CHAPTER III.

THE MINERAL DEPOSITS.

GENERAL STATEMENT.

A great variety of mineral deposits has been found in the Blue Mountains. They contain gold and silver veins, copper deposits, gold-bearing gravels, ores of iron, manganese, and chromium, coal, limestone, and gypsum. Many rocks are used for building stone, and mineral springs with useful medicinal qualities occur in widely separated places. Economically, the placers and the gold and silver veins are the most important and will be most fully treated. The gold and silver veins are so intimately connected that it is scarcely possible to separate them in a description of the region. They may, however, be divided into three groups—the gold veins, the gold-silver veins, and the silver veins.

PRIMARY GOLD AND SILVER DEPOSITS.

GENERAL CHARACTER.

The primary gold and silver deposits are, with few exceptions, normal fissure veins of a simple or composite character, carrying native gold, or sulphurets containing gold or silver or both native gold and sulphurets, in a gangue of quartz, more rarely calcite or dolomite. Sometimes the deposits contain also a notable percentage of lead, copper, or zinc, but ordinarily these metals are present only in subordinate quantities; and, on the other hand, the copper deposits are apt to contain a little silver and gold. Nevertheless, the two classes of deposits maintain their distinctive and separate characteristics.

GENERAL DISTRIBUTION.

Broadly speaking, the gold and silver veins occupy a belt 30 or 40 miles wide, beginning near the State boundary along Snake River and extending in a westerly direction for at least 100 miles. This area roughly coincides with the core of older rocks, the highest parts of the Blue Mountains, rising above the surrounding lava floods and late sediments. The accompanying map covers this area, but does not show quite the full extent toward the west, for gold placers are found on Long Creek and Cottonwood Creek, 18 miles west of Susanville, and isolated occurrences even farther west—as, for instance, at the Spanish Gulch placers, on Crooked River, 66 miles west-southwest of Canyon.

The principal deposits are in Baker and Grant counties, though some are found also in Union County and along the northern boundary of Malheur County.

When the distribution of the veins and vein systems, as shown on the map, is examined in detail, it appears at once that there is no well-defined and continuous belt of deposits extending across the whole auriferous area. What is found is a great number of local aggregations of veins, distributed without clearly apparent rule. In some districts the veins are scattered irregularly; in others there are local belts from 2 or 3 miles up to 15 miles in length. The Cornucopia, Sparta, and lower Burnt River districts may be selected as representatives of the former mode, while the long vein systems of Cracker Creek and Cable Cove show the latter arrangement. The region in which most of the important veins are concentrated extends from the Elkhorn mining district on the east for 35 miles in a west-southwest direction to the Greenhorn Mountains.

DIRECTIONS OF STRIKE AND DIP.

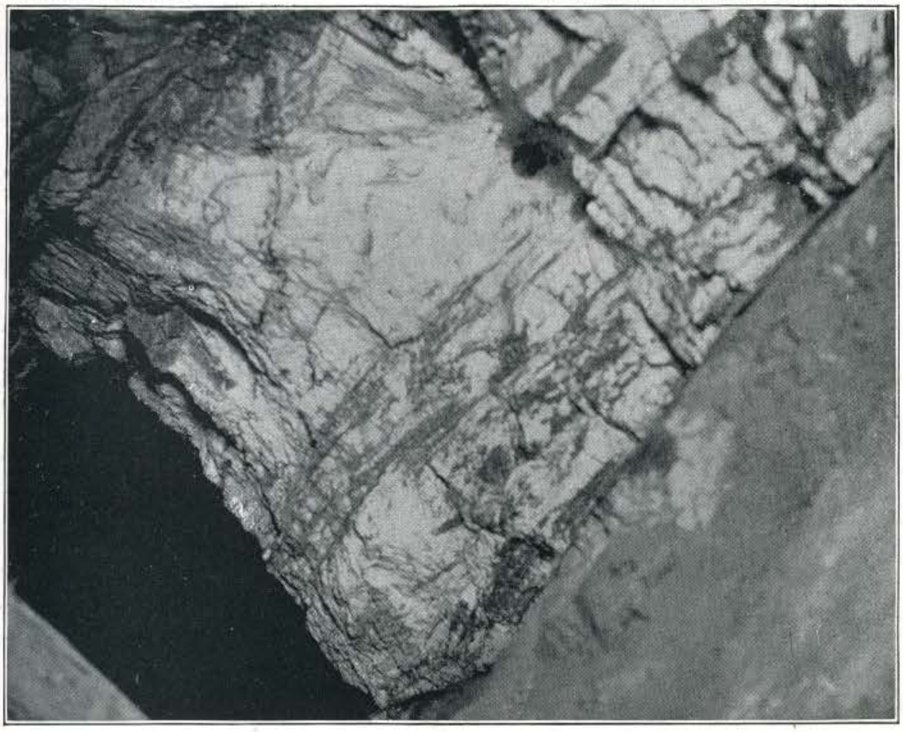
The prevailing direction of the fissures in and along which the precious metals have been deposited is northeast and southwest, sometimes changing to a due east-west direction. This is the strike followed by the great Cracker Creek and Cable Cove system, by the Magnolia, the Greenhorn, the Alamo, the Susanville, and the Quartzburg veins. The prevailing dip is to the southeast or south, at angles from 45° to nearly 90°; but there are exceptions—thus, for instance, the strong and persistent Eagle vein, in Cable Cove, which dips toward the northwest at a steep angle. On the other hand, there are some districts with vein systems striking nearly north and south, or a few degrees east of this direction. Among them is the Cornucopia district, with veins dipping at moderate or steep angles east or west; the Pocahontas district, where flat westerly dips prevail, and the Red Boy, the veins of which dip from 50° to 80° W.

Still rarer is a northwesterly strike, usually coupled with a moderate southwest dip. Such veins are found in the Virtue district, at Connor Creek, Gold Ridge, and in the Bonanza district.

Regarded in a general way, the northeasterly or east-northeasterly strike of the veins is characteristic of the whole gold belt, and also coincides with its extension as a whole; just as much so, in fact, as the north-northwesterly strike is characteristic for the majority of the veins of the California gold belt.

It may not be amiss, in this connection, to call attention to a paragraph and a map in a previous report,[1] in which it is emphasized that

[1] The gold and silver veins of Silver City, De Lamar, and other mining districts in Idaho: Twentieth Ann. Rept. U. S. Geol. Survey, Part III, 1900, p. 101.



A. UNION-COMPANION VEIN.

B MONARCH VEIN.

the veins of central Idaho, with few exceptions, strike in a general east-west direction. Similar directions are found in parts of southern Montana adjacent to Idaho—as, for instance, at Butte; and it is now shown that the veins of eastern Oregon adhere to this rule, though it is not quite so exclusively maintained as in central Idaho. It was also pointed out in the above-mentioned report that this constancy in the strike of the fissure systems indicated that at the time they were formed the whole region constituted a solid crust block, which acted as a unit toward the disturbing forces. Nor is there in the Oregon district any evidence militating against the conclusion reached during the examinations of central Idaho that the fissures were formed under the influence of compressive stress acting in the main from north to south.

Wherever extensive vein systems were formed they have the character of linked veins—that is, the fissures are not absolutely continuous, but branches are thrown off at frequent intervals. The most important veins die out at some point and are replaced by other parallel fissures. A very excellent illustration is furnished by the vein system of Elkhorn, Cracker Creek, and Cable Cove, shown on the map. Beginning at the Baisley-Elkhorn with northeasterly strike, the veins continue across Rock Creek with east-west strike; on the divide between Rock Creek and Cracker Creek the direction again turns sharply northeast and the powerful North Pole vein begins. Continuing through the Columbia and the Golconda veins, the direction again gradually turns east-west, and the fissure gradually splits west of the Bunker Hill claim. But a short distance north of this point the exceptionally straight Ibex vein appears and continues without interruption for 2 or 3 miles. Again, parallel east-west veins appear a short distance north of Rock Creek and connect with the extensive fissure system of Cable Cove, which gradually swings around until near its westerly end it closely approaches the Ibex vein.

VEIN STRUCTURE.

In regard to structure, several types may be distinguished among the fissure veins. The most common is that of the simple vein with a quartz filling, continuous over considerable spaces. The adjoining rock is rarely strongly sheeted by shear zones, and there are seldom parallel ore bodies in close contiguity. It is the simplest form of a gold-quartz vein, and is similar in type to many veins along the California gold belt. To this class belong the veins of Cornucopia, Sparta, Lower Burnt River, Pocahontas, Quartzburg, and many of the silver veins of the Greenhorn Mountains. It is illustrated by Pl. LXV, *A*, which shows a stope above the second level in the shaft of the Union-Companion vein, Cornucopia. It is an absolutely continuous filling of massive, coarse crystalline vein quartz with irregularly scattered sulphurets, 3 to 4 feet thick, between sharply defined and clear-cut walls of somewhat altered granodiorite. The assay value is about $20 per ton across the quartz. In both the upper and lower part the quartz is slightly sheared, as shown by the plate. For comparison a view of the Argonaut vein, Amador County, Cal., is represented in Pl. LXVI. This photograph was taken 650 feet below the surface, by Mr. O. H. Packer, a mining engineer of San Francisco. The vein is of massive quartz, containing some streaks of slate, as shown; it is in a country rock of clay slate and contains in the hanging many stringers of rich quartz; the vein itself is also good ore.

A second structural type occurs in regions of pronounced shear-zones, as, for instance, in the granodiorites of the Cable Cove district. The veins are here more closely spaced and there is more evidence of replacement. The sulphurets are more abundant, and parallel seams with new ore bodies may be found by cross cutting. The veins, however, maintain their individuality over fairly long distances. Some of the silver veins of the Greenhorn Mountains in diorite and granodiorite also show this tendency.

A third type is represented by the Cougar vein, which is a normal replacement vein. The values are contained entirely in the crushed argillite along a single fissure, and the quartz, if present, carries but little ore. The tourmaline-copper-gold vein of Copperopolis, in the Quartzburg district, is also practically a replacement vein, in which the diabase is irregularly altered into ore. On the whole this type is not common

A fourth type is developed in the pocket veins of Canyon. The fairly well-defined quartz veins of these deposits are poor or barren, while the seams accompanying them are filled with quartz or calcite rich in native gold.

The fifth type, and the most interesting, includes the gold and gold-silver veins in the argillite series. Among them are found the richest and strongest of the veins of eastern Oregon; they are chiefly developed in the Sumpter, Cracker Creek, Granite, Alamo, and Bonanza districts. Their peculiarities are due to the action of a strong, dislocating force on the brittle, siliceous argillites, so extensively developed in these districts. In their simplest type, as in the Monarch and Red Boy veins, they form strong and continuous fissures, with well-defined walls 2 to 5 feet apart. The vein filling is, however, not exclusively quartz, but a shattered mass of argillite, cemented by single veinlets or by a perfect network of veinlets with mineral quartz filling, often showing comb structure. Though altered and impregnated with pyrite, the slate does not often carry the pay, which is usually concentrated in the quartz seams. This type is illustrated in Pl. LXV, *B*, from a photograph taken in the Monarch vein, Red Boy mine, in a slope just above the tunnel level south of the crosscut.

ARGONAUT VEIN AT 650 FEET, JACKSON, AMADOR COUNTY, CAL.

In the Ibex and Bonanza veins the same type prevails, but the vein is wider, up to 40 feet, and of the composite type. There are sometimes several parallel walls and parallel masses of ore, consisting of shattered and recemented argillite. Frequent crosscutting is necessary; otherwise important ore bodies may escape attention. Most of the gold is contained in the quartz filling, but part of the ore also consists of a silicified argillite mud, which largely filled the fissures. Sometimes the breasts show a mass of argillite fragments embedded in massive quartz.

This type attains its extreme development in the North Pole vein, upon which some of the most celebrated mines of the Blue Mountains are located. It is a crushed zone, absolutely continuous for at least 4 miles and having a width of from a few feet up to 200 feet, averaging, perhaps, 25 feet. In very few places the walls approach each other within a few feet; no places were seen in which the fissure had locally closed down so as to contain no quartz. The normal developments show two well- or fairly well-defined walls, but no extensive system of parallel sheeting or shear planes. Between these walls lies a mass of quartz-argillite breccia; either of the constituents may locally prevail. Sometimes large bodies of pure, coarse, vein quartz appear, 10 feet to 20 feet in width, with only a few intermixed argillite fragments. Near the North Pole, Golconda, and the Bunker Hill mines enormous quartz croppings appear, measuring 100 and even 200 feet across. Very likely, however, this excessive thickness is deceptive and is caused in part by sliding or settling of the outcrops. At the Golconda mine the vein loses some of its distinctive features, and appears locally as a crushed zone, 200 feet wide, penetrated by irregular seams and veins.

FAULTS.

The veins of the Blue Mountains are very little affected by subsequent disturbances. Faults are not common and, when occurring, are of slight throw. In the Cornucopia district Neocene basalt dikes often cut and fault the veins, and similar conditions were observed in the Sparta district. Strong faulting movement has taken place in the Red Boy and in the Connor Creek mines. In the Cracker Creek and Cable Cove mines faults are not often encountered.

THE ORES.

The ores of these different classes of veins vary so much that they are best described under the types enumerated below. It may be said briefly that the predominating gangue is quartz, nearly always accompanied by a little calcite. More rarely the calcite or dolomite, the latter in serpentine areas, predominates. Accessory constituents are sericite, a chromium-mica (fuchsite?), and roscoelite. The latter two are found in several veins.

Among the ore minerals gold, more or less alloyed with silver, is of almost universal occurrence. The fineness varies from 930 to 500. The quantity amenable to plate amalgamation varies from a few up to 80 per cent. The sulphurets are those usually accompanying gold, viz, pyrite, arsenopyrite, zinc blende, galena, and chalcopyrite, the two latter rarely in large amounts. Arsenopyrite is very frequent, and, next to pyrite, the most common ore. Marcasite also occurs in the veins in argillite. Accessories are cinnabar, which is pretty common in the argillite veins, stibnite, tetrahedrite, mercurial tetrahedrite (schwatzite), pyrargyrite, and tellurides, the latter identified from the Cornucopia and the North Pole mines. A detailed list of minerals found in the area is given on pp. 642–643. The value of the ores milled at the mines ordinarily varies from $8 to $20, chiefly in gold; but considerable quantities of ore containing $40 per ton, or even much more, have been reduced in local mills. Concentrates and ores shipped to smelters vary from $30 to several hundred dollars per ton.

The silver veins carry in part the above-mentioned most common sulphurets; some of them carry also argentite, tetrahedrite, and pyrargyrite, but seldom much galena.

METASOMATIC PROCESSES.

The gold and silver veins contained in granodiorite, diorite, serpentine, and gabbro all show great similarity in the processes of alteration which the rocks have undergone close to the fissures. Excepted from this statement is the small group of tourmaline veins. The process consists in a metasomatic replacement of the ferromagnesian silicates, the feldspars, and to some extent also the quartz, by sericite, calcite, or allied carbonates and pyrite. In the Cornucopia mines and on the Gold Hill in the lower Burnt River district this alteration is particularly intense, but it is equally present in the Elkhorn district, in Cable Cove, and in the silver mines of Greenhorn Mountains. Locally the sericite or the calcite may predominate, and veins in serpentine and allied rocks present an exclusive alteration to dolomite. These abundant carbonates in the country rock stand in sharp contrast to the almost exclusively prevalent quartz filling of the veins.

The great similarity of ores and processes of alteration to the gold-quartz veins of California and of central Idaho, described elsewhere, is extremely striking and forms one of the most important generalizations to be drawn. The gold veins in the three States certainly owe their origin to extremely similar processes. The only difference between the California veins and those of eastern Oregon, as far as contents and alteration are concerned, is that the latter on the whole contain less free gold and more sulphurets than the former. Characteristic for both is the total absence of barite, fluorite, and tourmaline, as well as of garnet, ferromagnesian silicates, epidote, and iron oxides.

The interrelations of the vein systems prove almost conclusively that the veins in argillite are of the same age and of the same genesis as those in granular rocks, and yet in the more or less siliceous and carbonaceous argillite the metasomatic processes are of a different character. Extensive alteration has not ordinarily taken place, but very frequently the argillite is filled with sharply developed crystals of pyrite and also a little sericite. Where the alteration is intense a silicification has usually occurred, though the process is not widespread and does not affect any rocks outside of the walls, even in the largest veins. Some of the very richest shipping ore in the Columbia and the Golconda is probably a siliceous replacement of argillite.

In many veins two kinds of alteration appear; for instance, in the Badger mine, at Susanville; in the Golconda mine, at Sumpter, and the Connor Creek mine, on Snake River. Feldspathic rocks, whether sedimentary or igneous, are subjected to sericitization and carbonatization, while siliceous clay slates are silicified or impregnated with pyrite. The replacing solutions attack vigorously only the feldspars and the ferromagnesian silicates. Many argillites contain practically none of these minerals, but are composed of quartz and sericite, or quartz and kaolin, and on such minerals solutions of the kind here active are powerless as far as sericitization and carbonatization are concerned. But pyrite is formed, metasomatically, without difficulty, while the cryptocrystalline quartz is also recrystallized in larger and clearer individuals and additional quartz is deposited in every available space. In any rock with a large amount of quartz, mass action becomes a factor of importance when it is under the influence of this kind of solution, and more quartz will be deposited. The solutions contained much carbon dioxide, alkaline carbonates, and silica.

This course of alteration is entirely similar to that in the wall rocks of the California gold-quartz veins, though the reasons for the differences indicated were scarcely fully appreciated at the time the study of the latter deposits was undertaken.

PAY SHOOTS.

As in all gold-quartz mines, only certain parts of the veins contain gold-bearing material of sufficiently high grade to be considered as ore. It is recognized, of course, that the definition of ore is a fluctuating one, dependent upon the cost of mining and milling. Under the general conditions prevailing in eastern Oregon, this varies with the accessibility of the districts and the cost of reduction of the ores. Under favorable circumstances the cost of mining and milling can be estimated at $3 to $4 for free-milling ores, as well as for ores adapted for concentration, provided that a continuous ore shoot with a thickness of at least a couple of feet of ore is available. Theoretically, then, everything over $3 should be considered ore. As a matter of fact, the ores extracted run considerably higher, or at least $7 per ton. The mining and milling of ores of lower grade have not yet been extensively attempted, and when it is necessary to roast and cyanide or chlorinate the ore directly the expense must of necessity be much higher. In narrow veins with rich ore the expense of mining will also necessarily be higher, and in such districts distant from railroads merchantable ore must contain something like $25 per ton.

In most of the mines the development has scarcely progressed far enough to justify an opinion regarding the form of the ore shoots. Sometimes, indeed often, the ore bodies are very irregularly distributed, but in the majority of cases they are apt to form elongated bodies with a well-defined pitch in one direction or another on the plane of the vein. Ordinarily the pay shoots outcrop on the surface; this has been the usual case, many statements to the contrary notwithstanding. It was so in the Cornucopia, the Connor Creek, and the Virtue mines; also in Cable Cove, and in the North Pole, E. and E., and the Columbia mines. The Bonanza vein has been mined up to the grass roots, though the best ore was found only a couple of hundred feet lower. On the other hand, the Monarch pay shoot in the Red Boy mine did not reach the surface, though a few hundred feet below it has lengthened to 800 feet. The Red Boy vein had pay shoot only 100 feet long on the surface, which in depth attained a length of 800 feet. In the Golconda the croppings were very poor, and the ore body was revealed only after the shaft had been sunk. But this is exceptional. Extensive developments have often been undertaken below poor croppings without successful results. The conclusion is that, while good mines may be developed from poor croppings, the chances are against it, here in Oregon as elsewhere, where gold-quartz veins are concerned. The reason, however, why the barren croppings are so much more conspicuous than the rich is that the latter, being usually less compact and more easily oxidized, are very often eroded and covered by soil and detritus.

The quartz between the pay shoots is sometimes entirely barren, but is more apt to contain from a trace to $2 or $3 in gold. In some smaller veins pay appears wherever quartz filling has had an opportunity to form.

In the Union-Companion mine, Cornucopia, the ore shoot, as far as proved, pitches south on a vein dipping west. In the Virtue mine somewhat complete data are available, and the pay shoot has approximately the form shown in fig. 86. It will be noted that on the surface the shoot was only 200 feet long, but that below the first few levels it rapidly widened to 1,200 feet, a width maintained to a depth of 1,100 feet below the surface. On level No. 7 the vein became impoverished and very little pay was found; on No. 8, though, the vein continued without break. No very decided pitch was noted in the continuous, almost rectangular shoot, which comprises an area of 960,000 square feet. The average thickness was 14 inches, whence followed an average yield per square foot of the plane of the vein of $2.29, or a value per ton of $24.23, the total output being $2,200,000. This is more than the average value of the lower and larger part of the shoot, which was $16 per ton. From this it may be concluded that the value of the ore near the surface was considerably higher than the average in depth. (See below, under the heading "Secondary enrichment.") From the developments on levels No. 7 and 8 it was concluded that the pay shoot was exhausted, and the mine was considered worked out and allowed to fill with water. If the vein, as is stated, really continued unbroken on these levels it may be questioned whether this is a safe conclusion. Barren stretches for 200 feet in depth, or even more, are by no means unknown among gold-quartz veins, and without further and deeper exploration it would be rash to say that the ore deposition really had ceased at a depth of 1,000 feet from the surface.

In the great North Pole vein, in Cracker Creek district, are at least three pay shoots separated by wide spaces of poor quartz (fig. 81). The first is that of the North Pole, continued in the E. and E. mine. It is several hundred feet long measured along the levels, and pitches 20°–30° SW., the vein dipping 70° SE. It has been followed for 2,500 feet along its pitch. Fifteen hundred feet farther southwest is the Columbia shoot, also several hundred feet long, having the same pitch and having thus far been followed for 2,000 feet along this pitch. Two thousand feet farther southwest is the Golconda ore shoot, which has a more irregular outline, and thus far shows no decided pitch. The beginning of another ore shoot has been found northeast of the North Pole and E. and E. shoot in the workings of the former vein.

On the Ibex vein, continuous for 3 miles, a great number of pay shoots have been found, which, however, are usually of less extent along the strike of the vein than those of the North Pole vein, and which also, as a rule, are more irregular and show rapid variations in their tenor. In a distance of 4,500 feet in the Ibex and Bald Mountain mines at least six shoots occur, which, like those of the North Pole vein, pitch southwest on the vein, the latter having a steep southerly dip. The maximum length along the drift is 200 feet; the pitch is much steeper than in the North Pole vein.

An interesting observation is the general coincidence of the pay shoots on the parallel and adjoining Monarch and Red Boy veins in the Red Boy mine. Even the richest placers in the two veins appear to be opposite each other.

The next subject to be considered is the width of the shoots in the composite veins. In the simple veins the whole width of the quartz, or, in veins poor in quartz, the whole width of the sulphurets, ordinarily constitutes pay ore. A difference is sometimes found, as, for instance, in the Monarch vein (Pl. LXV, *B*), in which the 2 feet next to the foot wall contain the best ore. The whole width is, however, milled. Other instances of similar relations are not wanting. In the Baisley-Elkhorn mine, for instance, a 2-foot-wide body of rich sulphide ore was in one place adjoined by 2 feet of nearly barren quartz. In wide veins in granodiorite, like the Eagle vein in Cable Cove, which consists of 15 feet of crushed rock between well-defined walls, this width contains one or more pay streaks of sulphurets from a fraction of a foot to several feet wide. The pay streaks change from foot wall to hanging wall and occasionally overlap; but wherever there are sulphurets there is also pay.

In the pay shoots of wide, composite veins in argillite other and more complicated conditions prevail. Out of a total width of quartz and quartz-argillite breccia of from 7 to 40 feet, or even more, the pay is usually confined to a streak from 1 to 4 feet in width. This streak may lie on either wall and sometimes crosses diagonally from one wall to another, or it may break up into several stringers of pay ore. The pay streak is often adjoined on both sides by normal quartz, sometimes differing but little in appearance from the ore. Ordinarily, however, to the practiced eye there is a difference, consisting in a looser or more crumbling condition, or in the occurrence of finely distributed pyrite and arsenopyrite in the ore. This suggests at once that the pay streaks may be secondary breaks and fissures enriched by concentration from a great width of lean ore. This should not be understood as meaning concentration under the influence of oxidizing waters or a concentration in any way dependent on surface conditions. If these streaks really are secondary enrichments, they have been effected under the influence of the same kind of solutions that formed the vein as a whole, and may be relied upon to continue in depth. But the question is by no means simple, and much more extended observations than those which could be made on a rapid reconnaissance are necessary to settle the question. In some cases there seems to be no difference in the character of the quartz outside and inside of the pay streaks except in the content of gold in the latter. On the other hand, it is often found, as, for instance, in the North Pole vein, that extensive crushing and brecciating has taken place in the pay streaks and the fragments are recemented by calcite and secondary sulphurets. The cemented fragments are not barren quartz but contain arsenopyrite in unquestionable primary deposition. The argument for secondary concentration is further weakened by the fact that in many places the barren quartz shows a similar brecciation and calcitic cement. The difficulty is to account for deposition of ore in certain streaks which occasionally cross the vein, while the whole space was filled with metalliferous solutions and deposition of quartz went on throughout. The theory of a secondary concentration is very attractive, but the occurrence of well-defined and parallel pitching ore shoots on the plane of the vein remains to be explained as well on this supposition as on the theory of their direct formation from original deposition.

In some veins, like the Bonanza, and on the Belle of Baker claim, on the Ibex vein, large bodies of high-grade quartz and breccia of quartz and country rock occur with a width up to 40 feet, while parallel and closely adjoining fissures may carry very low-grade quartz. Again, there are some veins in argillite which in a width of 10 to 20 feet carry approximately even values of from $3 to $5 per ton.

Within the great ore shoots it is not uncommon to find smaller bodies of extremely rich ore. Pockets of gold and argentite occur in the Connor Creek mine and similar bunches of coarse, high-grade gold in the Virtue mine. Similar bodies are found in the North Pole, E. and E., Columbia, and Golconda mines, here containing pyrite, chalcopyrite, tetrahedrite, native gold, and sometimes telluride in a gangue of quartz and roscoelite. These rich pockets are small and irregular masses or narrow chimneys. An unusually large mass of this kind in the Golconda mine was 70 feet long and 14 feet wide and pitched flat in a southeasterly direction across the general trend of the vein, which is here a broad, crushed argillite zone with quartz stringers rather than a well-defined fissure. Most cases of this kind are not, I believe, due to a secondary concentration, but bear the ear marks of original deposition.

In conclusion, there is no uniform law as to the form and the pitch of the shoots. In the Nevada City and Grass Valley districts of California it has been shown that the shoots usually pitch to the left of the observer, standing on the croppings and facing in the direction of the dip of the vein. While this corresponds to the general observations in the Cornucopia district, the rule is reversed in the North Pole and in the Ibex veins.

The satisfactory explanation of the ore shoots is one of the most difficult parts of the study of ore deposits. None of the ordinarily advanced theories is entirely satisfactory. Prof. C. R. Van Hise, in a recent paper,[1] believes, in common with some other geologists, that the cause is to be sought in cross fractures carrying different solutions from those found in the main fissure. The ore is precipitated by the reaction of these differing solutions. It can not be said that much evidence has been found in this region to support this view. The only place where cross fractures seem to have any influence upon the ore at all is in the Cable Cove district (see detailed description), and here they locally interrupt the continuance of the ore rather than favor it.

[1] Some principles controlling ore deposition: Trans. Am. Inst. Min. Eng., Vol. XXX, 1901, pp. 27-177.

DEPTH ATTAINED AND THE QUESTION OF PERMANENCY.

The quartz-mining industry in the Blue Mountains is of comparatively recent date, and hence for the most part the mines have not as yet attained great depth. The Connor Creek mine, on Snake River, has reached a depth of 1,000 feet from the croppings, developed by tunnels. Rich ore has recently been found on the lowest level, though the ore shoot is not developed in full force as far as the present explorations go. The Virtue mine is 1,100 feet below the croppings, developed by an 800-foot vertical shaft. The ore shoot, continuous from the surface to a depth of 900 or 1,000 feet, was found to be too poor for working on the deepest level. While the ore in depth was poorer than the oxidized portion, I do not understand that a gradual decrease in the tenor took place. The Cornucopia mines have been worked 500 feet below the croppings with continuous ore shoots. The North Pole has been opened by tunnels to 1,000 feet or more below the croppings; the Columbia by a 500-foot shaft to a point 1,000 feet below the highest croppings on the same claim. The total vertical distance between the highest workings in the North Pole mine and the lowest in the Columbia mine is at least 1,700 feet, and on the deepest levels the ore continues of the same grade as nearer the surface, from the lower edge of the zone of oxidation. The Bonanza mine is opened by tunnels and shaft to a depth of 450 feet below the croppings, good ore being found in the lowest levels.

Regarding the permanency of the veins, there are very good reasons for believing that the strong, well-defined veins upon which most of the important mines are located will continue to the greatest depths yet attained in gold mining. Judging from analogy with other regions, it is also probable that the pay shoots will continue in depth, though the unbroken continuation of one and the same ore shoot should not be relied upon with confidence. It has been the experience of most deep gold-mining enterprises that barren levels will occasionally interrupt the richest and most extensive ore shoots. Smaller fissure veins, members of a great number of veins in close contiguity and which have no great length, are not to be relied upon with as much certainty. But, taken as a whole, the strength of the vein systems and the mineralizing action are important factors in favor of the future of this mining region.

SURFACE OXIDATION.

In eastern Oregon, as in most mining regions, the portion of the veins adjacent to the surface has undergone certain changes, due to the action of oxidizing waters. In late years much attention has been devoted to these phenomena, and the studies of Messrs. Emmons, Weed, and Van Hise have placed the active processes in a much clearer light. Their importance to the mining industry can not be overestimated, for the future value of a mine depends greatly on the extent of the secondary surface processes and of their certain identification.

In a broad way, the processes of oxidation and the sulphide enrichment accompanying them in greater depths are more active and extensive in an arid climate than in a region of heavy rainfall, where the water level stands high. The Blue Mountain region is essentially one of great precipitation, and has in all probability been so since Neocene time. It is further true, in a general way, that gold-quartz veins are less readily affected than silver and copper veins, due, no doubt, to the more difficult solubility of the gold. Furthermore, some of the districts in this region are located in areas of former glaciation, which has swept away the softer products of oxidation, the limonite and the cellular quartz of the "iron cap."

The general conclusion, then, is that secondary surface enrichment has played a comparatively unimportant part in this region. It is, however, undoubtedly present, as shown by the following examples selected from the detailed descriptions:

From Pedro Mountain near Rye Valley, from La Belleview and the Monumental mines in the Granite district, and from some parts of the Greenhorn Mountains come reports of extraordinarily rich silver ore in the croppings immediately below which poorer ore was found. This is in line with what is known about silver veins elsewhere, and may without doubt be attributed to surface enrichment.

Among the gold veins with coarse sulphides and no free gold the surface, down to 25 or 50 feet, is generally reported to contain limonite with free gold and richer ore than below. Those at Cable Cove and Susanville are examples of this.

Among the gold-quartz veins with much free gold the upper parts of the vein, from the surface to a depth of from 100 to 300 feet, are generally more or less oxidized and richer than the unaltered ore below. At the Sanger mine, on Eagle Creek, the uppermost 100 feet showed a narrow vein yielding $25 per ton, while below the vein widened and the average values were reduced to $12 per ton. At the Virtue mine the upper two or three levels yielded $25 per ton, while the main part of the ore shoot averaged only $16 per ton. Although in a locally arid district, deeper oxidation is excluded in this case, for below the first few levels the mine contained an abundance of warm water, in all probability under ascending pressure.

In the gold veins in argillite of the Cracker Creek and Granite districts the sulphides are generally in very fine distribution and the ore is often quite hard. In connection with a high permanent water level this results in an oxidized zone which, on the steep hillsides of the North Pole claim, extends 200 to 250 feet from the surface. The ore in this zone is only partly oxidized, and the difference in tenor between it and the deep unaltered ore is surprisingly slight. Average assays of surface ore give 0.968 ounce gold and 0.700 ounce silver per ton, a total of $20.40 per ton. In the fresh ore is very little free gold; in the oxidized ore a little more, but enough is not set free to convert the substance into free milling ore, so that a preliminary roasting is necessary for purposes of the cyanide process. If no great change of volume has taken place during the process, the weathering has had the effect of slightly increasing the gold and decreasing the silver.

The Ibex vein, situated in the glaciated area, shows little evidence of surface decomposition. I believe that the bodies of rich ore, 40 feet wide, found in the Belle of Baker near the surface, as well as in the Bonanza vein 300 feet from the surface, are due to primary deposition, and have not been enriched by oxidizing action.

No decided evidence of sulphide enrichment due to surface waters has been found. The ores should be expected to continue for great depth below the relatively shallow zone of oxidation without notable change in character and tenor.

AGE OF THE GOLD AND SILVER VEINS.

The gold and silver veins of the Blue Mountains with few exceptions consist of a number of very closely related structural and mineralogical types. It is difficult to avoid the conclusion that they are all of about the same age. They occur in argillite, granites, granodiorites, diorites, gabbros, and serpentines. They cut Triassic sediments in the Eagle Creek Mountains; they cut older argillites which with reasonable certainty may be assigned to the Paleozoic age; finally, they never appear in the Neocene basaltic, andesitic, and rhyolitic lavas. The conclusion is that they are post-Triassic and pre-Neocene. The California gold-quartz veins are post-Jurassic and pre-Neocene; we may even fix their age a little closer, for they are doubtless also earlier than the Chico Cretaceous. The vein systems of central Idaho are determined as post-Carboniferous and pre-Neocene. It is very probable that the veins in the three regions date from about the same period, i. e., the early Cretaceous.

A strong mineralization of the Neocene lavas has been noted in Owyhee County, in southern Idaho. The only instance in this region of a post-Neocene mineralization is in the case of a dike of rhyolite 9 miles south of Prairie, which undoubtedly contains traces of gold and silver.

INFLUENCE OF COUNTRY ROCK.

It has been stated that the gold and silver veins appear in almost all of the different rocks of the region, excepting the Neocene lavas; the influence of the country rock upon the character of the ore is next to be discussed. When smaller districts are examined differences due to the varying character of the country rock may be distinguished; but to a great extent these are effaced when the region as a whole is considered. Most of the big-producing mines are in slate or siliceous argillite; for instance, the Bonanza, Red Boy, North Pole, Columbia, Golconda, and Connor Creek mines; but, on the other hand, the Virtue is in tuffaceous greenstone, and the Baisley-Elkhorn and the Cornucopia mines in diorite or granodiorite. It may perhaps be said that in granite or diorite there is apt to be less free gold and a greater percentage of sulphurets, but this is a doubtful rule, for some of the greatest mines in argillite, like the North Pole and E. and E., contain very little free gold and abundant sulphurets. The same is true of the Badger mine at Susanville. Veins in serpentine are usually narrow and short, with much dolomite gangue and coarse, pure gold.

It would seem that here, as in California, the influence of locality overshadows that of the country rock entirely. That is, if gold-bearing veins are developed at any place, they are likely to be found in any of the various rocks which appear at that place.

No doubt the difference in the character of the fracture in argillite and in granitic rocks greatly influences the deposition. A wide fracture zone is apt to contain a different ore from narrow fissures through which the solutions found their way with difficulty; and the fact that granitic and dioritic rocks are altered in a different way and more easily than the siliceous argillite can hardly fail to make the character of the solutions circulating in the open spaces somewhat different in the two cases. This may account for a relative abundance of sulphides in the granular rocks and a less amount of free gold in them.

VARIATIONS OF THE PAY SHOOTS.

It is an interesting fact that adjoining pay shoots in one and the same vein may differ considerably in the character of the ore. This applies particularly to the North Pole and Ibex veins. The North Pole and E. and E. ore shoots on the North Pole vein contain very little free gold; the sulphurets are of high grade. The Columbia ore shoot contains more free gold and also more silver than the former. The Golconda contains free gold, but the sulphurets are poorer than in the Columbia. These data refer, of course, to the fresh, unoxidized ore. In the Ibex mine three pay shoots show successive variation of the relative proportion of gold and silver. The first shoot contains 90 per cent gold and 10 per cent silver, the last 40 per cent gold and 60 per cent silver.

GEOLOGICAL RELATIONS OF THE VEINS.

While at first glance the veins seem to be scattered irregularly in respect to geological areas, a closer inspection reveals some interesting relations.

Relatively few deposits are contained in the great area of granodiorite of the northern Elkhorn Range, the extensive area of sedimentary rocks of the Eagle Creek Range, or the area of argillites on both sides of the Burnt River Canyon above Durkee.

On the other hand, the veins certainly appear massed near the contacts of sedimentary rocks with granular intrusive rocks. Most conspicuously does this show in the great Elkhorn-Cracker Creek-Cable Cove vein system, which accompanies the contact for many miles—not closely, indeed, for none of the veins follow the actual contact. The veins are now in diorite or granodiorite, now in argillite, continually branching, crossing the contact, and throwing out divergent systems several miles either way from the contact. Near Granite another vein system is developed, crossing the contact. Near the Red Boy, Alamo, and Greenhorn districts another intrusive area of granodiorites, diorite, gabbro, and serpentine begins, and new vein systems appear in them or in the argillites broken by their intrusion. At Bonanza serpentine accompanies the argillite, as it also does at Susanville. At Canyon serpentine and diabase adjoin slate areas. In the southern Elkhorn Range dioritic rocks have shattered the sedimentary series. In the Virtue mining district the veins occur on both sides of a contact between diorites and gabbros and argillite. In the Cornucopia mining district rich veins appear at the intrusive contacts of granodiorite and schists; at Sparta in granite adjoining sedimentary rocks. Finally, the local gold belt of the lower Burnt River, extending from Connor Creek to Malheur, a distance of 30 miles, follows three intrusive areas of diorite and granodiorite—those of Lookout Mountain, Pedro Mountain, and Amelia.

These relations are too evident to be overlooked. It seems certain that the occurrence of rich gold and silver veins in this region is, in some way, connected with the occurrence of intrusive rocks, which more rarely are granites, more commonly granodiorites, diorites, gabbros, or serpentines. This by no means implies that all the veins, nor even a majority of them, are contained in these intrusive rocks. They are just as apt to be found in the sedimentary areas in the vicinity of the intrusive masses. This conclusion is important, as similar evidence has been gathered from so many other regions of auriferous veins.

To fully appreciate this connection and to reach the safe conclusion to be drawn from the facts, a careful comparative study of the auriferous regions of the world must be undertaken. This can not be done at this place, and the probable genesis of these deposits will, therefore, be merely indicated in a few words.

GENESIS OF THE VEINS.

The veins of the Blue Mountains were formed at a relatively remote period, and few traces of the active agents of their formation can be found now. From data concerning the character of the filling, it is here, as in the case of almost all gold-quartz veins, perfectly safe to conclude that the mode of deposition has been exclusively aqueous. From the fact that they occupy important systems of fractures which doubtless continue in depth to a distance commensurate with their extension in length, and from the fact that as far as followed they exhibit no notable change in the character of their filling, we may feel confident that the fissures were channels conveying currents of ascending waters. Wherever these solutions came in contact with rocks capable of metasomatic alteration, a strong action is noticeable on the latter, most intense nearest to the fissure and gradually fading away at a distance. From the further fact that by this alteration silicates are entirely converted to carbonates and sericite, we conclude that the waters contained a strong percentage of carbon dioxide and alkaline carbonates. All these facts point strongly toward thermal waters, hot ascending currents, as the chief factor in the deposition. Much of the gangue was doubtless extracted from the immediately surrounding country rock. Confirming this is the prevalence of dolomitic gangue in veins in serpentine; but the zone from which this material has been extracted is too limited to make it probable that the gold and silver were extracted from the country rock. Militating against this is also the fact that similar veins are found in most widely differing rocks. It is more probable, perhaps, that the thermal waters obtained their heavy metals from gaseous emanations along the contact of magmas cooling at great depth.

The comparison between the copper deposits and the gold-silver veins, which will be found at the end of the discussion of the former, is most interesting. Conceding aqueous deposition for both classes of deposit, the metasomatic processes and the general structural relations are very different, indicating for the gold deposits a deep-seated origin and for the copper deposits a genesis more closely connected with surface phenomena.

MINERAL CLASSIFICATION OF PRIMARY GOLD AND SILVER VEINS.

GOLD VEINS.

Virtue type.—These are simple fissure veins, with quartz filling, in sedimentary, and, more rarely, in igneous rocks. The ore consists principally of native free-milling gold, often coarse, and always very pure, ranging from 850 to 950 in fineness. The highest grade of gold is found in the Virtue and Connor Creek mines. A very small amount of arsenopyrite, pyrite, and more rarely other sulphurets is present. Occasionally, also, small amounts of tetrahedrite, argentite, and stibnite are found. Besides quartz, a little calcite and occasionally white massive scheelite (Flagstaff, Cliff) occur as gangue. The value is exclusively contained in the quartz filling, scarcely ever in the altered rock. In slates the alteration is confined to pyritization and occasionally a little carbonatization. In granular rocks there is strong carbonatization with the development of pyrite and a little sericite. Examples are the Virtue, White Swan, Flagstaff, Pocahontas, and Connor Creek mines; probably also the Sanger mines. Specimens from the Connor Creek mine show normal white vein quartz of coarse texture and partly idiomorphic outlines of the grains. It is filled with irregular inclusions and contains, crystallized together with the quartz, coarse idiomorphic arsenopyrite, with which the gold is associated; the latter, of deep-yellow color, either surrounds the arsenopyrite or occurs in intimate intergrowth with it. Most of it is coarse, though it also occurs as fine dust and films through the arsenopyrite. It is observed wholly included in the coarser quartz grains, but also along the contacts of the grains, as if deposited by a secondary migration. Wherever the quartz shows parallel partings or ribbon structure in the specimen evidences of pressure are observed in the sections. The large quartz grains throughout the slides are optically disturbed, and along lines coincident with the "ribbons" extensive crushing appears, with the formation of new quartz aggregates and veinlets of calcite, a mineral which sometimes also occurs in larger grains mixed with the quartz. Along these secondary fractures cubical pyrite has recrystallized and threads of gold are also observed, probably a mechanical deformation of the primary deposit.

The clay slate adjoining the vein is a microcrystalline mosaic of quartz, probably also feldspar, traversed by curved and contorted streaks of carbonaceous matter. It contains cubical pyrite as well as seams of calcite and quartz; calcite also in part replaces the slate.

An extremely altered narrow dike follows the Connor Creek vein throughout. Its structure is porphyritic and its groundmass microcrystalline, consisting of quartz and feldspar. Beyond that it can not be identified. The grayish soft rock contains about 20 per cent each of sericite and calcite, together with a few sharply defined crystals of pyrite. It is cut by a few normal quartz seams.

The quartz of the Virtue mine is similar to that from the Connor Creek, though arsenopyrite is generally absent. The wall rock is a soft, very altered greenstone, probably an old volcanic tuff. The rock is filled with seams of calcite, which also largely replace the rock. The remaining feldspars contain a little very minutely divided sericite. Pyrite and some pyrrhotite are also among the metasomatic developments.

The quartz of the Flagstaff mine is again similar, but contains some grains of brownish calcite intergrown with the primary quartz. This calcite again incloses small prisms of quartz.

Canyon and Robinsonville types.—These two divisions also contain coarse free gold of high grade, associated with some sulphurets, but they differ somewhat from the Virtue type. Apparently without exception they are contained in serpentine, gabbro, diabase or diabase-porphyry, and rarely have great length or width. The ore usually occurs in rich pockets.

In the Canyon type well-defined, almost barren quartz veins in gabbro or diabase-porphyry are accompanied by complicated systems of seams. Coarse gold is found in rich pockets in these seams and has a tendency to crystalline development. The gold occurs in quartz or in calcite. When in the latter it seems to be later than that mineral and its introduction is accompanied by a shattering of the coarse calcite and a simultaneous deposition of a little quartz (Pl. LXIX, *C*).

The country rock is greatly carbonatized and also contains metasomatic pyrite. The development of the latter along minute fissures and its characteristic calcite rim is illustrated in Pl. LXX, *B*. Sulphurets other than pyrite are generally absent. Veins of the Robinsonville type are also chiefly pockets, but the gold is more confined within the vein and the development shows greater variation. The vein filling is quartz of normal, coarse granular type; the crystals are sometimes (Pl. LXX, *A*) cemented by chalcedony. In serpentine, however, as in the Junebug and Don Juan veins, the gangue is chiefly of dolomite, no doubt derived from the country rock. Both dolomite and quartz contain coarse gold. Among the sulphurets, galena, remarkably enough, often predominates and is directly associated with the gold, but chalcopyrite is also present (Banzett, Diadem). The alteration of the country rock is usually a carbonatization, dolomite being frequently formed.

Cornucopia type.—These are normal, simple quartz-filled fissure veins, containing free gold of a fineness from 870 down to 700. The sulphurets, of which from 5 to 10 per cent is present, are usually rich in gold and sometimes also contain some silver. They consist of pyrite and arsenopyrite, with a little zinc blende, galena, and chalcopyrite. Tellurides are sometimes present. The ores are free milling to the extent of from 30 to 60 per cent. These veins show great similarity to certain California types. The country rock is usually a granodiorite, diorite, or diabase, and is strongly altered to a white, soft substance containing very abundantly calcite, sericite, and pyrite. Examples of this type are found at Cornucopia, Sparta, Gold Hill, and Gold Ridge (Burnt River). It is very similar to the Gold Hill type described from central Idaho.[1]

The quartz from Cornucopia is a normal, coarse vein quartz, greatly crushed and showing optical anomalies in thin section along lines where the ribbon structure appears in specimens. Abundant irregular aqueous inclusions are massed along certain lines. Intergrown

[1] Twentieth Ann. Rept. U. S. Geol. Survey, Part III, 1900, p. 105.

with this quartz are pyrite, chalcopyrite, and a colorless zinc blende. Secondary calcite has been introduced along irregular cracks.

The quartz from the Present Need mine, Quartzburg, shows normal coarse structure and is full of large irregular aqueous fluid inclusions with large bubbles. Between the grains lie anhedrons of pyrite, chalcopyrite, galena, and grayish-yellow marcasite. The pyrite and marcasite are intimately intergrown with native gold.

Cable Cove type.—In this type the sulphurets predominate, and the free gold makes up only a small part of the total value. When it occurs, the free gold is of a low value, from 650 to 750 fine. Among the sulphurets pyrite and arsenopyrite predominate, but zinc blende, galena, and chalcopyrite also occur. Rich silver ores are not uncommon (tetrahedrite and pyrargyrite), and altogether there is more silver than in any of the preceding types. Cinnabar is abundant in the placer mines of Susanville, and may have been derived from veins of this type occurring near by. The gangue, which is not very abundant, consists of quartz, but there is also considerable calcite present.

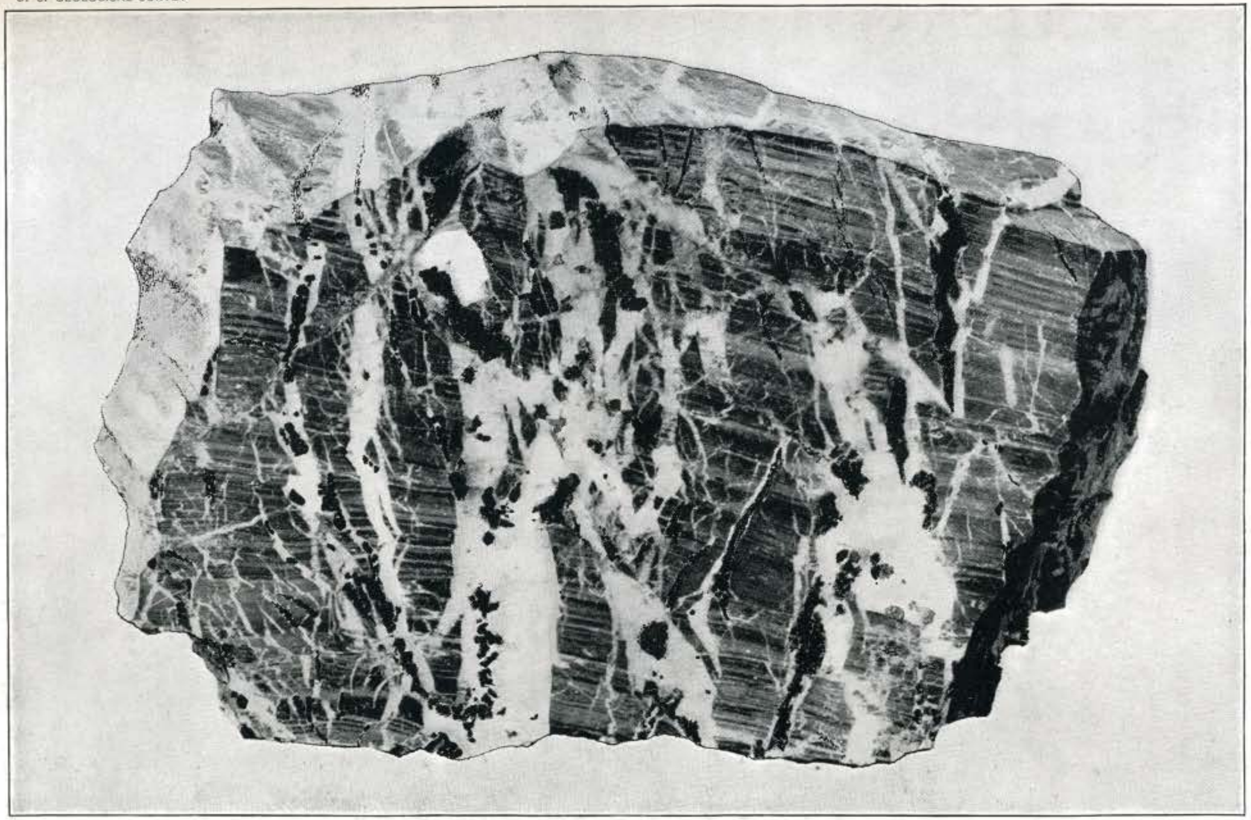
The alteration of the country rock, when of granodiorite or diorite, shows the normal sericitization and carbonatization. When the country rock is slate the veins are accompanied by local and slight silification. A part of the ore is probably formed by replacement of the country rock. Representatives of this type are the Cable Cove mines, the Baisley-Elkhorn, and the Badger mines, at Susanville. This type is somewhat similar to the Willow Creek type from central Idaho.[1]

At the Baisley-Elkhorn the free gold, which amounts to 25 per cent of the total value of the ore, sometimes occurs as wires in a black zinc blende, very intimately intergrown with calcite and a few grains of quartz.

The diorite from the same locality is greatly altered close to the vein. The feldspars are almost completely converted into sericite and calcite, the latter characteristically filling the spaces between the sericite foils. Cubes of pyrite develop in this mass and in the quartz, which otherwise is but little altered. The biotite is partly altered to chlorite, but chiefly to muscovite foils.

In the Cable Cove veins there is less free gold. The vein quartz, when present, is of the normal, coarsely crystalline type (LXIX, *A*), containing well-defined crystals of arsenopyrite and other sulphurets. In a few places a little chalcedony may be noted between the quartz grains. The aqueous inclusions are abundant, but small and irregular, mostly with large stationary bubbles. The granodiorite next to the ore is normally altered to sericite with a little calcite. Fairly pure galena from the Imperial contained 0.74 ounce gold and 60.86 ounces silver per ton, while the pure arsenopyrite from the same mine assayed 5.82 ounces gold and 7.08 ounces silver per ton.

[1] Lindgren, loc. cit.



SPECIMEN OF GOLD ORE, BADGER MINE.

At the Badger mine the coarse pyrite and arsenopyrite is of lower grade, while finer mixtures of these minerals with a little galena, zinc blende, and tetrahedrite contained 1.04 ounces gold and 909.08 ounces silver per ton. The country rock at the Badger mine is a clay slate, developed in at least two modifications. The metasomatic alteration differs correspondingly in an interesting manner. The first is a black, somewhat crumpled, imperfectly fissile clay slate. Under the microscope it has a banded and streaky appearance, due to narrow and curving belts of carbonaceous matter and to streaks of fine aggregates of brown biotite. The clearer parts evidently consist of a very fine microcrystalline aggregate of quartz and feldspar, and contain scattered clastic grains of quartz and twinned feldspars. The clay slate is penetrated by irregularly developed fine-grained aggregates of calcite, accompanied by anhedral pyrite. The calcite very evidently replaces the substance of the clay slate.

The second specimen is a black, fissile clay slate, traversed perpendicularly to the schistosity by a great number of narrow quartz veins containing pyrite, arsenopyrite, and a little zinc blende. The slate is free from sulphides. This clay slate is an almost cryptocrystalline mass, traversed by straight, but not very sharply marked, streaks of calcareous matter. Under highest magnifying powers the substance of the slate is resolved into a fine aggregate of at least two substances of different indices of refraction; many of the larger grains show fibrous undulous extinction. In all probability we have in this rock an intimate mixture of quartz and kaolin. Small and perfect prisms of tourmaline and a few minute sericite foils were noted. The rock is cut by sharply defined quartz veins, in places containing a little calcite and sharply defined crystals of pyrite. They are excellent illustrations of the comb-quartz veins, showing a growth of small crystals next to the walls and then a second generation of coarse crystals reaching entirely across the veinlets. Most of the rock is fresh and unaltered, even when adjoining the veins; but in some places a silicification spreads from the veins in irregular blotches, sometimes following the schistosity. These silicified parts are marked in ordinary light by a replacement of the granulated and dusty argillite substance by a clearer quartz mass, and in polarized light by a coarser, though still fine, aggregate of microcrystalline, interlocking quartz grains and scattered particles of calcite.

These two rocks show that a silicification may take place when the country rock is quartzose and contains no constituents which can easily be acted upon by the solutions. Mass action then becomes predominant, and the solutions containing alkaline carbonates, carbon dioxide, as well as silica, deposit the latter, and some of the kaolin is possibly removed. But when the rock contains feldspars and biotite, chemical reaction between the solutions and the rock produces a deposition of calcite, pyrite, and in most cases also of sericite.

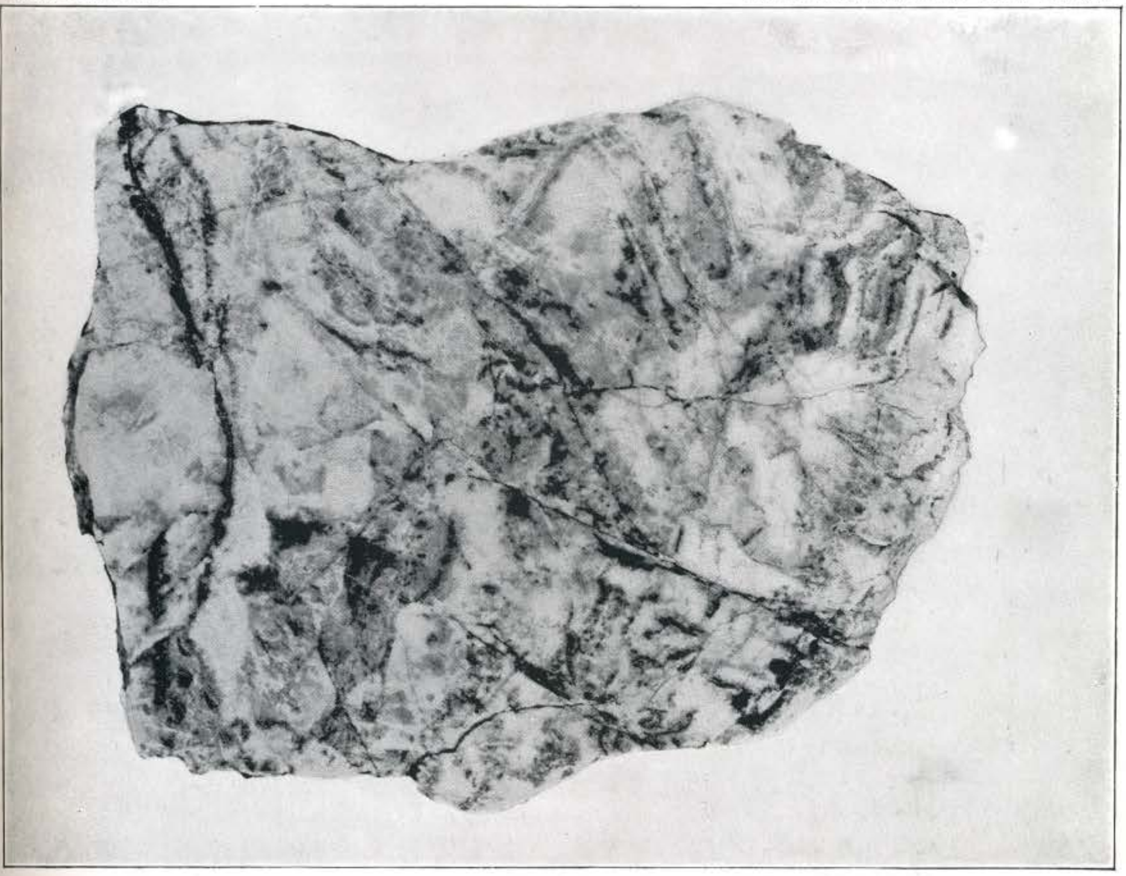
North Pole type.—This division includes the wide, composite veins in argillite and is characterized by a smaller quantity of free gold of rather low grade, together with finely divided sulphurets which usually are rich in gold. The amount of free gold varies from a few per cent up to about 40 per cent. The sulphurets consist chiefly of arsenopyrite and marcasite. Chalcopyrite, galena, and blende are uncommon. Accessory minerals are cinnabar, tetrahedrite, mercurial tetrahedrite, stibnite, and tellurides. The principal gangue is quartz; on secondary seams calcite appears. Chromium mica and roscoelite (vanadium mica) also occur. The ore is usually normal filling, more rarely replaced country rock. The alteration of the slate comprises chiefly a pyritization, occasionally also a silicification; porphyry dikes contained in the argillite are sericitized and partly also carbonatized.

In the North Pole mine the normal ore is a coarse, typical quartz with strong tendency to comb structure. The large crystals show concentric lines of growth upon which the new individuals develop with the same orientation as in the underlying crystals. The comb quartz contains in fine distribution idiomorphic arsenopyrite and less well-developed pyrite. Sometimes the arsenopyrite appears in several sharply defined thin crusts of primary deposition, each generation again covered by comb quartz. Aqueous inclusions of irregular form are common in the quartz. The only difference between barren quartz and ore is in the sulphides contained in the latter.

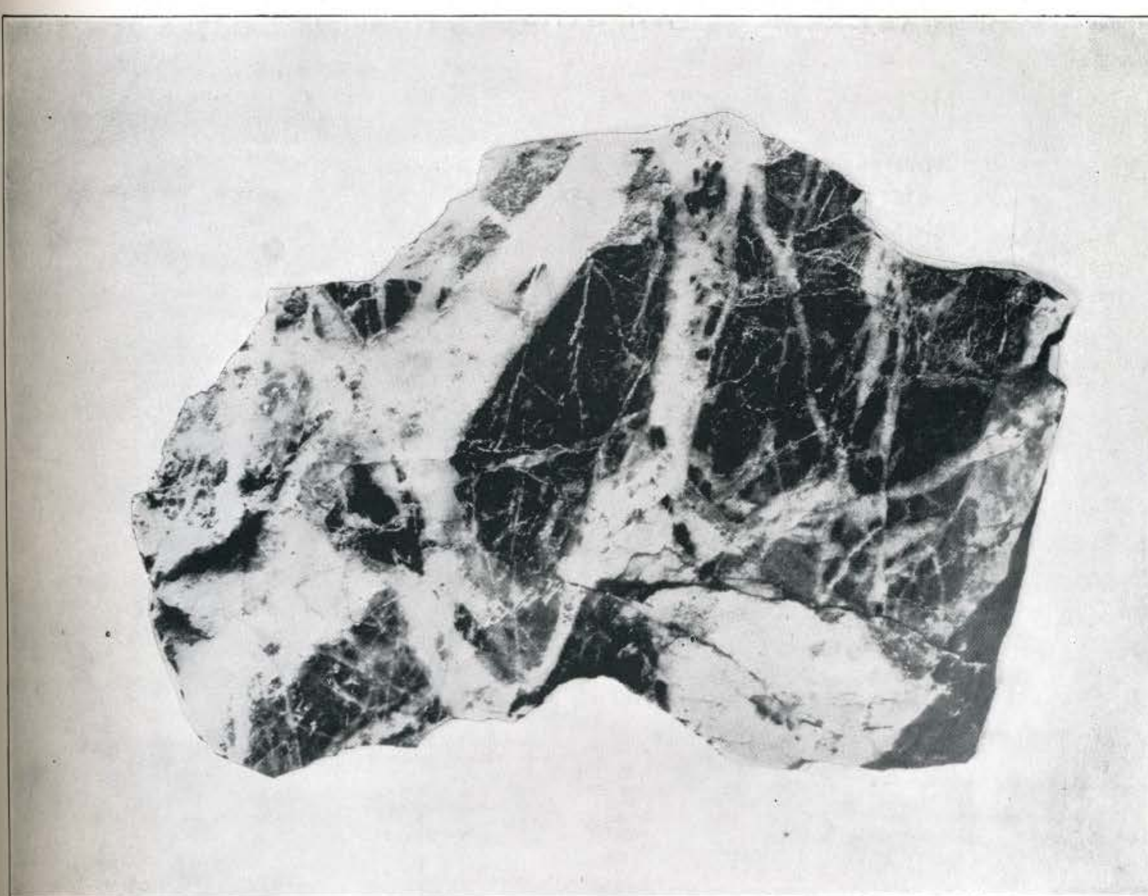
The country rock is siliceous and consists of closely packed, minute, allotriomorphic quartz grains. Between them lie a few fibers of sericite. The planes of the sedimentation are marked by streaks of black carbonaceous material. The principal alteration consists in the development of pyrite in small cubes. This pyrite may in places form larger aggregates, but the latter are always poor in gold and silver.

Secondary changes are frequent in the ore. In many places the quartz shows undulous extinction and is traversed by crushed zones. Whole masses of primary quartz with arsenopyrite in concentric deposition are crushed and recemented by quartz. This produces the peculiar brecciated appearance shown in Pl. LXVIII, *A*, with concentric streaks of arsenopyrite running in many directions and frequently sharply interrupted. In the secondary quartz are scattered sharply defined pentagonal dodecahedrons of pyrite. A third and latest phase of the vein formation is the introduction of calcite along narrow cracks throughout the barren as well as the rich quartz. With the calcite, pyrite and arsenopyrite again recrystallize.

A thin section of rich telluride ore from the North Pole is shown on Pl. LXIX, *B*. The principal mineral is hessite, which is lined with native gold and also contains small masses of another pale-yellow telluride. These minerals occur in apparently primary quartz.



A.



B.

SPECIMENS OF GOLD ORE FROM NORTH POLE AND COLUMBIA MINES.

In the Columbia mine similar relations prevail. The ore is prevailingly a quartz filling showing comb-quartz structure. The argillite is a very fine-grained but clear quartz mosaic, containing abundant streaks of organic matter. Cubes of pyrite are often inclosed in this carbonaceous substance. A slight silicification may have taken place. The argillite is cut by well-defined quartz veinlets, which again show a late infiltration of calcite. Dikes of a very altered igneous rock of doubtful original character are also cut by the vein. A specimen of altered porphyry from the lowest tunnel level consists of sericite fibers, calcite, and a few anhedrons of pyrite.

The rich shipping ore, ordinary specimens of which assayed 245 ounces gold and 166 ounces silver per ton, is a greenish-gray quartz of varying grain. Much of it is very fine grained and almost flinty, and darkened by finely distributed sulphurets. In some places fragments of a greenish-gray altered rock are included in quartz, the color being due to the finely divided roscoelite. Fibers of this mineral are also scattered through the whole rock. The sulphurets consist of pyrite, chalcopyrite, zinc blende, and a black mercurial tetrahedrite, besides much native gold. The latter occurs in intergrowth with the colorless or brownish zinc blende and the tetrahedrite, but not with the pyrite. It also is found intergrown with roscoelite wherever that mineral is abundant. In the prevailing mass of quartz lie small, well-defined inclusions, probably of argillite; these consist of microcrystalline quartz with a little sericite.

The prevailing mineral is a partly idiomorphic normal vein quartz, the grain of which varies considerably. The roscoelite is distributed throughout the quartz in fine aggregates of greenish fibers of strong double refraction. The specimens show no evidence of secondary crushing or deposition.

At the Golconda mine the big quartz vein splits up into stringers, and there is more ore derived from alteration of the country rock than at the other mines. The argillite here approaches normal clay slate, extremely fine grained, with curved streaks of carbonaceous matter. The groundmass seems to consist chiefly of interlocking and very minute quartz grains, together with a little chlorite and isolated crystals of tourmaline and zoisite. The altered rock near the veins contains green spots, due to some chromium mineral, probably fuchsite, besides much pyrite in well-developed crystals. In one specimen were found abundant small and wedge-shaped crystals of marcasite, sometimes also star-shaped, compound crystals of the same. The argillite is cut by veinlets of granular quartz with a little sericite and pyrite.

Dikes of undeterminable porphyries also occur in the mine, and some of them are sufficiently mineralized to be regarded as ore. They are dull grayish, or grayish green, and contain a little pyrite. One of these, collected from the dump, consists chiefly of sericite in ragged bunches of fibers, and a secondary quartz mosaic, as well as abundant and sharp pyrite crystals. Another dike, from the fourth level, which was considered as ore, consists largely of an extremely intimate mixture of dolomite and quartz, with a little pyrite. Veinlets of quartz, cut again by still later veinlets of some carbonate, traverse the slide. The original rock was probably a basic dike. Possibly the chromium found in the altered rocks is derived from this source.

The rich shipping ore found in the Golconda is similar to that from the Columbia. It consists of a dull-greenish rock of extremely fine-grained quartz, colored by films of roscoelite, and containing pyrite as well as abundant star-shaped marcasite crystals. This rock, which probably is an altered and silicified argillite, contains vugs and veinlets filled with coarser quartz, with native gold, chalcopyrite, pale-brown zinc blende, and probably tetrahedrite. Fine-grained chalcedonic veinlets also cut the rock. Altogether, the ore seems to be a crushed and greatly altered argillite.

In the Mountain Belle the normal quartz filling again appears. The quartz cements fragments of argillite, which is decidedly silicified and contains cubes of pyrite.

The ores of the Ibex vein are composed chiefly of normal quartz filling, the structure giving clear evidence that it was deposited in open space. Fragments of argillite are included in the quartz. These are decidedly silicified and converted to a quartz mosaic coarser than that of the normal rock. Pyrite and small fibers of sericite also appear in it. The ore minerals are finely divided native gold, pyrite, arsenopyrite, and a little pyrargyrite and cinnabar. The latter occurs on secondary fissures in the vein quartz.

The richest ore of the Ibex is a dark-gray breccia of quartz and argillite, the latter composed of microcrystalline quartz and a little sericite, carbonaceous matter, and pyrite. Most of the fragments are sharply defined and cut by quartz veins showing comb structure; but in other places there is an ill-defined mixture of argillite and quartz, strongly suggesting a mud of crushed argillite, between the particles of which the quartz crystallized. In this mixture of quartz and argillite are particles of native gold, together with coarse pyrite and finely distributed arsenopyrite. Several belts of secondary crushing traverse the specimen, and in these is much sooty, fine-grained arsenopyrite, as well as a little gold in fine wires.

Somewhat different from these examples is the Cougar vein, in which there is but little quartz, but much crushed argillite constituting the principal ore. The ore contains a considerable amount of silver, one sample assaying 0.68 ounce gold and 23.88 ounces silver per ton. The ore is composed of argillite, consisting of a very fine-grained and sharply defined quartz mosaic, with a few shreds of sericite and scat-

PLATE LXIX.

PLATE LXIX.

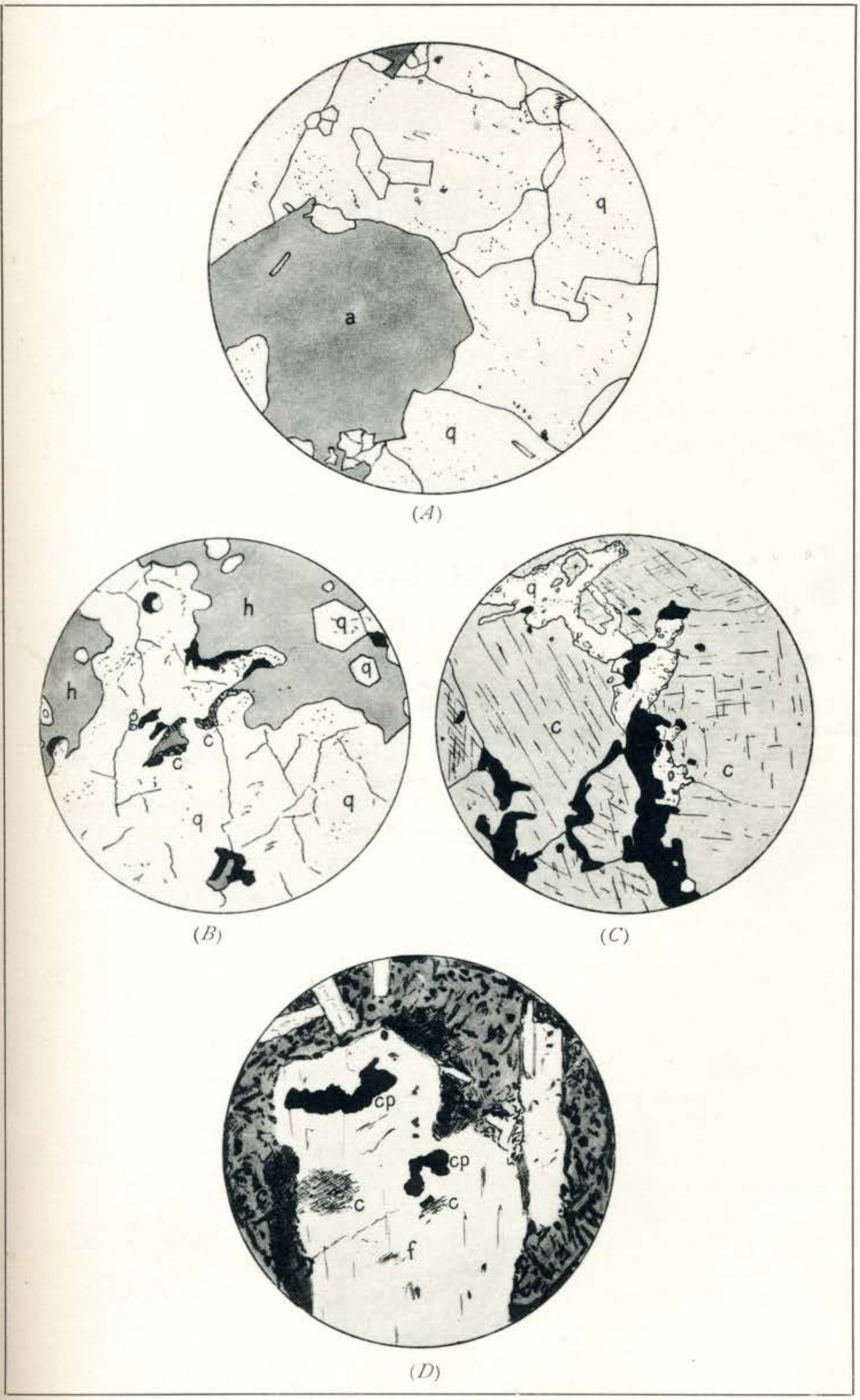
THIN SECTIONS SHOWING STRUCTURE OF ORE.

A. Normal vein quartz with arsenopyrite, from Imperial mine, Cable Cove; q, quartz; a, arsenopyrite. Magnified 16 diameters.

B. Telluride ore from North Pole mine; q, quartz; h, hessite; g, gold; c, calaverite?. Magnified 24 diameters.

C. Coarse gold in calcite with quartz; Great Northern mine, Canyon; c, calcite; q, quartz; gold, black. Magnified 12 diameters.

D. Copper, replacing feldspar in Triassic andesite or basalt. Copper Union, Copper Butte district; f, feldspar; c, chlorite; cp, copper. Magnified 120 diameters.



THIN SECTIONS SHOWING STRUCTURE OF ORE

THE MERIDEN GRAVURE CO.

tered crystals of pyrite and marcasite. Veinlets of quartz, with needles and star-shaped compound crystals of marcasite, traverse the argillite.

Many veins near Alamo belong to this type, and in most of them the ore contains bright-green spots, partly in the quartz, partly in the argillite. This color is due to chromium, and it is believed that the mineral causing it is a very finely divided chromium mica. It is especially prominent in the Little Giant mine, and may be explained by the fact that serpentine, always containing chromium, occurs in close vicinity to the vein; but it is also found in the Quebec, Wilson, and other veins a mile or two distant from serpentoid rocks.

Red Boy type.—This type consists of veins in argillite, similar in their filling to those of the North Pole type, but distinguished by predominant free gold of a low degree of purity. The gold makes up 60 to 90 per cent of the assay value, and varies in fineness from 500 to 600, the rest being silver. Sulphurets amount to 5 per cent at most, and are poor, the concentrates rarely assaying more than $30 per ton. They consist chiefly of pyrite, with a little arsenopyrite and chalcopyrite, or of argillite penetrated by veinlets of quartz, usually with comb structure. The gangue consists of normal vein quartz mixed with fragments of argillite. To this type belong the Red Boy veins, the Bonanza, and the Mammoth. At the Red Boy mine the black argillite seems altered only by the introduction of pyrite, while dikes of a porphyritic rock which can not be identified have suffered alteration to calcite and pyrite, accompanied by microcrystalline quartz.

At the Mammoth mine the country rock is partly granodiorite, partly a siliceous argillite. The latter has suffered no change, except the introduction of some pyrite. The granodiorite is carbonatized to a considerable degree. The ore, which forms thick bodies, consists of brecciated slate and granodiorite cemented by normal vein quartz, containing coarse, pale gold, together with a little pyrite and arsenopyrite. Closely associated with the gold is a dull-green vanadium mica, probably roscoelite. This forms irregular blotches and small aggregates in the quartz, and often surrounds the gold, as shown on Pl. LXX, *D*. There is no reason for believing that the rich ore which occurs near the surface is not due to primary deposition. The rich quartz is traversed by crushed zones and small slipping planes, often coated with gold. Irregular seams of calcite, the latest mineral formed, cut across the quartz. In other parts of the mine the ore is a breccia of sharp argillite fragments. The argillite is very siliceous, appearing under the microscope as a microquartzite. The metasomatic change consists only in the introduction of cubes of pyrite and slender prisms of arsenopyrite or marcasite. The cementing mass is chiefly calcite, coating the argillite in pretty crusts. The calcite contains inclusions of normal vein quartz.

IMPREGNATIONS.

In certain districts in which the vein-forming solutions have been especially active there is another type of deposit which has received little attention because the tenor in gold is usually very small. In this type whole masses of argillite, generally following the roughly defined planes of sedimentation, have been subjected to partial replacement, and no distinct fissures are found. The argillite is somewhat crushed, and quartz has developed on little seams and in nodules. Scattered crystals of pyrite replace the argillite, and there may also be a little dolomite and stains of chromium mica. Strata of argillites several hundred feet thick show these evidences of mineralization and contain throughout traces of gold. Examples of these deposits are found in the Alamo and Granite districts.

The presence of chromium mica in nearly all the veins and deposits of the Alamo district is very remarkable. Serpentine, which always contains chromium, is abundant a few miles from Alamo, but the veins contain this chromiummica whether close to or distant from the contact. I should think it probable that the vein-forming solutions ascended into the argillite from underlying masses of serpentine or peridotite.

SILVER VEINS.

Tempest type.—This type is very similar to the Cable Cove type among the gold veins. It occurs in the granodiorite of the Greenhorn Mountains. The gangue is quartz, forming a normal filling and containing very abundant pyrite, arsenopyrite, and zinc blende. There is little or no galena and no rich silver sulphides. The ore is accompanied by normal, sericitic-carbonatic alteration of the country rock. A little calcite fills secondary cracks in the quartz. In the Carbonate vein, which crops near serpentine, dolomite and a pure chromium mica are abundant.

Greenhorn type.—The deposits of this type are normal, simple quartz veins containing, intergrown with the quartz, tetrahedrite, and, more rarely, argentite and pyrargyrite. Representatives of this class are the Intermountain and Intrinsic veins on Greenhorn Mountain, the Monumental in the Granite district, and the veins of Pedro Mountain in the Rye Valley district.

Mineral type.—The only representatives of this type are the deposits at Mineral, Idaho, near Snake River. They are veins or irregular bodies connecting with fissures and containing pyrite, chalcopyrite, tetrahedrite, galena, and zinc blende, intimately intergrown with one another and with calcite gangue. The ores are in part surely formed by replacement of the country rock, a greenstone or greenstone tuff. The ores are ordinarily not rich in copper or lead. Average good ore

PLATE LXX.

PLATE LXX.

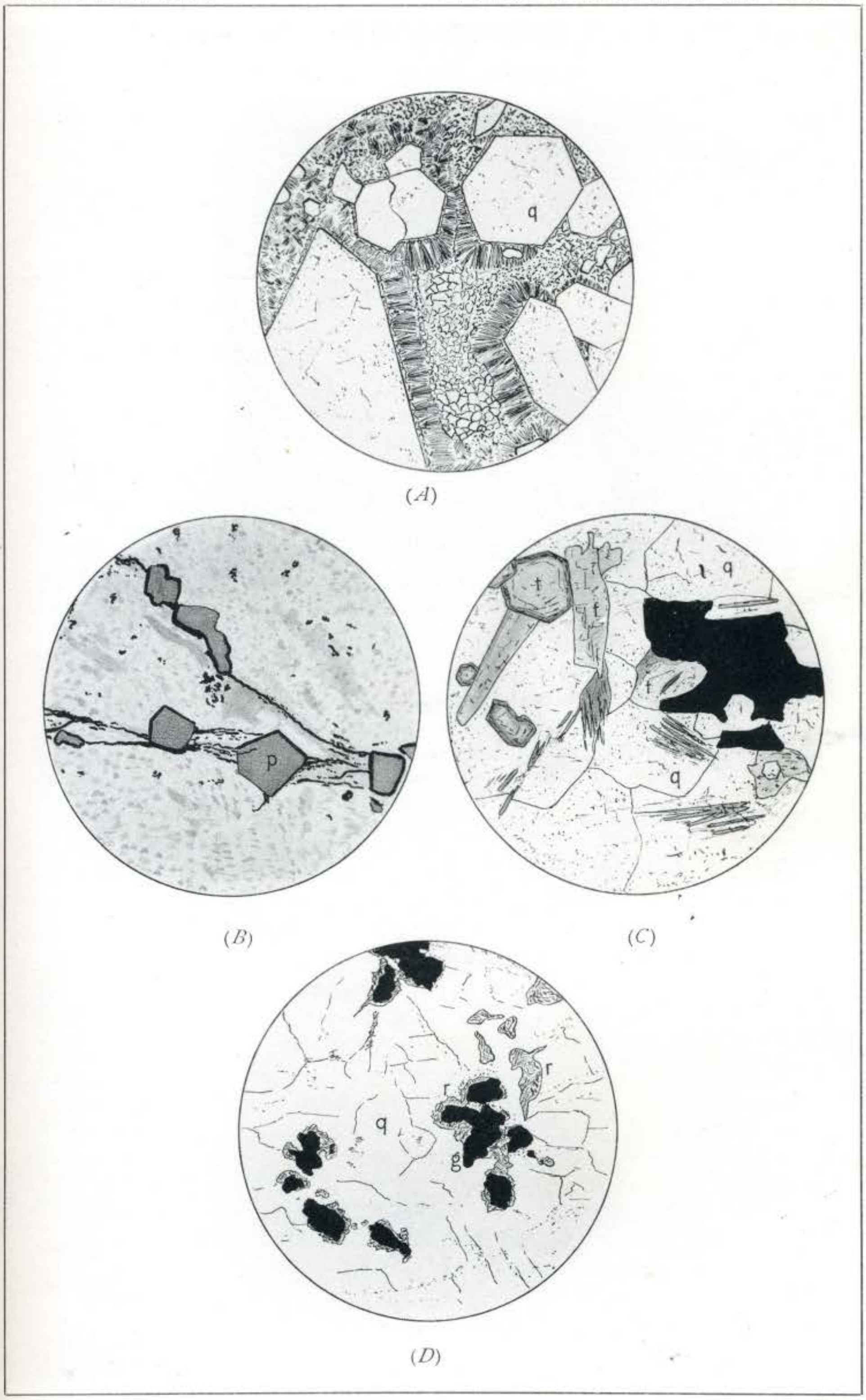
THIN SECTIONS SHOWING STRUCTURE OF ORE.

A. Comb quartz, cemented by chalcedony. Banzett mine, Robinsonville. Polarized light; q, quartz; fibrous and fine-granular aggregates, chalcedony. Magnified 12 diameters.

B. Crystals of pyrite, forming by replacement in chloritic diabase along cracks filled with calcite. Great Northern mine, Canyon. p, pyrite; black, calcite, also lining pyrite crystals; shaded in definite areas, chlorite. Magnified 12 diameters.

C. Tourmaline ore, Copperopolis, Quartzburg district. q, quartz; t, tourmaline; black, chalcopyrite. Magnified 28 diameters.

D. Gold-quartz ore. Belle of Baker, Mammoth mine, Sumpter; q, quartz; r, roscoelite; g, gold. Quartz has normal coarse-grained structure. Magnified 28 diameters.



THIN SECTIONS SHOWING STRUCTURE OF ORE

THE MERIDEN GRAVURE CO.

contains 0.28 ounce gold and 55.92 ounces silver. A peculiar feature is the extremely intimate intergrowth of galena and zinc blende into concentric aggregates.

COPPER DEPOSITS.

GENERAL STATEMENT.

Deposits in which copper constitutes the most valuable metal are rather extensively scattered over the eastern part of the region under discussion. Most of the deposits are contained in Triassic lavas interbedded with sedimentary rocks of the same age. While the gold and silver veins may contain some copper and the copper deposits almost always contain some silver and at least a trace of gold, the copper deposits form a separate class, with well-marked and distinctive characteristics pointing to a very different origin from that of the gold and silver veins. The copper deposits may be classified as follows: The Seven Devils type, the Tourmaline type, and the Snake River type. The first two are of rare occurrence.

SEVEN DEVILS TYPE.

This type includes contact deposits of irregular bodies of chalcopyrite and bornite between limestone and diorite. As gangue appear garnet, epidote, and other contact minerals. This type is represented only by a small prospect near Medical Springs (see p. 731).

TOURMALINE TYPE.

This type is characterized by chalcopyrite and pyrite associated with a gangue of quartz and tourmaline. The deposits form fissure veins or irregular replacements probably connected with fissures. Only two representatives of this type have been found.

The Copperopolis mine, on the east fork of Dixie Creek in the Quartzburg district, is the first. Brown fibrous tourmaline (blue and brown in thin section) is intimately intergrown with quartz (Pl. LXX, *C*), containing very abundant, mostly round, aqueous inclusions. The quartz is in part normal, coarse, vein quartz, in part idiomorphic, in part finer-grained allotriomorphic. The latter as well as the intermixed dirty-brown tourmaline were formed by replacement of the country rock, a diabase. The chalcopyrite is intergrown with quartz and tourmaline.

The Jessie vein in the Mineral district is the second. This is a fissure vein in diorite, accompanied in the hanging wall by a dike of basalt. The vein matter is a black gangue with massive pyrite and chalcopyrite. Thin sections of the ore show a somewhat interlocking, fairly coarse aggregate of quartz, calcite, and dolomite, all in anhedral development. In addition, a mineral which greatly resembles vesuvianite is present, also chlorite and an acicular or prismatic blue or dirty-brown tourmaline. Thin steel-gray lamellæ of specularite, single and in bunches, are embedded in both quartz and calcite. In translucent light the thin plates are deep red. Pyrite and chalcopyrite are intergrown with quartz, tourmaline, and specularite. The ore has been crushed, and along the cracks calcite has infiltrated.

This mineral combination is very remarkable for fissure vein. Especially is the occurrence of specularite noteworthy. It emphasizes the opinion given in another place[1] that the tourmaline veins are, as a rule, connected with deep-seated processes and formed under higher pressure and temperature than ordinary hydrothermal gold and silver veins.

SNAKE RIVER TYPE.

In general this type is characterized by finely distributed chalcocite or bornite, more rarely chalcopyrite, in Triassic lavas or tuffs. Metallic copper or malachite is sometimes present. The ores carry a little silver, and sometimes also gold. These deposits seem to be largely of metasomatic origin. The distribution of the sulphides is sometimes irregular, but more commonly follows well-defined directions, probably determined by systems of joints. A connection with sharply defined fissures can rarely be observed. The gangue minerals with which the sulphides are associated are quartz, epidote, actinolite, or chlorite, and according to the local prevalence three subtypes may be distinguished.

Epidotic subtype.—In this, chalcocite is associated with epidote in small replacement veins traversing the rock, and native copper occurs as a secondary product. At the North American Copper Company's prospects at Copper Union the ore-bearing rock is a soft, dark-green, very altered Triassic basalt, in places containing small amygdules of calcite. With the naked eye may be seen irregular grains of chalcocite and a little metallic copper, the latter mostly contained in the white veinlets traversing the slide. Under the microscope the basaltic character of the rock is apparent. Phenocrysts of labradorite are contained in a dark groundmass full of small prisms of the same mineral. Chlorite is very abundant in the feldspars as well as in small vesicules throughout the mass. The augite has disappeared completely. Along lines of pressure and deformation small replacement veins of chalcocite inclosed in epidote are noted; no other mineral accompanies the chalcocite. Throughout the section very finely divided metallic copper is distributed, especially abundant is it in little veins filled with zeolite, which corresponds well with natrolite and occurs in fibrous masses with radial structure. Much copper is also contained in the groundmass and in the feldspars of the rock, but it replaces the minerals in which it occurs and is accompanied by chlorite, a little quartz, and a

[1] Metasomatic processes in fissure veins: Trans. Am. Inst. Min. Eng., Vol. XXX, 1901, p. 67.

considerable amount of reddish or brownish limonite or hematite, which seems to surround the aggregates of chlorite near the copper (Pl. LXIX, *D*).

Neither chalcocite nor copper in their present form is a primary constituent of the rock. The chalcocite has been introduced first and the native metal seems a secondary product derived from the sulphide. While a secondary process, the formation of native copper can not justly be said to be due to surface decomposition, for it is clearly connected with the chlorite and the zeolites which may form at great depth. While there is thus no reason why the metallic copper could not occur throughout larger masses of rocks and on a larger scale, the fact seems to be that its occurrence is of subordinate importance to that of the chalcocite. The latter certainly has formed along cracks and joints, but is, nevertheless, not concentrated in well-defined fissure veins.

In the Snake River Canyon many similar deposits occur. Those especially examined were located near Ballards Ferry. The prevailing rock at McDougals camp, 2 miles below Ballards Ferry, is a brownish-gray volcanic tuff, probably of Triassic age. It contains clastic grains of quartz, feldspar, and a variety of fine-grained lavas. The cementing material is a finer mass of the same substances and irregularly distributed chlorite. Amygdules of calcite are common. Some of the prospects have the appearance of small fissure veins with a well-defined filling of white quartz, epidote, and massive chalcocite, the latter especially intergrown with epidote. The larger deposit forms a zone at least half a mile long and from 8 to 30 feet wide, in which an impregnation of calcite is noted. The thin sections show that the rock is fractured and deformed. On these fractures chalcocite, intimately intergrown and inclosed in epidote, has formed as narrow replacement veins. In other places isolated grains of chalcocite are surrounded by irregularly spreading epidote. Malachite appears as a product of decomposition of the chalcocite, but there is no metallic copper. The cryptocrystalline malachite forms veinlets and nests replacing the cement of the tuff.

Actinolitic subtype.—Deposits of this type were examined on the copper claims near the Snowstorm mine, not far from Sanger. The rock is here a dark-green diabase, in which some of the augite still remains, as well as some of the ilmenite, the latter otherwise altered to leucoxene. Throughout the rock light-green needles of amphibole are abundant as a secondary formation; the amphibole occurs throughout the feldspars, and especially along the fractures. Associated with it are irregular grains of chalcocite and bornite. Secondary quartz forms good-sized nodules in the rock and is also intergrown with bornite. Some malachite has formed from the sulphides and occurs intergrown with quartz.

Chloritic subtype.—This is best represented by the Iron Dike deposit. A large mass of a Triassic greenstone of uncertain original character is here shattered and filled with irregular veinlets of quartz with pyrite and chalcopyrite. Besides being thoroughly filled with chlorite it is certainly also largely replaced by quartz and pyrite, the latter often surrounded by chalcopyrite. Heavy bodies of pyrite and chalcopyrite occur at this place and are in all probability due to a complete replacement of the chloritic rock. This ore contains a little gold and silver, as well as occasionally some galena and zinc blende.

The River Queen deposit should perhaps be referred to this type. It has an irregular, vein-like form, and occurs in an old chloritic rhyolite with phenocrysts of quartz. The ores are cuprite, chalcocite, and pyrite.

The Standard mine, in the Quartzburg district, may also doubtfully be referred to this type. It occurs as a narrow, ill-defined vein, in a chloritic diabase, and is accompanied with small calcite. The ores are chalcopyrite, intergrown with the rare cobalt-arsenide, smaltite, and contain both gold and silver.

COMPARISON WITH GOLD-QUARTZ VEINS.

In the Snake River type of deposits the characteristic association is that of copper sulphides with epidote, amphibole, or chlorite, and in part, also, with quartz. This is in great contrast to the gold-silver veins, where the first three minerals are unknown constituents of the gangue. Further, the copper minerals do not occupy sharply defined and persistent fissures like the gold and silver veins, but appear along joints and small irregular fissures. The ores in their present form are clearly of secondary origin; they are not primary constituents of the rock. They are always, as far as known, associated with the Triassic greenstones, old basalts, andesites, and rhyolites. The difference between these copper deposits and the gold-silver veins is radical, alike in form, substance, and metasomatic processes. They were certainly not formed by the same or even by similar solutions. I would regard them as having probably been formed by a sort of lateral secretion, and by dilute, perhaps cold, solutions belonging to the general circulation of the ground water. The source of the metals was probably in the surrounding old lavas. The active metasomatic processes show a close connection with the general hydrometamorphism, which gradually changes the character of igneous rocks by the formation of amphibole, chlorite, quartz, epidote, and zeolite, while the gold quartz veins are probably due to thermal ascending waters. There is an undoubted parallelism between these copper deposits and those of the Lake Superior region, for both occur in part as replacement veins in amygdaloid rocks. But the Lake Superior veins contain chiefly metallic copper, the sulphides being very rare, while here the reverse is true.

OXIDIZED ZONES OF THE COPPER DEPOSITS.

In most cases the oxidized part of the copper deposits is very superficial, and sulphides, chalcopyrite, as well as chalcocite and bornite, appear immediately or only a few feet below the surface. A little malachite often appears on the surface, but sulphides are usually immediately associated with it. The large sulphide mass of the Iron Dike was covered by a brown shallow crust in which practically no copper was present. Immediately below this pale and partly decomposed pyrite appeared, and the chalcopyrite began only a few feet below the pyrite.

ECONOMIC CONSIDERATIONS.

Among the copper deposits of this region are a vast number of prospects, but thus far no producing mine. Only two or three prospects have made small shipments of high-grade ore. It is, of course, well known that the development of a low-grade copper mine is an enterprise demanding much time and money, differing in this respect from that of an ordinary gold-quartz mine. In the latter a mill adapted to the requirements of the ore and the size of the vein may be rapidly erected and the mine become producing in a short time. For low-grade copper ores very extensive and very carefully planned reduction works are necessary. Ores consisting of coarse pyrite and chalcopyrite with chlorite-quartz gangue, like the Iron Dike, are easy to concentrate and, provided the ore contains enough copper, will prove valuable. Ores containing chalcopyrite and tourmaline will be difficult to concentrate, owing to the high specific gravity of the latter. The majority of the deposits are zones of impregnation with chalcocite in fine distribution. These have been most widely advertised, and presumably ill-informed companies have issued glowing reports apt to mislead the unwary. Copper lodes 4 miles in length and a mile in width, with inexhaustible supply of 4 per cent ore, have been claimed to exist. The fact that ores in the Lake Superior region containing less than 1 per cent of metallic copper have been successfully worked has been duly placed before the public. As a matter of fact, most of these impregnated zones will not contain more than 1 or 2 per cent of copper, and the width ranges from a narrow seam up to 30 feet. The lowest grade of copper ore which can be considered in eastern Oregon, under present conditions, is one containing 3 to 4 per cent of copper, provided that large quantities of it exist. The successful treatment of this ore offers considerable difficulty. Leaching processes can probably not be employed, for the ore contains too much easily dissolved silicates of magnesia, lime, and iron. Concentrating will be difficult and attended with great loss, for fine crushing will be necessary and the chalcocite will form rich slimes. Should large bodies of ore containing metallic copper be found, these difficulties will be largely obviated, but at present there is no great probability of this. These remarks are not meant to discourage the search for and the development of the copper properties, but only to point out actual facts. Paying copper mines may well be developed in eastern Oregon, but it will be only by careful conservative work by men who understand the problems presented.

PLACER DEPOSITS.

EXTENT.

The placer deposits indicate the extent of the gold belt of eastern Oregon, being widely scattered over the whole area, from the sands of the Snake River on the east to the gravel bars of John Day River on the west. They were the first deposits discovered by the pioneer miners and yielded their millions in early days. Though the output is greatly diminished, the placers are at the present time by no means an unimportant factor in the gold-mining industry of the State. Oregon produces placer bullion to the value of about $300,000 annually; the amount is, however, slowly diminishing. The placers contribute about one-fourth to one-fifth of the total production of gold and silver (see p. 572).

The placer-mining districts are distributed as follows: On the east the Snake River bars still contribute some fine gold. In the Eagle Creek Mountains and at Sparta a small but steady production is maintained. Sparta, especially, was noted for its rich gulch diggings in early times. The belt extending from Connor Creek by Weatherby, Chicken Creek, Rye Valley, Humbolt, Clarks Creek, and Malheur was formerly the most important gold-mining region in the State and still maintains a diminishing production.

The Virtue placers, near Baker City, were long ago exhausted. West of Baker City is the gold belt of the southern Elkhorn Range, with the once celebrated camps of Auburn, Pocahontas, and Minersville. The headwaters of Powder and Burnt rivers, as well as those of Granite Creek, including the districts of Sumpter, Granite, Robinsonville, Bonanza, and Gimlet, may be said to form the central placer-mining region of the Blue Mountains. These placers, while not as extraordinarily rich as some of the others, have maintained a steady though small production, and seem likely to continue to do so for many years. Finally, on the western side are found the isolated districts of Susanville, Dixie Creek, and Canyon Creek, the latter having the reputation of having been the richest placer camp in the State. Both at Susanville and at Canyon a fairly steady production is maintained. Farthest west are the small placers of Fox Creek and Spanish Gulch, on Crooked River, the latter locality 60 miles west-southwest of Canyon.

GEOLOGICAL CHARACTER.

With few exceptions the placers are gravel deposits contained in the beds of the present streams and gulches, or bars and benches deposited by the same water courses at a former higher level; these benches are rarely found more than 200 feet above the present stream bed; most frequently they are 50 to 100 feet above the same. The depth of the gravels seldom exceeds 50 feet and is ordinarily much less. The bed rock may be any one of the formations found in the region, sometimes even Neocene volcanic rocks. The placers are thus not connected with any certain rock; it may be said, however, that they are most abundant in the districts where intrusive diorites, granites, and serpentines break through older sedimentary series. They are, as a rule, absent in the large granitic areas (northern Elkhorn Range) and in extensive areas of old sedimentary rocks. They are also absent in the great Neocene volcanic areas. In mountains which have been covered by glaciers during the ice epoch placers are rarely found. Examples of this are found in the Cornucopia, Cable Cove, and Greenhorn districts. No doubt gold-bearing gravels existed there before the advance of the ice streams, but the latter have dislodged the gravels and scattered the gold among the moraines, and the time since the close of the Glacial epoch has been too short to permit a new concentration of the gold. As a rule, in these districts placers are found below the terminal moraines.

All this means that the placers were chiefly deposited by the present streams at their actual level or at a former higher level. Placers antedating the present drainage system are of rare occurrence. This is not surprising when we consider that the drainage systems of the old mountain areas had been outlined and eroded long before the Neocene period.

According to their geological age the placers may be divided into:

1. *Prevolcanic* (*Eocene or early Miocene*) *gravels*.—Deposits of this age are preserved only when covered by volcanic flows. Owing to the fact that these flows mainly covered the foothills and the lower part of the mountains, and no uplift accompanied by deep erosion has occurred since, these channels mostly lie below the present drainage level. While many of them doubtless are rich in gold, it will be difficult to find them and still more difficult to work them profitably. The only places where these gravels have been worked are at Winterville and Parkerville, on the headwaters of Burnt River. It does not seem altogether impossible that new channels of this character might be found in this vicinity. The great influx of water into inclines and shafts would greatly increase the cost of working. Working placers by means of shafts has been successful only in very rich placer mines. The banks of these pre-Neocene gravels are only about

15 feet high. Most of the gold is coarse and lies on the bed rock. The Winterville pre-Neocene channel was a smaller stream of no great importance. It is sometimes stated that it was part of a large channel which traversed the Blue Mountains. There is no foundation for this view.

2. *Intervolcanic gravels.*—The volcanic outbreaks flooded the lower valleys with lavas. The upper valleys of Burnt River, Powder River, John Day, and probably also Grande Ronde River were thus dammed and accumulations of gravel at once began. These conditions were also favorable for the concentration of the gold, and placers were formed wherever streams from auriferous areas entered the basins. Of this age are the gravel benches of Sumpter and Canyon. In the case of these, the erosion of the main rivers draining the basins has not proceeded far enough to destroy the connection of the Neocene sediments. But in other cases, in the Granite Creek and North Fork of John Day, the volcanic dam has been cut down much deeper, and of the deposits once filling the basin only small fragments are preserved, as in the case of the Klopp placers (p. 687) and the Griffith gravels (p. 688).

As the canyon cutting proceeded, benches were formed at intervals, and some of these gravels remain at various elevations along the present streams. There does not seem to be any exact limit between the late Neocene and Pleistocene gravels. A gradual erosion was continued during the two periods, interrupted occasionally only.

3. *Pleistocene gravels* thus consist of the lowest benches and the deposits in the present channels. These deposits were the first to be mined and are now practically exhausted, as far as ordinary placer mining is concerned. Some of the deep stream gravels can, however, be profitably dredged.

GOLD AND ACCOMPANYING MINERALS.

The gold varies in size from large slugs and nuggets to the finest flour, of which several thousand particles or "colors" are needed to make 1 cent in value. The largest nugget reported is one said to have been found on McNamee Gulch, near Robinsonville, the value of which is said to have been $14,000. Slugs of a value of several hundred dollars have been found at Mormon Basin and at the Winterville placers (upper Burnt River). Pieces worth $200 and $300 were found at the latter place in the clean-up of the fall of 1900. Ordinarily gold is obtained varying in size from that of a mustard grain to a wheat grain. The purity of the placer gold averages, as usual, higher than that from the veins. A fineness of 900 to 990 is obtained from Canyon Creek, the bench gravels of upper Burnt River, and the Winterville placers. At Susanville and Dixie Creek the gold is 860 fine. At Rye Valley and Mormon Basin the gold varies from 650 to 800. At the Nelson placers it is from 700 to 740 fine. On Olive Creek and at Granite it varies from 680 to 800. The lowest grade is thus about 680, while from a few localities 990 or almost absolutely pure gold is obtained. In a general way, the fineness of gold from one and the same source is apt to increase as the grains grow smaller by attrition, and this has not unreasonably been explained by a gradual dissolving of the silver from the surface of the grains by ordinary surface waters. The flour gold in the bench gravels of upper Burnt River Valley has a fineness of 970, while the coarser gold in the stream bed is only 922 fine. At Canyon the placer gold is 900 fine, but in John Day River, a few miles below the mouth of Canyon Creek, it reaches 990. At Rye Valley the upper benches contain low-grade gold, 750 fine, while the lower benches, the gold of which has been worked over by the stream several times, is 800 fine. Regarding the Snake River gold see pages 759–761.

Platinum should naturally be expected from some placers, especially those in districts with much serpentine, as a connection between this rock and the metal mentioned has often been proved. It has, however, only been reported from one place, viz, Hindman's placers, at the junction of Camp Creek and Pine Creek in upper Burnt River Valley. Mr. Hindman states that a small quantity is found at each clean-up. Magnetite, zircon, ilmenite, and garnet, as usual, accompany the placer gold, the ilmenite often in very perfect, minute crystals. Much cinnabar is reported from Elk Creek, near Susanville. Monazite has not been observed, neither has cassiterite or tin ore been found.

As usual, the gold is largely concentrated on the bed rock, or in the gravels immediately above it, though instances are not wanting of even distribution through 10 or 20 feet of gravels (Nelson placers at Pocahontas). In dredging on Burnt River the top gravel is usually barren and the pay is only obtained from 2 or 3 feet next the bed rock.

The value per cubic yard of gravels in the gravel mines varies greatly. Ordinarily, averaging the content of the whole bank, it ranges from 10 to 35 cents. The stratum on the bed rock is of course much richer. Hydraulic mines working on a large scale may work gravels profitably which average only 2 cents per cubic yard, but such conditions scarcely obtain in this region, where the gravels should at least contain 5 cents per cubic yard. Dredging to a depth of 30 feet may be done for from 3 to 7 cents per cubic yard, but considering the heavy cost of installation and the possibility of losing the pay streaks, gravels for this purpose should ordinarily average 20 to 30 cents per cubic yard. Regarding dredging on Snake River and Burnt River see pages 762 and 766–767.

METHODS OF MINING AND FUTURE POSSIBILITIES.

Placer mining in eastern Oregon has never been carried on upon the large scale prevalent in the California gold belt. The banks are not high, and sluicing or small hydraulic jets throwing at most 500 miner's inches of water have been chiefly employed. The bench gravels of Sumpter, Rye Valley, upper Burnt River Valley, and Canyon are not exhausted, but will continue to yield moderately for many years. No great increase in the yield may be expected from these sources. It is otherwise with mining by elevators or dredges. At present there is only one dredger at work, at Weatherby, on Burnt River, and one elevator, at Malheur. Gravels, which probably are suitable for dredging are found on John Day River below Canyon, on the Middle Fork of John Day, near Susanville, and at many other places. It is in this direction that the placer-mining industry should be expected to advance, and it is very reasonable to expect that the next few years will see many dredgers in operation.

IRON AND MANGANESE ORES.

Incidental to the erection of the smelter at Sumpter, attempts were made to find a suitable flux of iron or manganese in the vicinity. A deposit of hematite is said to occur on the ridge between Powder and Burnt rivers, about 5 miles south of Sumpter, but nothing is known of its extent.

A soft, black manganese ore, resembling pyrolusite, was found on the same ridge about 4 miles west to southwest of Sumpter, and was used in the smelter during the short time in which it was operated. As far as known no other deposits of iron ore occur in this region.

A large deposit of magnetic iron ore is reported from Iron Mountain, a few miles east of Mineral, in Idaho. This ore contains some copper and is also stated to carry a certain percentage of titanium, which, of course, is not in its favor as far as smelting purposes are concerned. During the short time in which the smelter at Cuprum was in operation some of this ore was sent down the Snake River and hauled up to the smelter. As might have been expected, the material was not a success as a flux.

CHROMITE.

It would be surprising if chromite, so often accompanying serpentine, had not been found in the parts of the Blue Mountains where this rock is abundant. A small mass of chromite is exposed in the serpentine close by Gillespie's sawmill, 7 miles south of Prairie. Associated with it is a small quantity of very fine-grained white material which proves to be practically pure magnesite. Heavy float of chromite was noticed close by the placer mines of Winterville, near Bonanza mine.

The mineral is used in the preparation of pigments and in the production of chrome steel. Recently it has also been used as a basic lining in the furnaces of certain metallurgical processes. It is not probable that the occurrences in the Blue Mountains will be economically valuable. Delivered in Baltimore, the value of the ore is only from $20 to $25 per ton, and at the mines in California the value is not more than $8 per ton for 50 per cent ore.

LIMESTONE.

All of the sedimentary rocks developed in the Blue Mountains contain more or less limestone of good quality, interbedded with slates, shales, siliceous argillite, and volcanic tuffs. Very large masses are found in the Eagle Creek Mountains. Its quality is excellent, but distance from lines of communication has prevented its utilization.

The series of rocks exposed near Huntington also contains many beds of limestone of good quality. One of the largest of these masses, several hundred feet wide, is exposed 4 miles above Huntington on both sides of the railroad. At this point are extensive works which supply the larger part of the lime used in the State of Oregon. Other heavy strata of limestone are exposed at the head of Connor Creek and on the hills 4 miles southwest of Durkee.

The argillite series, so greatly developed in the vicinity of Baker City and Sumpter, is less rich in limestone. Smaller lenticular deposits occur about a mile north of the railroad at a point 6 miles southeast of Baker City, and also in the hills 3 miles northeast of Pleasant Valley. At both localities lime has been burned, but only the latter is worked at present. The Elkhorn Range contains a few heavy deposits of limestone of thick lenticular form. The most important of these is exposed on Marble Creek at an elevation of 5,500 feet. Lime was formerly burned there, but at present the works are idle. At Sumpter and west of that place limestone is not abundant. A deposit of apparently limited extent is found half a mile north of the city of Sumpter and has locally been used for smelting purposes. At the Winterville placer mines, a short distance below Bonanza mine, another small mass of limestone appears adjacent to serpentine. No work has been done on this. From this point westward no limestone deposits are known to exist in the area under consideration.

GYPSUM.

Beds of gypsum, or hydrous sulphate of calcium, are not uncommon in sedimentary beds, usually occurring as strata or lenses associated with limestone and shales. It is generally regarded as a chemical deposit resulting from the evaporation of shallow inland lakes. In the area here described one deposit of this mineral has been found which is of sufficient extent to be commercially valuable. This occurs about 6 miles north of Huntington, near the summit of the ridge overlying Snake River Canyon. The deposit attains a total thickness of over 40 feet, and is interbedded with limestone, shales, and volcanic tuffs. Its age is uncertain, though it is not unlikely that it is Triassic.

This is, I believe, the only deposit of gypsum thus far found in Oregon. It is utilized for purposes of fertilizing and for the preparation of plaster of paris. A more detailed description will be found on page 753.

CLAY AND KAOLIN.

Beds of clay suitable for bricks occur in the valley of Powder River and at many other places in the Blue Mountains.

Pure kaolin has been found near the mouth of several of the creeks at the foot of the Elkhorn Range; for instance, on Pine Creek and on Salmon Creek. The deposits, which are from 1 foot to 15 feet deep, cover the gravels of the creek and have the appearance of an extremely fine, almost impalpable white powder, at first glance suggesting an infusorial earth or a rhyolite tuff. Similar kaolin beds were noted in other parts of the region, though not so prominently developed. The origin of this kaolin, which has not been investigated in detail, probably dates from a time when the Powder River Valley was covered by a shallow sheet of water. It is not impossible that this kaolin may be found of some economic importance, if it can be obtained in large quantities sufficiently free from impurities. The mineral is of the nonplastic variety.

COAL.

In the lake beds occurring in many parts of the Blue Mountains thin strata of lignite are occasionally found interbedded with the clays, sands, and tuffs. A long-known occurrence of this kind is at Auburn, near the southern end of the Elkhorn Range. The soft beds underlying the auriferous gravels here contain a thin bed of lignite of poor quality, an analysis of which is given in Raymond's report of 1873. It was made by T. M. Drown, of Philadelphia, and runs as follows: Moisture, 14.68 per cent; volatile matter, 38.95 per cent; fixed carbon, 42.57 per cent; ash, 3.80 per cent; total, 100. The coal is noncoking, and, as the analysis shows, of inferior quality. It is not likely that it will be of economic importance. Another bed of shaly lignite, about 2 feet thick, is found on the southern side of Powder River opposite the mouth of Goose Creek. It is interbedded with tuffs and clays and covered by a basaltic flow. The quality appears inferior and the deposit is probably of limited extent.

Coaly material is also found in the lake beds at the eastern end of Eagle Valley, as well as in lake deposits in the John Day Valley, not far from Prairie.

MINERAL SPRINGS.

Mineral springs occur widely scattered over the area described, but they can not be said to be very abundant. The best-known locality is at Medical Springs, 20 miles north-northeast of Baker City. At this place thermal springs issue from two orifices in a rock belonging to the greenstone series. The aggregate flow amounts to several miner's inches and the temperature is 140° F. The appended analysis is said to show the composition of the waters, which are locally used for medicinal purposes:

Analysis of mineral water from Medical Springs, Oreg.

[Parts per 100,000.]

Constituent.	Parts.
$CaCl_2$	5.552
$MgCl_2$	.466
KCl	.642
NaCl	5.758
Na_2SO_3	.524
Na_2SO_4	50.638
Na_2CO_3	.579
$FeSO_4$	.558
$CaSO_4$	12.175
$CaCO_3$	1.417
SiO_2	9.698
Organic	1.553
Total	89.520

The Virtue mine, in its lower levels, contained a great amount of water of moderately warm temperature. The mine being, unfortunately, closed, no data could be obtained as to the composition of these waters. From the foothills just east of Baker City, near the small stamp mill erected in the outskirts of the city, springs with tepid water are said to issue. Along Snake River a remarkable spring is said to occur at Tartar's ranch, about 8 miles above the mouth of Powder River, where it has formed a considerable deposit of soda.

Hot sulphur springs also exist in the Snake River Canyon on the Idaho side, a mile above Brownlee Creek, and again on the same side a little below Miller Bay.

At the point where the road from Durkee to Rye Valley crosses Burnt River two hot springs issue in the bed of the river just above the water level. The quantity of water is not large, and the water is only moderately warm. It does not seem to be rich in mineral constituents. Just above the bridge calcareous sinter appears and covers an area of several acres. No doubt this has been deposited by now extinct hot springs. The region of upper Burnt River and upper Powder River seems to contain very few waters which might be classed as mineral. In John Day Valley noted springs of hot water issue 9 miles above Prairie, near the mouth of Reynolds Creek, and are locally used for medicinal purposes. Still another hot sulphur spring is reported from Camp Creek about 6 miles south of Susanville.

On the whole the thermal waters of this region may be characterized as weak mineral waters containing a small amount of salts, together with a little hydrogen sulphide.

MINERALS.

Following is a list of minerals occurring in the Blue Mountains, arranged by mining districts:

List of minerals occurring in the gold belt of the Blue Mountains.

	Elkhorn.	Pocahontas.	Sumpter.	Cable Cove.	Granite.	Alamo.	Greenhorn.	Robinsonville.	Bonanza and upper Burnt River.	Susanville.	Quartzburg.	Canyon.	Virtue.	Copper Butte.	Sparta.	Cornucopia.	Lower Snake River.	Connor Creek.	Mineral.	Lower Burnt River.	Rye Valley.	Mormon Basin, Malheur.
Gold	×	×	×	×	×	×	×	×	×	×	×	×	×	...	×	×	...	×	...	×	×	×
Silver	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...
Platinum	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...
Copper	...	...	×	...	×	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...
Quicksilver	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pyrite	×	×	×	×	×	×	×	×	×	×	×	×	×	...	×	×	×	×	×	×	...	...
Marcasite	...	...	×	...	×	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...
Pyrrhotite	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...
Galena	×	...	...	×	...	...	×	×	...	×	×	...	...	...	×	×	...	×	×	...	...	...
Zinc blende	×	...	×	×	...	...	×	...	...	×	×	...	...	...	×	×	...	...	×	×	...	...
Stibnite	...	...	×	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...
Cinnabar	...	...	×	...	×	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...
Argentite	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	×	...
Chalcocite	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	×	...	...	...	...	...
Chalcopyrite	×	...	×	×	...	...	×	×	...	×	...	...	...	...	×	×	×	×	×	...	...	...
Bornite	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	×	...	...	...	...	...
Arsenopyrite	×	...	×	×	×	...	×	...	×	×	...	...	...	...	×	×	...	...	×	...	...	...
Tetrahedrite	...	...	...	×	...	...	×	...	...	×	...	...	×	...	...	...	...	...	×	...	...	...
Tetrahedrite mercurial (schwatzite)	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Freibergite	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pyrargyrite	×	...	×	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...
Hessite	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Sylvanite	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...
Quartz	×	×	×	×	×	×	×	×	×	×	×	×	×	...	×	×	×	×	×	×	×	×
Zircon	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...
Opal	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...
Chalcedony	...	...	×	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Chromite	...	...	...	...	...	...	...	...	×	...	...	×	...	...	...	...	...	...	...	...	...	...
Cuprite	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...

List of minerals occurring in the gold belt of the Blue Mountains—Continued.

	Elkhorn.	Pocahontas.	Sumpter.	Cable Cove.	Granite.	Alamo.	Greenhorn.	Robinsonville.	Bonanza and upper Burnt River.	Susanville.	Quartzburg.	Canyon.	Virtue.	Copper Butte.	Sparta.	Cornucopia.	Lower Snake River.	Connor Creek.	Mineral.	Lower Burnt River.	Rye Valley.	Mormon Basin, Malheur.
Specularite (hematite)	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...
Magnetite	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...
Ilmenite	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...
Pyrolusite	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Limonite	×	×	×	×	×	×	×	×	×	×	×	×	×	...	×	×	...	...	×	×	...	...
Garnet	...	...	...	...	...	...	...	...	×	...	...	...	...	×	...	...	...	...	...	...	...	...
Vesuvianite	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...
Epidote	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	×	...	...	...	...	...
Tourmaline	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	×	...	...	...
Natrolite	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...
Erionite	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...
Serpentine	...	...	...	...	...	...	×	×	...	×	...	×	...	...	...	...	...	...	...	...	...	...
Fuchsite or mariposite	...	...	×	...	×	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Roscoelite	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Calcite	×	...	×	×	...	...	×	×	...	...	...	×	...	...	...	×	...	×	×	×	...	...
Dolomite	...	...	...	×	...	...	×	×	...	...	...	×	...	...	...	...	...	...	...	...	...	...
Magnesite	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...
Malachite	...	...	...	...	...	...	...	...	...	...	×	...	...	×	...	...	×	...	×	...	...	...
Calciovolborthite	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...
Scheelite	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...
Gypsum	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	×	...	...
Chalcanthite	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...

NOTES TO THE LIST OF MINERALS.

Roscoelite.—This rare mineral is of considerable interest, as it generally has been found closely associated with native gold in gold-quartz veins. First discovered in several small quartz veins near Coloma, Eldorado County, Cal., it has again been found in Boulder district, Colorado, and lately also in Kalgoorlie, western Australia.[1] The mineral belongs to the group of the potassium micas in which the alumina is partly replaced by vanadium. The analyses disagree somewhat, and a definite formula is not as yet established. The original analysis by Genth gave:

Analysis of roscoelite.

Constituent.	Per cent.	Constituent.	Per cent.
SiO_2	47.69	K_2O	7.59
V_2O_3	20.56	Na_2O	.19
Al_2O_3	14.10	H_2O	4.96
FeO	1.67	Total	98.76
MgO	2.00		

[1] T. A. Rickard: Eng. and Min. Journal, Nov. 17, 1900.

This interesting mineral has been found at several mines in eastern Oregon, always associated with rich ore, and ordinarily much free gold. It occurs abundantly in the recently discovered rich shoot of the Belle of Baker, in the rich shipping ore found some time ago in the Golconda mine, and in a similar rich shipping ore lately discovered in the Columbia mine. The mineral has a dull-greenish color, with a tinge of yellow. It occurs intimately intergrown with quartz in yellowish-green microcrystalline aggregates of tufted fibers, generally so fine that its separation from the quartz is almost impossible. The mineral has high double refraction, but the fibers do not seem to be strongly pleochroic. The gold is frequently intergrown with it or surrounded by it, as shown in Pl. LXX, *D*. An attempt to procure sufficient material for analysis failed on account of the impossibility of separating it from the quartz.

Chromium mica.—The argillites and quartz in many of the mines of the Greenhorn Mountains contain greenish spots which have often been mistaken for copper, but which in reality consist of finely divided chromium mica, fuchsite, or mariposite. The same mineral also occurs at Golconda mine, and the stain is somewhat similar to that of roscoelite, but of a slightly more bluish tinge.

Calciovolborthite.—A mineral allied to this species was found in the Little Baby copper prospect near Gilkeson's ranch, about 25 miles northeast of Baker City. It occurs as bright, citron-yellow scales and aggregates with pearly luster on the black, soft argillite in which the copper prospect occurs. Only a small quantity could be obtained for examination. It is, according to Dr. W. F. Hillebrand, essentially a vanadate of copper, but contains, besides, some sodium, and while corresponding approximately as to its percentage of copper and vanadium with the mineral mentioned, it is probably, in fact, a new species.

Scheelite.—This mineral, recently discovered by Mr. C. King, of Baker City, in the Flagstaff and Cliff mines in the Virtue district, is not altogether unusual in gold-quartz veins. It has been found in such deposits near Grass Valley, Cal., Warren, Idaho, and also in New Zealand.