John Tait Milliken, of the LeClair Consolidated Mines Co., the present owner. Production in the Mary McKinney mine began in 1893 and according to Mr. Milliken amounts to about $7,400,000, with an average gold content of 1.277 ounces to the ton. According to figures supplied by C. W. Henderson, of the United States Bureau of Mines, the production from 1901 to 1932 was 250,464.26 ounces or $5,177,-096.25. The difference between Mr. Milliken's and Mr. Henderson's figures implies an average annual production of about 10,540 ounces between 1893 and 1900. Production was negligible in 1901 and 1902, but between 1903 and 1916 it ranged from 10,733 to 25,521 ounces, except in 1911, when it was only 5,960 ounces.

The mine was drained below level 7 by the El Paso tunnel, probably in 1906, and levels 8 to 13 were developed after drainage by the Roosevelt tunnel in 1910 and subsequent years. Mr. Milliken states that level 13 is drained southward through open fractures to the Roosevelt tunnel, which is 3,500 feet away and 43 feet lower. The open character of the ground raises a question as to whether deeper development could be economically carried on by pumping or would have to depend on a still lower drainage tunnel.

The principal vein dips steeply westward but has not reached the granite contact at a depth of 1,382 feet (altitude 8,153 feet). The vein was in a large mass of phonolite down to level 9, which was reached in 1912. As it passed out of the phonolite, both northward and downward, it split or branched and became poorly defined. A large quantity of ore of good grade was mined on level 10, which was reached in 1913, but less was found on level 11, reached in 1915, although the grade remained good. Level 12 was reached in 1916, and level 13 probably the next year, but comparatively little ore was mined from either level. The mine has shown some production for each year since 1916, but mainly or wholly from leasing operations on dumps and shallow levels. No specific reason for discontinuing deep exploration has been published, but the deep work stopped at just about the time when easily found ore became scarce and operating conditions incident to the World War became unfavorable.

A large amount of ground below level 5 and south of the shaft was left unmined because of difficulties over ownership, but the entire ground is now owned by the LeClair Consolidated Mines Co., which took over the Mary McKinney and adjacent properties in 1929. Further exploration on levels 12 and 13 may also be justified, but without more detailed knowledge of structural conditions no specific suggestions regarding it can be offered. The general conditions, so far as they can be interpreted, suggest that the ground may overlie a local deep source of ore, but whether structural conditions have permitted the formation of continuous ore shoots below level 10 is uncertain.

The bottom or ninth level of the Jackpot shaft has an altitude of about 8,810 feet and is comparatively shallow. The Doctor-Jackpot vein zone on the upper levels was very persistent and productive and showed more evidence of movement than most veins of the district, although no great amount of displacement could be proved. These features would imply downward continuity of the vein fissure, in contrast to its lack of development below level 9. The large production from the upper levels and the structural conditions, so far as they may be inferred from published evidence and from comparison with conditions in the deeper mines of the district, would imply an important local deep source of ore, probably the same one that supplied the Mary McKinney ore.

In addition to the question of downward continuity of ore, the complicated structure at the north end of the Mary McKinney zone, in the vicinity of the Howard "flat" and the

Anaconda tunnel, where persistently high-grade ore was formerly mined, also in the northeastern continuation of the Doctor-Jackpot workings, suggests that further development may disclose ore shoots of small to moderate size, but Koschmann's study of recent activity in workings cut by the Moffat (Ophelia) tunnel emphasizes the importance of concentrating work along parts of veins that contain second-stage minerals. These workings expose dikes of latite-phonolite, phonolite, and basalt and veins of first-stage fluorspar and quartz, which indicate repeated fissuring. Several of the veins and basalt dikes occur in "flats." The "big basalt" or Hodges "flat" in the Little Clara and Callie claims strikes northeastward, dips 5°-20° N., and ranges from 2 to 14 feet in thickness. It is followed by a vein of first-stage fluorspar and quartz, which may be a branch or upward continuation of the Black or Work vein of the Mary McKinney mine. Both the vein and the basalt are crisscrossed by veinlets of second-stage dolomite, light-purple fluorspar, and tellurides, which form the ore shoot. This shoot contained many vugs which, according to oral information by Dick Hodges, were lined with tellurides. Ore valued at about $1,000,000 was taken from this flat, and shipments were said to average nearly 3 ounces to the ton, whereas samples of the remainder of the vein assayed mostly from 0.2 to 0.5 ounce to the ton. This shoot was found where the "flat" was cut by several veins that were somewhat productive to the south.

There has been much exploration just west of the Hodges shoot, especially in the Grover Cleveland and Little Fauntleroy claims, where supposed continuations of the Virginia M. and Lincoln veins are exposed on the tunnel level, but results have been discouraging, even where the veins intersect dikes. Large cavities lined with third-stage quartz crystals are common at these intersections, but no second-stage minerals have been noted. Because of the occurrence of the rich Hodges shoot at the intersection of veins with a dike, considerable faith has been placed in other intersections; but intersections seem to be of little value unless they were open during the second stage of mineral deposition. The locally complicated group of veins, which strike and dip in several directions, and the correspondingly complicated adjustment that doubtless took place along them renders prospecting difficult. A consistent though expensive method would be to trace the streaks of second-stage minerals from known ore shoots wherever they happen to lead. They may shift from one fissure of a steplike group to another or may turn and follow an intersecting vein, and there may be considerable intervals between shoots of commercial size; or the ore minerals may have become so widely dispersed along small fractures in shattered ground, as in the northern part of the Mary McKinney mine, that there may be few or even no shoots minable on a small scale, but large blocks of low-grade ground that might be suited for large-scale operations.

El Paso Mine

Development and production

The El Paso mine, which includes the C. K. & N., Ajax, and Nichols workings, is on the west side of Beacon Hill, about half a mile southwest of the main area of breccia. The original El Paso Co. was organized in 1894 and was later reorganized as the El Paso Consolidated Gold Mining Co. The mine, according to Professional Paper 54 (p. 349), had produced a total of 82,176 ounces of gold ($1,698,576) up to the end of 1903. The next year was the most productive; according to figures supplied by C. W. Henderson, of the United States Bureau of Mines, the output in 1904 was 65,550.26 ounces, with a gross value of $1,354,923.87. After 1904 production on the whole declined gradually until 1916, although there was a temporary increase in 1910-12, evidently from level 7. The total production from 1904 to 1932 was about 489,000 ounces of gold, with a gross value of $10,108,000.

In 1913 the shaft was completed to the Roosevelt drainage tunnel or level 9, whose altitude is 8,090 feet, 1,332 feet below the collar of the shaft. Exploration of levels 8 and 9, however, developed very little ore of satisfactory grade, and by 1915 the company was in debt. Since then production has been small and intermittent and mainly by lessees. In 1928 the mine was taken over by the New El Paso Mines Co., but it remained idle, except for shipments of dump ore, to the end of 1933, when it was reopened by Hidalgo Gold Mines, Inc.

Geology

Loughlin has had access to only parts of levels 2, 4, 5, 6, 7, and 9 but has been aided by a rather complete set of maps and by information in Professional Paper 54 (pp. 349-361).

The El Paso and adjacent mines are along the El Paso master shear zone (pp. 278-281), which is continuous with the prevolcanic fissure of north-northeastward trend along which the southwest corner of the main crater was developed. The granite in this area is rather gneissic and contains several lenticular inclusions of schist, which also trend north-northeastward. Thoroughly sheared zones of granite of similar trend have also been locally called "schist."[63] That fissures along this zone were open to some degree soon after the formation of the main crater is shown by the presence of a small latite-phonolite dike at the north end of level 7 of the El Paso mine. During the pre-phonolite stage of compression, when the ground east of the shear zone pressed northeastward against the main crater, the fissures already developed served as planes of shearing, and fissures of north-northwestward to west-northwestward trend were locally opened or reopened by tension. In the subsequent stage of relaxation these same fissures became filled by dikes of phonolite. The intrusion of phonolite, as shown on page 290, was preceded by a local explosive eruption that opened the way for the intrusion of the Beacon Hill plug or knob. This knob at the surface is 2,200 feet long in a north-northeasterly direction and 1,200 feet wide, but it tapers downward, especially below level 4 of the El Paso mine (fig. 18), until in the Roosevelt drainage tunnel it appears as a dike 100 feet wide, striking north-northwestward and dipping 80° W. The thicker part of the plug exerted sufficient pressure on the adjacent granite to form a

[63]Lindgren, Waldemar, and Ransome, F. L., op. cit., pp. 349-361.

conjugate system of "flat" fissures that dip at low angles to the northwest or southeast. Dikes and sills or "flats" branched from the plug along these as well as the steeply dipping fissures and locally influenced the fissuring that preceded ore deposition. The largest of these dikes (fig. 1) trends southwestward from the northwestern part of the plug and dips 45°-50° NW., away from the plug.

The northerly movement that preceded mineral deposition exerted mild tension along the fissures of north-northeastward and east-northeastward trend in the granite, especially at shallow levels near the margins of the resistant plug of phonolite and at intersections with dikes and "flats" of phonolite. First-stage fluorspar and quartz were deposited as relatively continuous narrow veins, but minerals of the second stage were more restricted to the intersections with phonolite. Undulations in the courses of the principal veins and intersections with minor veins also controlled the positions of ore shoots to some degree, whereas the passage of a vein from granite into schist commonly marked the end or at least an interruption of an ore shoot, even though other conditions were favorable. Further exploration of the intersections of veins and dikes may be one of the most promising methods of ore hunting on the present levels of the mine.

The veins trend about N. 35° E. with the exception of the C. K. & N. vein, whose trend is from northeast to east-northeast. The prevailing dip is steep to the northwest except along two minor veins that follow and closely parallel the southeastward-dipping margin of the phonolite plug on the upper three levels. The most productive veins have been the El Paso, Tillery, and C. K. & N. The El Paso and Tillery veins are roughly parallel for the most part but locally converge and unite and are also connected by minor cross veins. The El Paso vein has been very productive on the upper three levels in the southern part of the mine, where it approached or followed the main phonolite dike; but at lower levels, where it diverges from the dike, it has not been productive. The Tillery vein has been very productive from level 3 down to level 7, also in the southern part of the mine. Its geologic relations on levels 4 have provided good places for ore deposition; however, the increasing distance from the phonolite plug, which was the immediate source of the dikes and flats at higher levels and influenced fissuring there, lessens the probability that deeper dikes or "flats" will be found, and the general tendency for open places at intersections with other fissures to become smaller and fewer with increasing depth will probably apply here as elsewhere.

Where the C. K. & N. vein turns east-northeastward, away from the phonolite dike, on level 3, just north of the phonolite plug, a branch vein continues north-northeastward along the dike and is continuous, except for a small steplike interval, with the Ajax vein, which was productive in the vicinity of the Ajax and Nichols shafts down to level 5. The steplike interval increases downward, and the Ajax vein below level 5 is rather well isolated. A more intimate acquaintance with its structural details might lend some encouragement to the downward exploration of this vein or a steplike continuation of it.

As the veins of the El Paso mine are in a zone that trends toward the Mary McKinney mine, they may have been derived from the same local deep source. Considerable work that might throw light on this question has been done between the El Paso and Mary McKinney mines, but no information regarding it has been obtained by the writers. Such a derivation would encourage deep prospecting above and below present drainage level in this intervening area, but, because of the general restriction of ore shoots to the intersections of veins with dikes, it is equally possible that the ore-forming solutions moved southward until they finally reached the favorable open fissures controlled by the phonolite plug and its branches. The southwest pitch of the C. K. & N. vein may suggest a more local deep source and offer more justification for exploration below level 9, but the pitch of a single intersection or ore shoot is not a reliable indication of the ultimate source of the ore. Such a local source, moreover, has no close relation to the dikelike root of the phonolite plug, which is not accompanied by any significant amount of mineralized ground in the Roosevelt drainage tunnel. As other local sources of ore are closely associated with the deeper parts of the main crater, it seems more likely that the El Paso ore was derived from the suggested source to the northeast than from a strictly local source deep in the pre-Cambrian granite and half a mile or more from the main crater.

Conundrum Group

The Conundrum group, just southeast of the town of Cripple Creek, includes the Conundrum, Midget, and Moon Anchor mines, which are believed to overlie the Conundrum subcrater, described on page 269 and shown in figures 8 and 9. This subcrater is attributed to explosive eruptions along the junction of northwestward and east-northeastward fissure zones. Only level 6 and lower levels of the Conundrum mine have been accessible to us, and information on the other mines is taken from pages 299-305 and figure 28 of Professional Paper 54.

The workings are mostly in breccia but extend westward and downward into gneiss, whose contact with breccia slopes eastward to southeastward at steep to moderate angles. The principal exposed fissures trend in several directions. Two nearly vertical fissures of east-northeastward trend pass from gneiss into breccia and may represent reopened prevolcanic fissures. One of them, which passes northwest of the Midget and Moon Anchor shafts, is filled by a phonolite dike and vein material. One fissure, of northeast trend and 75° NW. dip in the northern part of the Conundrum mine, is entirely in gneiss and is also filled by a phonolite dike. Another, of west-northwestward trend and vertical dip, north of the Moon Anchor shaft, is in breccia and contains a mineralized "pebble dike" where it intersects the east-northeastward phonolite dike. An undulating fissure trending a little west of north and dipping steeply east follows the breccia-gneiss contact down to level 6 of the Conundrum mine and continues downward in gneiss, with a steplike interruption on level 11. It is followed by the basaltic dike and the principal ore shoot of the Conundrum mine. This also may be a reopened prevolcanic fissure. One more fissure, followed by the Midget vein and its extensions, trends north-northeastward and dips 60° E. in the southern part of the mine, where it forms a small angle with the breccia-granite contact; but it curves to a N. 40° E. trend and 80° SE. dip, and north of the Moon Anchor shaft it may cut the phonolite dike at a small angle, as well as the "pebble dike." Other fissures in the vicinity converge toward this intersection. In the long east crosscut on Conundrum level 14 the Silver vein of the Moon Anchor mine strikes northeast and dips 72° SE., approximately in line with the northeastern part of the Midget vein and with the inferred trend of the northwest wall of the subcrater. The curving course of the Midget vein and its tendency to parallel the walls of the subcrater strongly suggest that it was formed during adjustments within the crater, caused either by upward explosive force or by subsequent settling. The "pebble dike," called the "Granite vein" because it consists largely of granite fragments brought up from below, and the converging fissures near it point to late explosive activity, which may have been followed by settling.

The relations of the different fissures to regional compression are not so clear here as in the southern part of the district, in part at least because of the isolation of the Conundrum group from the larger mines studied by us; but they are not incompatible with the general interpretations that have been made throughout the report. The major prephonolite movement, which pressed the granite against the steep south walls of the crater and produced the Granite and El Paso master shear zones, should have been compensated in the area that includes the Conundrum group by a local westward tensional movement (fig. 15) and a consequent tendency for fissures of easterly and northeasterly trends to open and admit the phonolite dikes, as well as to favor subsequent local explosions. The mild renewals of regional compression are not so clearly defined, presumably because they involved local adjustments of blocks against one another along intersecting fissures. The Conundrum basaltic dike entered along a fissure of northerly trend, but the Granite vein, whose granite fragments were altered to spongy aggregates of secondary feldspar during first-stage mineralization, followed one of east-southeastward trend. The productive veins, in contrast to these restricted occurrences, follow fissures of various trends, and their ore shoots occur mostly along or near intersections.

The Cobb vein, which follows the east-northeastward phonolite dike east of its intersection with the Granite vein, contained an ore shoot 200 feet long that was continuous with one of N. 40° E. trend and 45° NE. pitch along the adjoining part of the Midget vein. These shoots tapered downward along the intersection of the two veins. On Conundrum level 14 the Silver vein gave encouraging samples, but no ore could be found in short raises above the level. Ore shoots along the southern part of the Midget vein were few and small and were confined to the upper levels. Only one ore shoot above Midget level 6 was found along the Intermediate vein, which follows the phonolite dike west-southwestward into gneiss. It was in breccia close to the contact, which was followed by the locally barren basalt dike. The Bonanza King vein, which trends east-northeastward south of the Midget shaft, has two irregular ore shoots: one, in breccia east of the Midget vein, was stoped from Midget level 6 to the surface and had a maximum length of 300 feet; the other, mainly in gneiss, was stoped, with some interruptions, between levels 5 and 8 and had a maximum length of 250 feet and maximum width of 20 feet. Westward continuations of this second shoot were followed along intersections with fissures of north-northeastward trend from level 5 to the surface.

The main ore shoot of the Conundrum mine, which follows the basaltic dike from level 1 downward to level 10 (altitude 8,852 feet) and is said to have yielded more than 72,500 ounces of gold, pitches northward, crossing the shaft between levels 4 and 6, and attains a maximum length of 600 feet on level 5. In the northern part of the mine, between levels 5 and 6, an irregular shoot was opened in shattered gneiss between the basalt dike on the west and the phonolite dike of northeast trend. The ore was said to pass through the phonolite dike below level 6. Another irregular shoot in gneiss 200 feet east of the basalt shoot has yielded about 14,500 ounces of gold between levels 6 and 9, but samples from level 10 below it have averaged only about 0.2 ounce to the ton.

This distribution of ore shoots obviously increases the difficulty of ore hunting. The steplike arrangement, illustrated by the Conundrum dike and ore shoots, serves as a partial guide, but ore cannot be foretold where the productive part of one fissure ends against a productive fissure of different trend. Here, as elsewhere, the effort to follow second-stage minerals is the most consistent procedure. In spite of the rather scattered distribution and different trends of ore shoots and the pitch of certain shoots away from the subcrater, it seems likely that the ore-forming solutions spread upward along devious courses from the subcrater and that the productive ground as a whole will be found to taper downward toward it, especially toward its northwest wall beneath the intersecting fissures near the Moon Anchor shaft. The Anchoria-Leland and other deposits to the east are presumably related to the same subcrater.

The downward tapering of a small vent and the tendency of the breccia in its lower part to be squeezed by the settling of overlying rock would not favor the development of prevailingly open fissures. Conditions in this small, comparatively shallow vent at depths not far below the present workings should be similar to those at much greater depths in the larger vents, and solutions rising under pressure along the deeper, prevailingly tight fissures may not have been able to deposit appreciable quantities of gold tellurides until they could spread into the more open fissures in the upper, flaring part of the vent.

ABE LINCOLN MINE

The Abe Lincoln mine is north of the Conundrum group and so far as structure and ore deposition are concerned may be considered an outlying member of it. The mine is developed mainly in granite close to the crater's contact, which locally trends east-northeastward. The contact is very steep near the surface but slopes more gradually below the first level. It has not been exposed with certainty on level 8. There, about 600 feet south-southeast of the shaft, some coarse breccia with a phonolite matrix but no truly explosive breccia has been exposed and may be well within the granite. The contact between the granite and this coarse breccia dips about 30° SE. beneath a slightly exposed mass of phonolite. The granite is cut by two sets of phonolite dikes, which trend east-northeastward and eastward. The largest of these dikes, exposed in the southern part of level 8, has the breccia just mentioned for its southeast wall and granite for its northwest wall. The phonolite that overlies the breccia is presumably a sill-like branch from the dike. The large dike is cut lengthwise along its middle part by a basaltic dike. This large dike and the granite adjacent to it are considerably impregnated by pyrite, and a fissure called the "sand vein," which trends northward from the dike, is filled with crushed quartz and pyrite, but neither has any close relation to ore. A small vein from which a picked sample assayed 13 percent of lead and 9 ounces in silver and about 0.3 ounce gold to the ton was cut along the eastern wall of the large phonolite dike. It lies about 300 feet southeast of the known ore shoots. The ore, on both the bottom and the higher levels,[64] forms small shoots along or near the intersections of fractures. The shoots on level 8 occupy intersecting fractures of easterly and northerly trend that appear to have been opened in a local stretched block between two shearing planes, one of which contained the "sand vein." No trunk channel along which the ore-forming solutions were introduced has been identified, and it can only be inferred that the solutions, after entering the complexly fractured granite, followed a complicated course, traveling short to considerable distances without noteworthy deposition until they found local open places, commonly at or near the intersections of fractures, where deposition of gold tellurides was possible. Obviously the uncertainty of further downward exploration is increased under such conditions, and its justification should be based mainly on the size and value of the ore shoots already mined.

[64]Lindgren, Waldemar, and Ransome, F. L., op. cit., pp. 276-279.

GLOBE HILL CRATER

There have been no deep developments in the Globe Hill crater, which lies north of the schist and granite "islands," and very little can be added to the descriptions in Professional Paper 54. Four small centers of mineralization have been explored in this crater—the C. O. D., Deerhorn, Hoosier, and Jerry Johnson. Koschmann examined the accessible workings of the C. O. D.-Gold King, Jerry Johnson, and Forest Queen mines in 1931, but no information later than that published in Professional Paper 54 has been obtained on the other mines.

C. O. D.—GOLD KING—MOLLIE KATHLEEN MINES

The C. O. D. group, which includes the C. O. D., Gold King, and Mollie Kathleen mines, is close by the southwest corner of the northern crater. The breccia-schist contact has been cut on level 7 of the C. O. D., where its relations to the outcrop indicate a very steep northeast dip; but the contact on level 8 of the Gold King, only 350 feet to the west, has an irregular north-northeastward trend, at nearly right angles to the outcrop, and even indicates a small overhanging embayment, as shown in figure 8. If this irregular exposure is a fair indication of the trend of the western wall of the crater, it implies an average easterly slope of 50° or more above level 8. The breccia in the vicinity is cut by dikes and irregular masses of latite-phonolite, syenite, phonolite, and "basalt." The presence of all these intrusive rocks suggests that one of the roots of the Globe Hill crater is beneath this southwest corner, and the steepness of the crater wall and its overhanging embayment accord with such an interpretation. The dikes and the more persistent veins trend north-northeastward in the C. O. D. and Gold King mines but turn more to the northeast in the Mollie Kathleen mine. The most persistent dike, the Gold King (basalt), dips northwest and is followed in the Gold King mine by a vein of minor importance. The main vein of the Gold King is said to follow a phonolite dike 300 feet east of and parallel to the basalt dike. The two veins are practically connected by a barren north-northwestward vein. The C. O. D. vein zone is in breccia and is roughly parallel to the productive Gold King veins, although it curves northward and has a steplike interruption to the northwest. Similar interruptions would bring the C. O. D. vein zone nearer to the main Gold King vein with increasing depth.

Neither of the Gold King veins continues northward into the Mollie Kathleen mine, although the basalt dike does. Only the 200-foot and 700-foot levels have been developed in this mine, and the lower level exposes an irregular mass of pyritized syenite west of the shaft. To what extent this syenite influenced the fissuring is not known, but the fissure zones in this mine trend northeast and northwest and are not persistent. The ground was apparently warped somewhat but was protected from the fissuring that characterized the C. O. D. and Gold King mines. The only noteworthy ore shoots in the Mollie Kathleen were two along the basalt dike—one a wide shoot extending from the surface to a depth of 75 feet and the other at the intersection of a northeastward-trending fissure zone with the dike on the 200-foot level.

The arrangement of the principal vein and dike fissures in the group as a whole is one that could have resulted from a mild northward compression that became weaker as distance from the contact increased or from a rotational stress in which the west side moved north relative to the east side. Too little is known of the details of the vein structure to justify more than a tentative suggestion as to the continuity of the veins, but from the data available it would appear that the main Gold King vein is the strongest and most persistently productive and is the most entitled to further downward exploration. The other veins may have been supplied with material that escaped from the Gold King fissure along minor oblique fractures at moderate depth, but the steplike structure of the C. O. D. veins, as already noted, is encouraging for further exploration to the northwest and southeast, especially on the upper levels.