while the excess of lead flowed off, or was absorbed by the material of the hearth bottom. Evidence of this is found in the fact that the material of the bottom was saturated with lead oxide.

Mr. Pearce also presented specimens of the rare mineral wurtzite, from near Butte City, Montana, and of a gold sand from a tributary of the Snake River, Idaho Territory. The more precise locality of the latter is probably above and near the great waterfall. The gold of this sand is in curious grains which seem made up of lenticular particles, and are not worn.

MEETING OF MARCH 5TH, 1883.

Ore Deposits of Summit District, Rio Grande County, Colorado, By R. C. HILLS.

[WITH TWO PLATES.]

The object of this paper is a description of the phenomenal ore deposits of Summit District, Rio Grande County, Colorado. In what follows I will endeavor to explain that the vein-like masses of auriferous quartz constituting these deposits have resulted from the alteration and mineralization of an eruptive rock by solutions circulating along a contact plane. That subsequent folding and erosion gave rise to the existing series of parallel quartz-bands having much the appearance of true veins. In consideration of the peculiar features presented I shall also offer a few remarks respecting their origin.

Plate I shows the relative position and sinuous course of the outcroppings, and also a section along the dotted line A.B. illustrating the manner of folding and number of plications.

The deposits are confined to the neighborhood of South Mountain, principally to the northern and eastern slopes. The horizon of the metal bearing zone is near the middle of the Tertiary eruptive series of Southern and Western Colorado. Only a few of the rocks of this series bear any relation to the present subject, which may be better understood by a brief description of those exposed in the vicinity of the deposits. They occur in the following order, beginning with the oldest.

Andesite, containing minute crystals of a triclinic feldspar and a decomposition product of hornblende or augite, with some pyrite. The rock is of a dark green to black color, largely due to disseminated magnetite.

Granular rhyolite, in which large twin crystals of sanidine and transparent granules of quartz are a characteristic feature. Biotite is common in the greenish-gray groundmass, and hornblende and apatite are occasionally developed.

Trachyte breccia, composed of several varieties of eruptive rocks, generally much kaolinized, although the individual fragments are plainly discernible. It occurs interposed between the rhyolite just described and the succeeding member of the series. It doubtless originated during the folding, and is not always present in cross section.

Andesitic-trachyte, containing large twin crystals of sanidine and often much biotite in a base composed mostly of plagioclase.

Black rhyolite, with developed crystals of sanidine and biotite in a semivitreous groundmass.

Gray-andesitic-trachyte, containing small sanidine crystals and biotite, This is the most recent rock exposed within the limits of the district.*.

The aggregate thickness of all the rocks above the black andestite does not exceed 300 feet.

Immense pressure acting horizontally has produced six complete folds terminating in a series of undulations in the direction of least resistance, which was northeast and southwest. Subsequently, similar pressure, operating northwest and southeast, produced a vertical flexing of the strata, indicated by the sinuous course of the outcroppings. The folds and undulations extend over a surface of country two miles long by one mile wide, the longest distance being in the direction of greatest resistance. The lower or synclinal portion of several of the folds and undulations has been exposed by erosion. In the Treloar and Columbia fold a remnant of the quartz forming a part of the original apex is still in place, as shown by the broad out crop on the Golden Queen claim. (See plate 1). With [this exception all the apices of the folds have been removed.

The Bobtail and Major folds are exposed in a natural cross section; several sections are also afforded by the tun-

*I am indebted to Mr. Whitman Cross, of the U. S. Geological Survey for a preliminary microscopical examination of nearly all the above described rocks.

nels driven at right angles to the course of the veins, two of which are shown in plate 2.

The metalliferous quartz-bands are conformable with the folded strata along the plane of contact between the granular-rhyolite and the breccia, or with the andesitic trachyte when the breccia is absent. In the Winchester tunnel the quartz seems to have been divided during the folding, and the intervening space filled with fragments of rock that have since been consolidated into the existing breccia. This rock occurs also in the tunnel on Golconda No. 2 and in the French tunnel, but does not separate the mineralized matter, as in the Winchester. Owing to the more complicated nature of the fold in the latter I decided to make careful measurements of the rocks passed through. Fig. 1, Plate 2, is a section based upon these measurements, which are as follows: the tunnel mouth being in quartz.

Granular rhyolite, showing quartz granules and kaolinite pseudomorphs; rock much kaolinized and traversed by a small vein of quartz near the center	89	feet
Quartz and kaolinized matter	34	"
Trachyte breccia	12	"
Highly kaolinized matter with a band of quartz, 8 feet wide, near the center	46	"
Andesitic trachyte, partially kaolinized	75	"
Quartz	5	"
Trachyte breccia	25	"
Quartz and kaolinized matter	25	"

Then trachyte breccia to the point where the tunnel is closed by fallen rocks.

The silicious material is usually divided from the trachyte or breccia, as the case may be, by a well defined contact line, but merges into the granular rhyolite and has evidently resulted from its alteration. The thickness of the silicified bands varies from three to thirty feet and appears much greater where, during the folding prcoess, two or more layers of the quartz sheet were forced into a contiguous position, as shown at D in Plate 1.

That portion of the quartz corresponding to the groundmass of the rhyolite is usually of compact structure and rarely exhibits any tendency towards crystallization. The transparent quartz granules characteristic of the original rock seem to have resisted the action of the altering solution and can always be detected in the compact matrix.

The large twin crystals of sanidine, so conspicuous in the unaltered rhyolite, have for the most part disappeared, although their former existence is indicated by numberless cavities still retaining the form of the removed feldspar. Porous alteration-pseudomorphs of quartz after carlsbad twins are of occasional occurrence, but there is absolutely no indication of mica, although biotite is always present in the unchanged rock.

The mineralized matter may be separated into three divisions or zones, viz: of sulphides, oxidation, and impoverishment. In the zone of sulphides the quartz is generally of a dark gray color, contains disseminated pyrite and considerable enargite in bunches, or filling feldspar cavities, and forming imperfect pseudomorphs after sanidine. Enargite occurs in this manner even where the pyrites have been entirely removed by oxidation, showing that the former is less readily affected by meteoric agencies than the latter The pyrites are more or less auriferous, but rarely contain silver; the enargite is usually associated with a small amount of both these metals, which, however, do not seem to occur in economic quantities below the oxidized zone. Native sulphur occurs sparingly with the metallic sulphides, and insignificant amounts of sphalerite and galena have also been observed.

The zone of oxidation extends to a depth varying from a few feet up to 50 fathoms. The quartz is colored dark brown by oxide of iron, and the more highly auriferous material is characterized by an abundance of this oxide. The gold is alloyed with a small proportion of silver, about .025; otherwise the latter material rarely occurs, except with isolated bunches of enargite. All the more valuable bonanzas thus far discovered are confined to this zone. In the Little Ida and Little Annie claims, which are both on the same vein, gold is most abundant near the center of the band, usually in a disseminated form, sometimes as innumerable small grains so aggregated as to appear like a thin continuous sheet of metal. Occasionally the grains unite and form flat nuggets, one or more ounces in weight. A large fragment of ore recently taken from the Little Annie contained several such nuggets. The occurrence of this exceedingly rich material is confined to the immediate vicinity of a central channel which has been filled with earthy matter, fragments of rock and oxide of iron.

This channel seems to occupy the plane of contact between two portions of the quartz sheet brought together by the exclusion of the rhyolite in an anticlinal fold. Elsewhere the vein is divided and the ore of much poorer quality. A similar fold is shown in the Major, which is also in bonanza, but not sufficiently developed to afford satisfactory evidence of the mode of occurrence of the gold in depth. In the Morse there is no central channel, and the gold is found disseminated through the mass of vein-stuff.

In the lower level of the Little Ida, at a depth of 250 feet, aggregations of minute grains and crystals of gold occur in cavities with enargite. This ore does not contain more than a trace of silver, but at the same point masses of oxidized ore are found very rich in silver.

In the Aztec mine, along the contact between the quartz-bands at the perpendicular fold shown in plate 2, is a seam of valuable material from a few inches to a foot or more in width. It is composed of earthy silicates of alumina and magnesia with comminuted vein matter and crystals of barite. It contains only traces of oxide of iron, nor is there more than a small amount of this oxide present in the quartz. The value is about equally divided between the gold and silver, the latter being distributed in specks as a sulphide containing some antimony. The gold is in a very finely divided condition, and is usually of a light snuff color when separated from the rock. It is very evenly distributed, and is found not only in the earthy silicates, but even in such portions of the seam as consist almost wholly of barite. In the latter case it is probable that much of the gold has been introduced into fractures or between plates of the mineral; in ore from the Little Annie there is positive evidence that gold has been introduced in this manner. In the case of the Little Ida and Major, contiguity of the quartz bands results from horizontal folding, but is due to vertical folding in the Aztec.

The zone of impoverishment, with two exceptions, embraces the outcroppings of all the quartz masses, and extends downwards to a depth of 50 feet or more. The quartz which is only slightly impregnated with oxide of iron is not sufficiently auriferous to be considered valuable under the circumstances. The exceptions alluded to are the bonanzas discovered on the Little Annie and Major claims. The former, which is located at E, Plate 1, occupies a steep, rocky point terminating a precipitous ridge crossed nearly at right angles by the vein. The ore is remarkably rich, colored reddish-brown by oxide of iron, and often contains barite. The outcrop of ore in the Major occurs under similar circumstances to that in the Little Annie, that is, at the point where the quartz reef crosses the ridge above mentioned. The gold is mostly confined to fractures containing oxide of iron; occasionally as dodecahedral crystals a millimeter in diameter, imbedded in the oxide. So far as I have observed there is no evidence of silicification or deposition of ore along the contact of the black andesite and base of the granular rhyolite; nor along any other contact plane at present exposed.

Turning now to the enclosing rocks, inspection shows that even where they retain their original solidity decomposition of the feldspars is progressing on the surface of the crystals and along the cleavage planes, and indeed, imperfect kaolinization has taken place on an extensive scale. Very thorough decomposition is a marked feature in the immediate vicinity of an ore body; there the feldpars are completely altered to kaolinite. Operating on small quantities in the wet way I seldom obtained traces of either lime or potash, although both are constituents of the enclosing rocks in their normal condition. Biotite, a common ingredient of the andesitic-trachyte and frequently of the granular rhyolite, has invariably suffered alteration, as exhibited in the abundance of white pearly laminae of potash mica.

However, it must not be supposed that complete kaolinization has been confined to the parts adjacent to the bonanzas. On the contrary, it has taken place on a large scale in localities remote from the deposits and where little or no quartz exists. For a distance of three miles from South Mountain southward, the rocks lying between the andesite and black-rhyolite are very thoroughly decomposed. Such is also the case for some distance north-west from the deposits. The black-rhyolite and gray-trachyte are not much altered except where they occur in the synclines between the two bands of andesitic-trachyte; and even then decomposition has not taken place to any considerable degree as compared with other rocks. In the anticlines kaolinization has been most intense in the granular-rhyolite. I have frequently observed small casts that once contained six-sided prisms, probably of apatite, indicating that that mineral, which is an accessory ingredient of the rock, has been removed.

In the Missionary and Golden Star claims are two vertical veins running approximately north and south. They traverse the black-andesite and granular-rhyolite, and connect with the quartz in the latter. There are several small vertical veins in the district, but these are the only ones that appear to have been mineralized, the others being merely filled with kaolin or a little calcite and earthy matter. The metalliferous material exposed in the Missionary tunnel is from five to seven feet wide, but without defining walls; the compact quartz matrix passing insensibly into the andesite, from which, through alteration, it has been produced. The only metallic minerals present are pyrite and enargite with more or less gold and silver, the latter being associated only with enargite. In comparison with other unoxidized Summit District ore it is found to contain a greater abundance of pyrite in proportion to enargite. Otherwise, except in the absence of quartz granules and pseudomorphous minerals, there is no essential difference in mineralogical composition. Here, as elsewhere, the tendency has been to produce only small crystals or none at all; those of enargite which are the largest, never exceed three millimeters in length.

So far as I could ascertain from the limited extent of the exposures, the product of alteration where the veins pass through the rhyolite is similar to the mineralized material in the folds. The andesite is kaolinized to a very limited degree adjacent to the veins; otherwise the only evidence of decomposition is the production of a chloritic substance from horn-blende or augite. This decomposition product is a characteristic of the normal rock, and its presence is independent of any action that has taken place in the veins.

The intimate relation of the above two classes of deposits to the enclosing rock, the analogy in composition and degree of crystallization may be regarded as evidence not only of a common origin, but of contemporaneous minerailzation. Nor do the existing differences readily present any obstacle to this view. The absence of quartz granules, feldspar cavities and pseudomorphous minerals in the vertical veins is consistent with the alteration of a microcrystalline rock like the enclosing andesite.

I will now consider the question, did the folding precede, or did it follow the alteration? If the former, the vertical veins in the Missionary and Golden Star might be expected to pursue a direct course through the folded strata irrespective of cleavage planes, since their tendency to influence direction would be modified by the formation of innumerable cross fractures during the folding. But in no instance has anything in the form of a vein, either of quartz or other material, been observed traversing the rocks occupying the synclines between the altered bands. On the other hand, veins have been discovered traversing the granular-rhyolite and andesite in the anticlines; for instance, in Golconda No. 2, in the Winchester tunnel, and in the upper main tunnel on the Little Ida. Furthermore, while it is easy to conceive that a well defined mineralized band might be formed along a horizontal contact plane under conditions favorable to aqueous circulation, it is difficult to understand how such bands could be formed where the rocks had been previously shattered by disturbances, for in this case the inevitable diffusion of the mineralizing solution would tend to produce the general kaolinization observed in places characterized by the absence of silicious material.

Before dismissing this part of the subject it will be as well to call your attention to a few facts showing not only the shattered condition of the rock, but indicating that while during the earlier stages the folding may have advanced gradually, it culminated suddenly and with considerable violence. Approaching the center of disturbance from the southeast, or in the direction of the axis of horizontal folding, it is found that the gray-trachyte is broken up into large blocks of many tons weight, and that the blocks are much smaller in the vicinity of South Mountain than elsewhere.

On the south side of the mountain is an area of trachyte, several hundred feet across, that has been shattered with such violence as to pile the whole mass into a promiscuous heap. It is not at all likely that it resulted from some earthquake movement subsequent to the folding, as the shattered rock is confined to the area embracing the undulations.

In the Major fold is a portion of the andesitic-trachyte that for some reason has resisted kaolinization; it has been crushed to such an extent that the fragments are seldom large enough to afford ordinary hand specimens. It soon merges into a compact kaolinized mass exhibiting no trace of fracture. Evidence of a similar nature is found in the fold north of the Major. As most of the rocks are more or less decomposed, it is quite probable that large masses originally in a fragmental condition have since been consolidated under moderate pressure aided to a considerable degree by decomposition. There is good reason for supposing that the trachyte-breccia found in the Winchester and elsewhere has been thus consolidated. Nevertheless, even under the present circumstances, it would be impossible for mineral waters to be confined to contact planes, and we are forced to the conclusion that the folding must have followed the silicification.

Allusion has already been made to the fact that thc gray-trachyte is the most recent of the rocks exposed in the vicinity of South Mountain. Along the eastern slope of the range, flanking the San Luis Valley, it underlies eruptive rocks of a higher horizon; but, for the reason that it caps all the more elevated peaks in the district and forms the apex of a broad plateau-like eminence known as Lookout Mountain, it is hardly probable that it has ever been covered by subsequent overflows within the area containing the deposits. This conclusion is important as indicating the depth at which alteration occurred, which does not appear to have exceeded 300 feet and was probably much less. Consequently, although great pressure may have increased the solving power of the mineralizing solution in its course through the underlying rocks, it can hardly be regarded as a factor in the silicification of the granular-rhyolite.

The perfection with which the form of the carlsbad twin is retained, both by the quartz pseudomorphs and numerous cavities present in the quartz, is opposed to the idea that the mass has undergone any considerable contraction since the removal of the bases. Yet it is evident from its compactness that more silica is contained in a given bulk of the groundmass than was originally present in the same bulk of rhyolite base. At the same time, it does not seem reasonable that more than a very limited amount was derived by precipitation from the altering solution; for, if so, we might expect to find the feldspar cavities lined with crystals of quartz as well as enargite, which is never the case except in highly mineralized portions occurring at considerable depth. Even then, the minuteness of the crystals and the evidence of crystalline structure in the mass of the quartz suggest that their formation may be due to a rearrangement of molecules since the silicification. And this conclusion is not materially affected by the possibility of the removal in solution of a portion of the feldspar constituents as simple hydrous silicates; for it will be seen further on that in all probability the silicification was brought about by the removal of the bases only.

I will now endeavor to point out the nature of the altering solution as indicated by what has already been stated. In explaining the cause of the silicification of the rhyolite, the following points must be considered. That little or no silica has been removed, while the alkalies have been extracted. That during alteration the biotite suffered complete decomposition and was, so to speak, entirely obliterated.

It is well known that silica dissolves to a limited extent in solutions containing alkaline carbonates, while under the same circumstances silicate of alumina is not affected, although the compound silicates containing alumina, such as sanidine, will, in presence of carbonic acid, be decomposed with the formation of hydrous silicate of alumina which is slightly soluble. Silica is practically insoluble in solutions of alkaline sulphates and chlorides and in those containing hydrogen sulphide and free sulphuric acid. Under the same conditions silicate of alumina is decomposed, and soluble sulphate or chloride of alumina formed. If the decomposition is effected only by alkaline salts, including those of calcium and magnesium, more or less soluble silicates of these bases will result and be removed contemporaneously with the alkaline silicates already present in the feldspar. This would cause the extraction of a larger proportion of silica than if the decomposition had been effected by carbonates or carbonic acid. But if the decomposition is owing to the action of free sulphuric acid, sulphate of alumina will be formed with separation of silica, and a similar reaction will take place in the case of the alkaline silicates. From this it appears that a solution that will decompose the silicates of alumina and potash, the constituents of the normal orthoclase of which the granular-rhyolite is composed, extract the bases and separate the silica, should contain free sulphuric acid. For if carbonates, carbonic acid and silicates only are present, simple kaolinization will result. If sulphates and chlorides predominate, in the absence of free sulphuric acid, silica will be removed to an extent not reconcilable with the condition of the altered rock. It is possible that sulphuric acid may have been generated through the oxidation of hydrogen sulphide, the former existence of which may be argued from the presence of native sulphur. It is true that separation of sulphur takes place during the oxidation of many metallic sulphides, particularly galena; but contact with the atmosphere or with aérated water likewise separates sulphur from hydrogen sulphide, and by the same means sulphuric acid may also be produced. But the most conclusive evidence that free sulphuric acid existed in the silicifying solution is furnished by the disappearance of the mica. Muscovite is not acted upon by carbonic acid, although under the same circumstances biotite is more or less altered by extraction of a portion of the magnesia. At the same time it is not affected by solutions containing chlorides or sulphates except calcium sulphate. Even in this case decomposition does not proceed beyond the formation of potash-mica, which, unless it is a product of alteration, cannot be further decomposed even by sulphuric acid. It is proven by the experiments of G. Rose and Kobell, as quoted by Bischof, * "that while biaxial-mica resists the action of the strongest acids, uniaxial-mica is completely decomposed by digestion with sulphuric acid."

From this it seems that if carbonic acid determines the decomposition of biotite, potash-mica will result, but if sulphuric acid is the decomposing agent it may be entirely removed, as in the quartz masses of Summit District. If the evidence bearing upon the depth at which alteration occured is of any value, it is quite likely that oxidation of hydrogen-sulphide might take place at a much greater depth. At least there are no good grounds for supposing that any other agent than sulphuric acid determined the silicification. According to Bischof, † "in the Island of Milo, sulphuric acid originating from the oxidation of hydrogen-sulphide has decomposed the masses of feldspar; the greater portion of the silica occurring in a gelatinous state, a smaller part of it as quartz." This he attributes to the more powerful decomposing action of sulphuric acid as compared with carbonic acid. The same writer also states that ‡ "in the Island

*Chemical Geology, Eng. Ed. Vol. 2, Page 371.

†Chemical Geology, Eng. Ed. Vol. 2, Page 127.

‡Chemical Geology, Eng. Ed. Vol. 1, Page 332.

of Lipari there is a lava-bed converted by the waters containing sulphuric acid penetrating it into a compact, coarse-grained and perfectly colorless rock." We may conclude that from a similar alteration originated the silicious masses of Summit District.

In respect to the metallic sulphides it is obvious from their presence in the feldspar cavities that they were deposited there since the alteration of the rock, and possibly under somewhat different circumstances. Yet it is by no means certain but that the sulphides existing in the compact matrix may have been precipitated during the alteration; and for this reason the conditions under which sulphides might be deposited are of some importance. There is a probability of their having existed as sulphates associated with alkaline sulphates, since these salts must have predominated in the solution. Or they might have been precipitated from solution in alkaline sulphides or in sulphuretted hydrogen. The latter seems the most plausible, for we may infer from the abundance and minuteness of the pyrite and enargite crystals that deposition took place very rapidly; consequently, the reduction of sulphates to sulphides would require the presence of organic matter in much larger proportion than is generally found in mineral springs. However, it is hardly possible to arrive at a definite conclusion upon this point owing to the incompleteness of the evidence. At least there is nothing to indicate that the solution from which the sulphides were deposited must necessarily differ in kind from that producing alteration. The same is true of the precious metals; moreover, they occur in such small proportion as compared to the baser ones that it is not likely that they exercised any material influence on the chemical changes then going on.

I found that most of the rocks in the vicinity of Summit District contained a trace of gold, which may be enclosed in pyrite, as this mineral is frequently met with, especially in the black-andesite. It is then possible that the gold in the deposits may have been seggregated from the underlying rock. The silver was probably derived from the same source as the enargite with which it is associated, doubtless that from which nearly all the ores of Southern Colorado have been derived, viz: the older Tertiary eruptives.

I will now call your attention to a second, and, from an economic standpoint, more important class of phenomena the oxidation and impoverishment of the surface ore, and the concentration of the gold in the bonanzas; that is, the enrichment of the lower zone at the expense of an upper one. It is a well known fact that in the majority of cases auriferous veins are more productive at the surface than elsewhere. Some attempt has been made to account for this on the supposition that as oxidation and erosion progress, the gold is carried down into the veins, either in solution or by virtue of its greater specific gravity. I have already called attention to the connection existing between the gold and hydrous oxide of iron in the Summit bonanzas; such connection is by no means rare, as those familiar with auriferous ores can testify. But in Summit District it is much more intimate than I have heretofore observed in the auriferous veins of Western North America. There is no doubt but that pyrite was disseminated originally through the entire mass of quartz and that sulphate of iron, and finally limonite, resulted from the oxidation. The latter mineral, rich in gold, is very abundant along the circulating channel near the center of the Little Ida and Little Annie bonanza. The probable origin of this channel has been previously explained.* We may reasonably suppose that if the Little Ida vein has been formed by the partial consolidation of separate portions of the quartz sheet, as indicated in the sections, there would be more or less kaolinized matter between the bands. Such is really the case, except in the central channel just mentioned, where there has been the greatest deposition of gold and hydrous oxide of iron. Hence, if the latter has resulted from the decomposition of sulphate of iron, formed by the oxidation of pyrite, it is probable that feldspathic matter existed here also and has since been silicified through the removal of the base by the acid of the iron salt. Decomposition was doubtless aided by the comminuted matter conveyed into the channel from above, and which has since been consolidated by cementation with the precipitated oxide of iron and separated silica. In the Little Ida channel, at a depth of 250 feet, the filling is so imperfectly cemented that it crumbles in the hand, and where an occasional space remains unfilled the surrounding surface presents a botryoidal or stalactitic appearance from precipitated iron oxide, which

*Ante, page 24, first line from above.

is of a light brown color and seems to have been quite recently deposited. This material, with the auriferous enargite ore lying adjacent to it, is the richest at that depth, and would no doubt, after sufficient time had elapsed, become as firmly cemented as that near the surface. But, whatever may have determined the decomposition of the ferrous salt, it is certain that the conditions were not wanting and that it actually took place. We may infer from the association of the gold with oxide of iron, and its known behavior with iron salts, that the former was in solution with the latter and that both were precipitated at about the same time. Doubtless in this instance the deposition of oxide of iron may be regarded as analogous to the formation of copper oxide below the gossans in many copper veins. It is well known that gold is slightly soluble in ferrous sulphate, still more so in ferric sulphate, and both salts might be formed during the oxidation of pyrite. It is also soluble in ferric chloride, but it is very doubtful if this compound has been instrumental to any considerable degree in the translocation of gold. Le Conte, in alluding to the formation of nuggets, remarks.* "It is well known that although gold exists in the iron sulphide of the unchanged vein only in minute, even microscopic crystals and threads, yet in the changed upper portions of the vein it exists in quite visible particles and often in large nuggets weighing several ounces." This fact he considers "is additional evidence that sulphate of iron is the natural solvent of gold."

I once saw on the San Miguel River, in Ouray county, several limonite pseudomorphs after pyrite, taken from the placers in that locality, and which were interesting from the fact that each exhibited an irregular shaped grain of gold embedded in the crystal. Since unaltered pyrite is only known to contain gold in very minute particles, I was led to suppose that the original pyrite had been very rich, and that during slow oxidation the gold had been dissolved and reprecipitated in one mass. Limonite pseudo morphs are by no means rare in placers; I have frequently observed them in the California gulches, and it is possible that much of the ordinary detrital gold may have been derived from them.

The veins in the Morse, Major, Aztec, Little Ida and Little Annie are nearly vertical; in the two former there is

* Elements of Geology, Page 239.

no central channel and the gold is disseminated through the entire mass, while in the latter veins the ore, and especially the rich ore, occurs in proximity to a well defined central channel. It is evident then that all these veins lie in the direct line of gravitation of the descending surface water, and where the solution was confined to a channel there has been the greatest concentration of gold, and where the solution has been forced to spread itself through the mass of vein matter the gold is disseminated. In searching for the cause of the concentration of gold in the Summit District bonanzas, if we consider their richness in connection with the barrenness of the outcroppings and the reasonable certainty that during the oxidation of the pyrite a solvent of the gold was generated, the conclusion is natural that to the decomposition of this solvent by silicates in the deeper zone is due the deposition of the gold in its present concentrated form.

I observed in places along the walls of several of the tunnels hydrous oxide of iron being deposited from water flowing in through seams in the rock. It is quite probable that impoverishment of the surface ore has taken place since the complete oxidation of the sulphides, and the same operation may still be going on, as the surface quartz always yields small amounts of gold. It is easy to understand how solution may be brought about in the case of the oxide of iron by the reducing action of organic matter, and it might be of interest in this connection to know to what extent gold may be soluble in organic salts of iron, since their formation under these conditions is not improbable.

The absence of gold bands and nuggets in the central channel of the Aztec becomes intelligible when we consider that only traces of iron occur with the barite and white earthy silicates with which the channel is filled. Nevertheless, these latter compounds must be regarded as of secondary formation, for in no instance have they been observed below the oxidized zone. For this reason the absence of oxide of iron is not easily explained, especially when we consider that the quartz has the same aspect as that elsewhere, and that the vein on the adjoining claim, the Golden Vault, contains considerable oxide of iron.

It can be seen from the diagram of the Aztec fold that the ore body differs from all others in the district, not only in the small quantity of iron present, but from the fact that it is enclosed on all sides by the granular-rhyolite. During the process of silicification, if, as I maintain, it antedated the folding, the resulting sulphates would be largley absorbed by the subjacent rock. If, after the folding occurred, these sulphates were not entirely decomposed by silicates, they would be leached into the central channel of the vein by percolating water. At the same time oxidation of pyrite would add sulphate of iron containing gold to the solution. The presence of alkaline sulphates would tend to prevent the decomposition of the iron salt and consequently any considerable precipitation of gold, while the precipitation or decomposition of sulphates might cause the precipitation of a small quantity of gold, since it is known to be slightly soluble in most salts. Doubtless a larger proportion of sulphates was leached into the Aztec channel than into any other ore body in the district, for the simple reason that the rock originally underlying the altered quartz sheet forms both walls. In this manner the large proportion of silicates and barite and small proportion of oxide of iron present may be accounted for. But it does not explain the concentration of silver, nor does it seem possible until greater depth is obtained and other facts brought to light to speculate with any degree of probability on the formation of this peculiar ore-body.

There is no doubt but the concentration of silver in the Little Annie, Morse and Major veins has taken place at a greater depth than that of the gold, as indicated by the masses of oxidized ore rich in silver recently encountered in the lowest workings on the Little Ida. Unfortunately I am ignorant of the exact condition in which it exists, and for this reason can offer no remarks respecting it.

In the two exceptions previously alluded to, where impoverishment has not taken place, or only to a limited degree, the extreme hardness of the quartz outcrop as compared with the surrounding kaolinized material has resisted erosion to such an extent as to form a precipitous ridge, on either side of which the snow accumulates to a considerable depth, much more on one side than on the other, the ridge itself being kept free by the prevailing wind during the winter. As a consequence there is less surface water circulating here than at any other point in the district where ore-bodies are known to occur. This condition has doubtless prevailed for a long period of time and may have had much to do with the unequal impoverishment of the outcroppings.

The foregoing statements and conclusions point to the following as the sequence of changes culminating in the existing series of deposits:

First, silicification of the granular-rhyolite by a solution containing free sulphuric acid and the deposition of the metallic sulphides with gold and silver.

Second, folding of the strata.

Third, oxidation and impoverishment of the surface ore and concentration of the precious metals in the bonanzas. The last is evidently the most important, since otherwise the ore would be comparatively worthless.

The question naturally arises, to what depth do the folds extend that contain the ore-bodies? This might be susceptible of an answer if the folds were uniform, which they are not. Nor is it likely that a knowledge of their depth would prove of economic importance, since in all probability the bonanzas will not extend below the line of oxidation. For fear the last remark should create a false impression as to the value of the deposits, it may be as well to add that the magnitude of the reserves does not justify any immediate apprehensions on the part of the companies operating there.

In the preceding remarks on the genesis of these deposits it may appear that some of the conclusions are based upon insufficient evidence, but the anomalous features presented certainly demand something more than a mere statement of observed facts. For this reason I have ventured to put forward my own views in this particular case, and although they may be only approximately correct, they are such as seem to me the most plausible under the circumstances.

Mr. Cross gave the result of a microscopical examination of the gold sand from Snake River, Idaho Territory, presented by Mr. Pearce at the previous meeting.

The minerals determined in a portion of this sand mounted in balsam were:

1. *Garnet.* Very abundant, usually pinkish in color, sometimes reddish brown, and rarely almost colorless. Grains seldom show crystal form, are quite free from inter-