quito Range, but, with the exception of molybdenum, fully 99 per cent of the production has come from a narrow northeasterly belt, scarcely more than 3 miles wide, that extends diagonally across the range from Leadville to North Star Mountain. This belt roughly coincides with the belt of dikes and stocks, but extends slightly south of it. Well over 90 per cent of all the production from the east side of the range has come from the part of this belt that lies within the Alma district. Away from the belt the deposits, in general, decrease both in number and size, although valuable deposits have been found outside of it. This zone is part of the narrow mineralized belt that extends through Leadville, Alma, Breckenridge, Montezuma, Silver Plume, Georgetown, Idaho Springs, and Central City.

CLASSIFICATION

A classification on the basis of geologic occurrence is usually more simple and more easily applied to the search for ores than one on the basis of metal content, but it happens that for the major production of this district a classification on the basis of metal content will also group the deposits as to geologic occurrence; hence, the following classification of ores in the Alma district is offered:

- Gold deposits:
  - London type.
  - Quartzite replacement type.
  - Other types.
- Silver-lead deposits:
  - Limestone replacement type.
  - Other types.

These types may be considered as to their relation to geologic structure, their relation to the inclosing rocks, and their relation to centers of mineralization.

RELATION OF ORES TO GEOLOGIC STRUCTURE

Major structural features.—The ore deposits of the Alma district bear a very close and definite relation to the major features of the structure. (See fig. 6.) Most of the

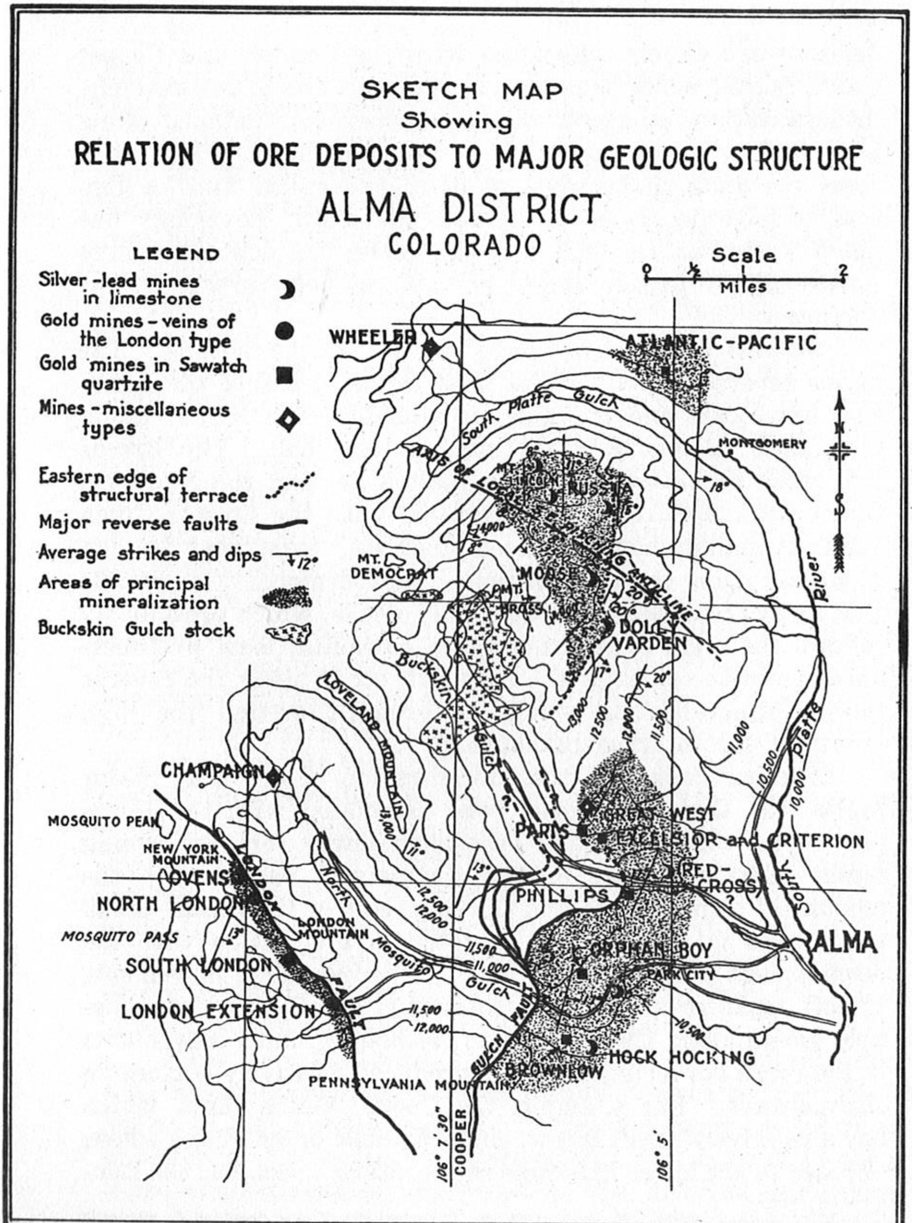


Figure 6.—Sketch map showing relation of ore deposits to major structural features in the Alma district, Colorado.

deposits are closely associated with the London and Cooper Gulch faults, which trend northwest and north, respectively. Mineralization extended for a considerable distance along these faults but seems to have been strongest where they cross the northeasterly belt of dikes and stocks and, in general, to have decreased away from that belt. Lovering[15] has noted a similar regional localization of ore deposits where northwesterly breaks cross the mineral belt farther to the northeast.

Several factors may have caused these relations. The major reverse faults were at least initiated before the intrusion of stocks, and the magma probably rose higher along them than elsewhere in the northeasterly belt. The Breece Hill stock at Leadville is in a fault zone, and the Buckskin Gulch stock apparently is associated with the Cooper Gulch fault. A similar but unexposed stock may exist near London Mountain along the London fault. Furthermore, it is possible that away from the belt of dikes and stocks, which presumably follows the crest of an underlying batholith, local protuberances from the sides of the batholith occur along the reverse fault. Mineralization would be greatest around the high points of the inferred batholith.

Another cause for the concentration of ore near major faults was that the broken zone associated with the faults provided a continuous and deep channelway for ore-forming fluids. The character of the channelway varied with the amount of displacement and the character of the rocks. Small movements in brittle rocks resulted in brecciation with the development of little or no gouge, whereas large movements in soft rocks resulted in the formation of a heavy, impermeable gouge along the fault itself, although minor movements in the rocks bordering the fault produced relatively permeable channelways. For example, the Cooper Gulch fault, which has a relatively small throw, contains little or no gouge where exposed in the lower Paleozoic sedimentary rocks, but the Lon-

[15]Lovering, T. S., Preliminary map showing the relations of ore deposits to geologic structure in Boulder County, Colo.: Colorado Sci. Soc. Proc., vol. 13, no. 3, pp. 79-83, 1932.

don fault, which has a large throw, contains a heavy impermeable gouge where schist forms the hanging wall. The London fault could not be examined where granite forms the hanging wall, but it seems probable that less gouge is present at such localities. Although each of the fault zones is permeable, the distribution of the ore differs according to the amount and distribution of gouge. Where there is no gouge, as along the Cooper Gulch fault, the rising solutions tended to enter fissures in the hanging wall, and the associated ore deposits may therefore be at some distance away from the main fault, on the hanging-wall side; on the other hand, a heavy impermeable gouge tended to keep the solutions close under the main fault of the London zone, and the associated ore deposits are therefore in the footwall, except where minor quantities of solution leaked through local thin or interrupted places in the gouge and entered the hanging wall.

The mineralization on Mount Bross and Mount Lincoln apparently was localized by another type of structure—namely, the structural terrace, which doubtless represents the northward extension of the eastern branches of the Cooper Gulch fault, extending slightly west of north from the Dolly Varden mine. As may be seen in Figure 6, the regional dip east of the Dolly Varden mine is 17°, whereas west of the mine it is 5°. Toward the north the flattening of the dip is less abrupt, but the terrace extends across Mount Lincoln to the point where the sedimentary rocks are entirely eroded, in South Platte Gulch. Mineralization along this terrace has been especially intense in the vicinity of the local anticline, shown in Figure 6, that pitches southeastward from the saddle between Mount Cameron and Mount Lincoln.

Many deposits, most of them small, are not associated with major structural features trending north to northwest, but occur along minor faults in the northeasterly belt of dikes and stocks. These deposits were presumably formed by solutions, emanating from the crest of the inferred underlying batholith, that did not collect in any of the main channelways, but worked their way upward along the many discontinuous minor faults in the northeasterly belt. On North Star Mountain the mineralized fissures in the Sawatch quartzite strike northeast, whereas those in the underlying schist strike nearly north, approximately parallel to the strike of the schistosity. The Champaign mine, which is along a relatively large minor fault, and other deposits near by in North Mosquito Gulch possibly belong to this class.

Minor structural features.—It has been pointed out that the regional distribution of ore deposits in the Alma district was largely determined by the structural features that trend north to northwest, and that the deposits are most abundant where such features cross the northeasterly belt of dikes and stocks. Individual ore bodies within the areas of regional mineralization, however, without exception have been localized by the premineral, minor faults. Throughout most of the district the prevailing trend of the minor faults is northeast, but in the vicinity of Mount Lincoln and also along the London fault their prevailing trend is northwest. Although a few of the minor faults are large, most of them die out within short distances, laterally and vertically, and therefore few of the individual ore bodies are very long; yet within a mineralized area a series of discontinuous ore bodies, each along a different fissure in steplike arrangement, may continue for a considerable distance. Perhaps the most continuous group of veins in the district is that along minor faults auxiliary to the London fault in the porphyry zone of the London mine.

Relation of Ores to Inclosing Rocks

Within the thick series of rocks present in the district a very large part of the ore has come from three very thin zones—the upper part (Leadville limestone) of the "Blue limestone," the porphyry at the base of the Weber (?) formation, and the Sawatch quartzite. Minor zones are present in the Dyer dolomite member of the Chaffee formation (Devonian part of the "Blue limestone"), in the "White limestone," and in the pre-Cambrian rocks.

"Blue limestone."—Nearly all the production from the silver-lead replacement deposits was obtained close to the top

of the "Blue limestone," beneath the impervious Weber (?) shales or porphyry sills that in many places have been intruded into the basal part of the Weber (?) formation. The Russia mine, described in detail in a previous paper, exemplifies this horizon at which, in addition, are the Moose, Dolly Varden, and numerous smaller mines in the Alma district, as well as the Hilltop, Peerless, and Sacramento mines farther south. Likewise, a great part of the production at Leadville came from this horizon, as is fully described in the Leadville professional paper.

The localization of deposits at this horizon may be attributed to a combination of chemical and physical conditions. The "Blue limestone," here as at Leadville, is a nearly pure dolomite, which is readily replaceable and is so brittle that, for considerable distances from fissures, it shatters into small fragments and therefore may be thoroughly permeated by ore solutions. It is overlain by impermeable rocks that force solutions to spread laterally in the shattered limestone. These conditions combine to make the horizon one of the most favorable for ore deposition.

Porphyry at base of Weber (?) formation.—The gold deposits of the London type occur in porphyry sills that have been intruded into the Weber (?) formation, a few feet above its base. The localization of ore in these sills at London Mountain is due partly to local stresses, which formed permeable fissures at a low angle across the dip, and partly to the presence of impermeable Weber (?) shale above the sills. Likewise, the siliceous composition of the sills seems to have been favorable to the precipitation of gold deposits. The rocks at this horizon are not likely to yield much ore in other places, where the local structure is different from that at London Mountain.

Sawatch quartzite.—The third important ore zone is the Sawatch quartzite which has been productive in an area extending northeastward from lower Mosquito Gulch to lower Buckskin Gulch and is represented by the Brownlow, Orphan Boy, Phillips, Paris, Excelsior, and other mines. Smaller production has come from North Star Mountain in the Atlantic and Pacific, Magnolia, and Lee Goss mines. Elsewhere in the district scattered mines have yielded small quantities of ore from this formation. The deposits at this horizon contain gold and silver in proportions that vary greatly even in different veins of the same mine. In all of them, however, gold is at least an important constituent, in contrast with the silver-lead deposits, which contain little or no gold.

The reasons for the localization of ore at this horizon have not been clearly recognized, but the number of developed deposits prove that it is a favorable horizon. One reason may be the decided tendency, observed throughout this district as well as at Leadville, for gold ore to be present in siliceous rocks. Ore shoots occur only in certain beds, mostly in the middle and upper parts of the quartzite series, where the wall rock has been replaced for a distance of several feet from minor faults while other beds contain only narrow and unproductive veins. This replacement probably occurred in beds having some calcareous cement, which was more readily replaced than the siliceous cement of the other beds.

Other ore zones above the pre-Cambrian rocks.—There has been some production from deposits at other horizons within the sedimentary series, where the localization of ore seems to be related to local causes. The Great West and Morning Star mines, for example, are beneath a dense lenticular quartzite at the boundary between the Devonian and Mississippian parts of the "Blue limestone." A considerable part of the production of the Hock Hocking mine has been obtained from strata in the "White limestone" that locally are overlain by shaly members. Elsewhere in the district mineralization in the "White limestone" has been small compared to that in the "Blue limestone."

Pre-Cambrian rocks.—Mineralization was widespread in the pre-Cambrian rocks, but production from these rocks has been comparatively small. Most of the output has come from the granites and granite gneiss, and only minor amounts from schists and injection gneiss. This localization corresponds to the relative production from these different rocks throughout the mineral belt of the Front Range, where Lovering[16] has shown that the fissures were more open and permeable in the relatively brittle granitic rocks than in the relatively tough schists. The largest production from veins in granitic rocks has come from the Champaign mine, but there has been noteworthy production also in the Wheeler and other mines. The Ling mine is probably the largest producer from veins in schists.

Relation of Ore to Centers of Mineralization

It is generally recognized that mineralization tends to occur around definite centers, which commonly are at the top or apex of an intrusive stock. There is a general zoning of the minerals both upward and outward from the center. Such zoning around the Breece Hill center at Leadville and in the outlying areas has been discussed in the Leadville professional paper and in an unpublished paper by Behre and Loughlin.

Mr. Loughlin has kindly written the following summary of the zonal relations that he and C. H. Behre determined for the ores on the west side of the Mosquito Range:

"The ores of the Leadville district, according to data in the Leadville report, may be grouped into four distinct zones and a possible fifth zone with respect to the Breece Hill stock. Deposits of the first or innermost zone, close by the stock, contain magnetite, specularite, and silicates. The magnetite especially contains interstitial manganosiderite, which began to form at the end of magnetite deposition and marks a transition into the second and commercially most important zone. This second zone, most extensively developed in the limestones west of the stock, contains large quantities of manganosiderite, which forms casings around the large replacement deposits of sulphides and is partly replaced by sulphides. As distance from the main feeding fissures increases, transition into the third zone is expressed by the disappearance of the manganosiderite casings and the appearance of quartz casings in their stead. The abundance and proportions of the

[16] Lovering, T. S., Localization of ore in the schists and gneisses of the mineral belt of the Front Range, Colo.: Colorado Sci. Soc. Proc., vol. 12, no. 7, p. 244, 1930.

sulphides, however, do not appreciably change, and the third zone is about as important commercially as the second zone. Pyrite is by far the dominant sulphide in both zones, iron-rich zinc blende (marmatite) is next in abundance, galena is third, and chalcopyrite is very scarce. Silver ordinarily amounts to a few ounces to the ton, and gold is negligible, but locally the ore bodies have been reopened and enriched by small deposits containing bismuth and silver sulphides, chalcopyrite, and gold.

"On the east side of the stock, where siliceous rocks (quartzite, 'Weber grits,' and porphyries) predominate, manganosiderite is not prominent, and the second zone therefore is not clearly defined except as a mere fringe to the magnetite deposits. The deposits are mostly quartz-sulphide veins that locally expand into replacement deposits where they cut limestones. They contain the same ore and gangue minerals as the replacement ores with quartz casings in the third zone, but their contents of chalcopyrite and gold are relatively high. These two minerals, although deposited later than the quartz, pyrite, and zinc blende, evidently prefer pyritic veins in siliceous rocks, regardless of their areal position in the zonal scheme. Some of these pyritic veins cut the magnetite deposits of the first or innermost zone and give the erroneous impression that gold occurs mainly in the high-temperature ore of the inner zone, whereas it really occurs in the moderate-temperature ore of the third zone.

"Transition from the third to the fourth zone is marked by the appearance of abundant barite, which with quartz constitutes the principal gangue and in places is accompanied by such carbonates as ferruginous dolomite and rhodochrosite. Zinc blende in the fourth zone is relatively low in iron, and the ratio of galena to blende is probably higher than in the second and third zones; but so much of the ore mined has been partly or completely oxidized that this difference is not clearly defined. Tetrahedrite or freibergite and tennantite are also present, at least in small amounts, but their relative proportions also have been obscured by oxidation. They account for a characteristically high silver content. The fourth zone may be regarded as ordinarily the outer or marginal zone of the well-defined area of ore deposition.

"A fifth, still more remote zone, however, has also been tentatively recognized, in which neither barite nor quartz is present in noteworthy quantity and dolomite is the principal gangue mineral. The zinc blende and galena have essentially the same character and ratio as in the fourth zone, but the silver content is low. Deposits of this variety have been recognized only at Weston Pass and are too far from deposits of the fourth zone for their zonal relations to be more than tentatively recognized."

In the Alma district the association of ore deposits with centers of mineralization is not so ideally or completely represented as in the Leadville district, because erosion has largely removed ore zones from the vicinity of some centers and has not yet exposed some of the zones around others; but the centers are clearly present. As compared with the Leadville district the first or innermost zone is only slightly developed, the second zone is absent, and the third zone is represented only by veins in siliceous rocks. The fourth zone is well developed, however, and the fifth zone may be represented by a few small prospects in Fourmile Gulch southeast of the Sacramento mine. Four distinct centers are recognized—in Buckskin Gulch, lower Loveland Mountain, London Mountain, and North Star Mountain.

Buckskin Gulch center—The Buckskin Gulch stock, which is the only stock exposed in the district, has a northeast elongation and probably extends under Mount Bross. It is probably one center of mineralization. The sedimentary rocks surrounding the stock have been eroded almost everywhere except to the northeast, and many of the ore deposits originally present have probably also been removed. What remains, however, exhibits a tendency to zoning. Close to the stock, in Buckskin Gulch, are small magnetite deposits that have no commercial value. Farther away are the important silver-lead replacement deposits in the "Blue limestone" on Mount

Bross and Mount Lincoln. They contain galena, sphalerite that is moderately low in iron, some pyrite, and a little chalcopyrite, tetrahedrite, and freibergite. Iron-bearing dolomite is the chief gangue mineral but there are considerable quantities of barite and some quartz.

Lower Loveland Mountain center.—Another center, associated with the Cooper Gulch fault, may lie under the lower part of Loveland Mountain, where a northerly zone of mineralization roughly parallels the easternmost branch of the fault, on the hanging-wall side. Within the central part of this zone, extending from the Brownlow to the Paris mine, a group of mines in the Sawatch quartzite yielded considerable gold. Most of the production has come from oxidized ores, and the primary minerals in most of the deposits have not been found. Pyrite was abundant, however, and the sphalerite has a fairly high iron content; dolomite, the chief gangue constituent, contains small quantities of iron and manganese, and quartz is moderately abundant. The mineralogy, therefore, suggests deposition in the upper intermediate zone. The Great West mine, just north of the Paris mine; contains in the lower part of the "Blue limestone" an oxidized gold-silver deposit, the original sulphides of which were probably formed at a slightly lower temperature than the deposits in the quartzites.

The gold deposits are surrounded on all sides, except to the west, by silver-lead deposits that represent a more marginal type of mineralization. North and east of the Great West are several small replacement deposits in the upper beds of the "Blue limestone." Still farther north, at Mineral Park, are small deposits, containing chiefly galena and barite, with some nearly iron-free sphalerite but very little silver. They are of a type formed far from a center.

Likewise, a group of mines in the "White" and "Blue" limestones west, south, and east of the Orphan Boy mine produced silver and lead with little or no gold. The most productive of these is the Hock Hocking mine, whose replacement veins, except one that was fairly high in gold, are very similar mineralogically to the bedded replacement deposits of the Russia mine. It is of interest that the sphalerite of the Mosquito Gulch mine, at Park City, is a variety nearly free of iron.

The area south of the Hock Hocking mine has not been studied, but there has been little development work as far as the Sacramento mine, more than 3 miles away. The Sacramento mine contains a deposit of the distinctly marginal or remote type that may be associated with another center of mineralization or may represent solutions that traveled a long distance through fractured ground along the London (or perhaps the Cooper Gulch) fault zone.

London Mountain center.—At London Mountain there is extensive mineralization close to the London fault on its footwall side. In the North London, South London, American, and London Extension mines are gold deposits formed at intermediate temperature. Pyrite, dark sphalerite, chalcopyrite, and galena are the principal sulphides. Gold occurs as free gold. Quartz, the principal gangue mineral, is very abundant.

North of this central area are silver-lead replacement deposits in the "Blue limestone" adjacent to the fault at New York mountain. Still farther north there is no productive deposit along the fault as far as the crest of the range, where the presence of several mines suggests the existence of another center close to the point where the London fault meets the Mosquito fault.

Development work has not yet determined the southern limit of mineralization associated with the London Mountain center, and the formations exposed along the London fault on Pennsylvania Mountain and vicinity are not of the kinds that ordinarily contain workable deposits. The Mudsill and other small deposits, which are on the hanging-wall side of the fault near Fourmile Gulch, 5 miles away, are of the remote type, and it is possible that they were formed by solutions that circulated southward along the fault zone from the London Mountain center; but it seems more likely that they, together with the Sacramento deposit, may be related to some nearer though obscure center.

North Star Mountain center.—There is possibly a center under North Star Mountain. According to John W. Vanderwilt, some of the deposits in that area contain magnetite, specularite, and pyrrhotite, in addition to simple base-metal sulphides—a combination of minerals that is generally considered to represent deposition at high temperature; however, Vanderwilt notes that the magnetite is a relatively late mineral, suggesting a rise in temperature after deposition of the sulphides. Coarsely crystalline quartz-pyrite-hübnerite veins near Montgomery also suggest deposits formed at moderately high temperature. If there is a center in the vicinity of North Star Mountain, as seems probable, the lower-temperature types are not well represented, although they may have been present in the sedimentary rocks that formerly overlay the area.

Oxidation

It is not the purpose in this preliminary paper to discuss in detail the process of oxidation but only to state the results. Before glaciation all parts of the district underwent extensive oxidation, but oxidation during and after glaciation has been slight. Glacial erosion has removed almost all of the oxidized material from the valleys that were covered by ice (See fig. 5), but on the ridges, where the preglacial topography has not been greatly changed, oxidized material extends to a maximum depth of 900 feet.

Oxidation has produced different results in the different types of deposits. In the replacement deposits in "Blue limestone" the sulphides have changed to oxides, carbonates, and sulphates, and locally native silver has been formed. The process doubtless increased the lead and silver content to some extent but was not the main factor in determining the richness of most of the deposits. These changes, which were discussed in the paper on the Russia mine, do not essentially differ from the changes in similar deposits at Leadville.

The gold-bearing ores in the Sawatch quartzite probably have undergone considerable change in metal content. Many deposits of this type originally were high in pyrite, and during oxidation there was considerable removal of iron and sulphur with residual concentration of gold. Nearly all the ore that has been mined was at least partly oxidized, and some was thoroughly leached; hence it is questionable whether many deposits of this type could be profitably worked below the zone of oxidation.

The ore of the London type is oxidized near the surface. Although it was not possible to study the oxidized portions of the veins, available information seems to indicate that notable enrichment did not take place.

Placer Deposits

Placer mining has been of comparatively little importance in the Alma district. The large placer deposits whose source was in the Mosquito Range are either in valleys that were not glaciated or mainly downstream beyond the farthest extension of the glaciers. However, there are some placers associated with recessional moraines.

It is probable that in preglacial time several of the valleys, such as Mosquito, Buckskin, and Platte Gulches, had deposits of gold-bearing gravel similar to those of California Gulch, near Leadville. The glaciers swept the gravel from these valleys, and it was redeposited in the moraines at the end of the glacier and in the material that was carried out from the glaciers by glacial streams. The most extensive placers derived from the east side of the Mosquito Range were deposited in this manner below the terminal moraine just west of Fairplay.

As the ice was melting back during the last glacial stage, the Platte Valley glacier halted for a period and built a well-developed moraine at the old town of Dudley, above Alma. During this period the bench on the east side of the river, opposite Alma, was built up of material that in some layers shows rude stratification but in the main is glacial till rather than assorted outwash gravel. The placer mining at Alma has been done in this material. It is reported that the material is richest for a few feet above bedrock, so that in spite of the till-like character of the material the gold seems to have been concentrated in the lower part of the deposit.

There have been small placer operations in Buckskin Gulch for half a mile downstream from Buckskin Joe, and a little placer mining has been attempted on the South Platte River for a mile above Quartzville Creek.

Guidance In Prospecting

The known ore deposits of this region are most abundant in a northeasterly belt extending from Leadville to North Star Mountain; outward from this belt the size and number of the deposits in general decrease. They are not distributed uniformly, however, but are concentrated above or around centers of mineralization, most of which are associated with major faults that trend north to northwest and cross the northeasterly belt. Moreover, most of the ore is found at certain horizons that are physically or chemically favorable to ore deposition. Hence, although some ore doubtless exists remote from the centers of mineralization, the chances for locating new deposits are much greater in the vicinity of these centers than anywhere else. Prospecting at such localities should be confined to the favorable zones where they are cut by minor faults.

London Mountain Center

Limits of ore.—The known conditions at the London Mountain center may be summarized as follows: At London Mountain intense mineralization took place at an intermediate to high-intermediate temperature; northwest of London Mountain mineralization was progressively less intense and at a lower temperature; the higher-temperature deposits have their greatest value in gold, with silver, lead, and copper subordinate; zinc is present in all the deposits but is of no value; the lower-temperature, marginal deposits have their greatest value in silver and lead, with gold relatively unimportant.

It is to be expected that southeast of London Mountain, toward the margin of the mineralized area, there will be a change in metal content analogous to the one toward the northwest; but, owing to the tendency of the ore-forming solutions to travel northwestward up the pitch of the fold, the changes toward the southeast may be more abrupt than those toward the northwest. As far south as the No. 8 raise of the London Extension mine there is no indication of any change in mineral composition of the ore, and farther south development work has been insufficient to prospect the area thoroughly. Present development, therefore, rather definitely indicates that gold ore similar in quantity and quality to that at London Mountain is not to be expected toward the northwest, but that toward the southeast the limit has not yet been located, and exploration to find this limit seems justified.

Sructural control.—The distribution of ore bodies close to the London fault on its footwall side shows that the fault has been a major factor in localizing the ore. At London Mountain, where the hanging wall is mainly schist, the fault has a thick impermeable gouge. In the foot wall the relatively hard and brittle rocks, from the top of the "porphyry zone" at the base of the Weber (?) formation to the pre-Cambrian rocks, were very much fractured by the folding that preceded and accompanied the reverse faulting, and this fracturing produced a permeable zone extending for several hundred feet from the fault; but in the weak rocks of the Weber (?) formation above the "porphyry zone" fissures were less abundant and were filled with gouge, so that these rocks remained impermeable. Hence the permeable zone was bounded upward by the impermeable Weber (?) formation and eastward by the impermeable gouge of the London fault. The meeting of the two impermeable layers formed an inverted trough pitching gently to the southeast. In the "porphyry zone" and probably in the other brittle rocks the bending of the beds opened fissures that strike nearly parallel with the strata but dip a little more gently. Ore solutions, rising along the fractured zone under the London fault, were stopped by the inverted trough of impermeable material and tended to migrate

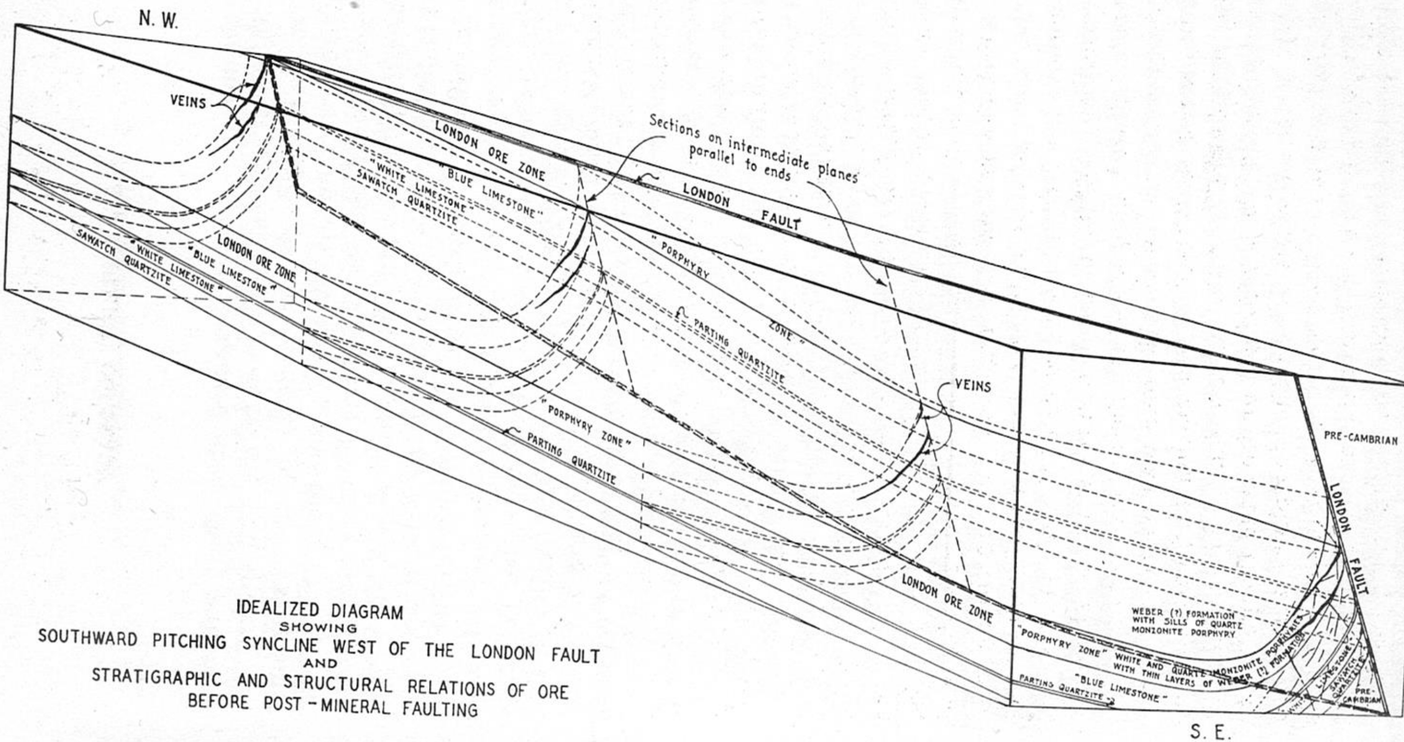


Figure 7.—Idealized diagram showing southeastward-pitching syncline west of the London fault and stratigraphic and structural positions of veins before postmineral faulting.

up the pitch along the open fissures in the "porphyry zone," thereby forming the London veins. (See fig. 7 and the cross sections of the London mine appended to this paper.) Good ore has been mined to a maximum distance of 600 feet west of the fault, but no ore has been found west of the area of pronounced folding. It is probable that the amount of fracturing decreases progressively westward from the fault and therefore that most of the ore was formed near the fault.

This does not preclude, however, the existence of local conditions that permitted ore to form at other localities. It is possible that in places some of the solutions leaked out to form deposits in fissures farther west, although none of importance have been found. If such deposits exist, they probably are at the top of the "Blue limestone," for where the dip is gentle no open fissures nearly parallel to the dip are likely to exist in the porphyry sills.

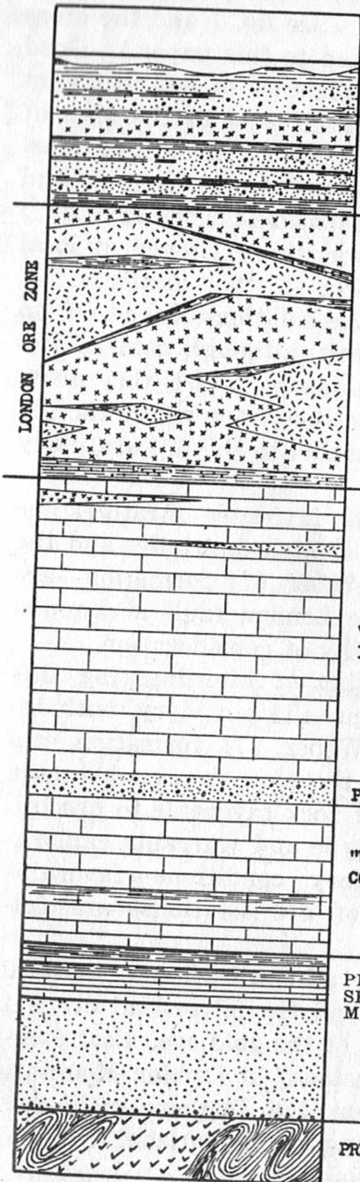
Stratigraphic control.—All the favorable stratigraphic zones—the "Blue limestone," the Sawatch quartzite, and the porphyry sills at the base of the Weber (?) formation—are present along the west side of the London fault at London Mountain (fig. 8), and all are worthy of consideration.

The "porphyry zone," consisting of interfingering sills of white porphyry and quartz monzonite porphyry, with included lenses and layers of the Weber (?) formation, has yielded most of the production and therefore is regarded most favorably. It evidently consists of rock favorable to precipitation of gold ore of the London type and warrants exploration wherever the other necessary conditions—favorable structure and former presence of ore solutions—are fulfilled.

The "Blue limestone" shows mineralization at several places in this area. It contained all the silver-lead ore but has yielded only a very small part of the gold ore. Past experience in exploring the "Blue limestone" at London Mountain has not given much encouragement, but as there really has been comparatively little prospecting at this horizon, it should be regarded as having some possibilities.

GENERALIZED COLUMNAR SECTION AT

LONDON MOUNTAIN



TYPE OF ROCK	THICKNESS
WEBER(?) FORMATION, WITH SEVERAL QUARTZ MONZONITE PORPHYRY SILLS	700'±
"PORPHYRY ZONE" INTERFINGERING SILLS OF WHITE PORPHYRY AND QUARTZ MONZONITE PORPHYRY, WITH LENSES OF WEBER(?) FORMATION. ALMOST EVERYWHERE A 10'-20' LAYER OF WEBER(?) SHALE, QUARTZITE, AND, LOCALLY LIMESTONE OCCURS AT THE BASE.	175'-275'
"BLUE LIMESTONE" - CONTAINING LOCAL SILLS OF PORPHYRY.	Approximately 240'
PARTING QUARTZITE	20'
"WHITE LIMESTONE" - POSSIBLY CONTAINING PORPHYRY SILLS	Approximately 120'
PEERLESS SHALE MEMBER SAWATCH QUARTZITE-POSSIBLY CONTAINING PORPHYRY SILLS	Approximately 135'
PRE-CAMBRIAN	

Figure 8.—Generalized columnar section at London Mountain, Alma district, Colorado.

The Sawatch quartzite, which contains gold ores at some places in the district, has not been prospected in the London Mountain area, and thus no basis exists for an opinion as to whether it may prove productive there. As the Peerless shale member of the quartzite is a much less effective dam to ore solutions than the Weber (?) shales, it is not likely that ore bodies as extensive as those in the "porphyry zone" will be found at this horizon. However, in view of the favorable character of the Sawatch quartzite in other areas, there is justification for some prospecting of it in the London Mountain area, but such work should be undertaken with the chances of success as an open question. It should be kept in mind that the exact locality at which the Sawatch quartzite is most likely to contain ore is not known. The ore solutions undoubtedly migrated for some distance up the pitch of the fold in the "porphyry zone," and development work has not yet yielded sufficient data to determine the place at which the solutions entered the "porphyry zone"; consequently, it is not known at what place the ore solutions passed through the Sawatch quartzite, nor whether the quartzite contained fissures that permitted part of the solutions to migrate up the pitch in a manner similar to the migration in the "porphyry zone."

Other possible centers of mineralization along the London fault.—There is some indication of a center of mineralization near the junction of the London fault with the Mosquito fault, but here the favorable zones and the favorable structural features have been eroded.

The writers have not studied the London fault zone south of Mosquito Gulch in detail. The structure there is probably favorable to ore deposition, and the favorable zones are everywhere present west of the fault, although they do not crop out. The position of centers of mineralization in this area is not known, but there is a suggestion of one near Fourmile Gulch. The Mudsill deposits, located on the north rim, are in the lower part of the "Blue limestone," close to the London fault on the hanging-wall side. They were probably formed by so-