CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
1520 West Adams St.
Phoenix, AZ 85007
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

The following file is part of the

Arizona Department of Mines and Mineral Resources Mining Collection

ACCESS STATEMENT

These digitized collections are accessible for purposes of education and research. We have indicated what we know about copyright and rights of privacy, publicity, or trademark. Due to the nature of archival collections, we are not always able to identify this information. We are eager to hear from any rights owners, so that we may obtain accurate information. Upon request, we will remove material from public view while we address a rights issue.

CONSTRAINTS STATEMENT

The Arizona Geological Survey does not claim to control all rights for all materials in its collection. These rights include, but are not limited to: copyright, privacy rights, and cultural protection rights. The User hereby assumes all responsibility for obtaining any rights to use the material in excess of "fair use."

The Survey makes no intellectual property claims to the products created by individual authors in the manuscript collections, except when the author deeded those rights to the Survey or when those authors were employed by the State of Arizona and created intellectual products as a function of their official duties. The Survey does maintain property rights to the physical and digital representations of the works.

QUALITY STATEMENT

The Arizona Geological Survey is not responsible for the accuracy of the records, information, or opinions that may be contained in the files. The Survey collects, catalogs, and archives data on mineral properties regardless of its views of the veracity or accuracy of those data.

PRINTED: 08/29/2001

ARIZONA DEPARTMENT OF MINES AND MINERAL RESOURCES AZMILS DATA

3 of 3

PRIMARY NAME: HILLTOP MINE

ALTERNATE NAMES:
HAND

COCHISE COUNTY MILS NUMBER: 11

LOCATION: TOWNSHIP 16 S RANGE 30 E SECTION 32 QUARTER SE
LATITUDE: N 31DEG 59MIN 07SEC LONGITUDE: W 109DEG 17MIN 21SEC
TOPO MAP NAME: RUSTLER PARK - 7.5 MIN

CURRENT STATUS: PAST PRODUCER

COMMODITY:
LEAD
ZINC SULFIDE
SILVER
COPPER OXIDE
GOLD LODE
MOLYBDENUM
CADMIUM DELETERIOUS?
TUNGSTEN

BIBLIOGRAPHY:
KEITH, S.B., 1973, AZBM BULL. 187, P. 52
ADMMR HILLTOP MINE FILE
BRITTAIN, R. L, U OF A THESIS, 1954
USGS BULL 1385-A, 1973
THE MINES HANDBOOK, 1918, P 381
PAPKE, K.G., U OF A THESIS, 1952
USBM 1940 MINERALS YEARBOOK
USGS MAP I-1312, 1982

USBM MLA 12-93.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES
MAKES NO REPRESENTATIONS AS TO THE ACCURACY
OF THE CONTENTS OF THESE DOCUMENTS.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES
MAKES NO REPRESENTATION AS TO THE ACCURACY
OF THE CONTENTS OF THESE DOCUMENTS.

C O P Y

GEOLOGICAL REPORT ON THE HILLTOP DISTRICT

Cochise County
Arizona

By
Charles B. Berkey

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES
MAKES NO REPRESENTATIONS AS TO THE ACCURACY
OF THE CONTENTS OF THESE DOCUMENTS.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES
MAKES NO REPRESENTATION AS TO THE ACCURACY
OF THE CONTENTS OF THESE DOCUMENTS.

C O P Y

GEOLOGICAL REPORT ON THE HILLTOP DISTRICT

Cochise County
Arizona

By
Charles B. Berkey

ARIZONA DEPARTMENT OF MINERAL RESO
MAKES NO REPRESENTATION AS TO THE ACCU
OF THE CONTENTS OF THESE DOCUMENTS.

C O P Y

Report on the Geology of the Hillton and Hillton Extension Mining Properties in The Chiricahue Mountains, Arizona

Part 1. General Statement

Object and Range of Studies

The purpose of the range of studies included in this report has been to determine the geological facts represented by this ground and its immediate surroundings, to arrive at an understanding of the geological conditions, and to formulate a practical statement covering the nature and origin and expectable behavior of the ore deposits. All of these items fall into the scheme of a general geological report, the explanations and conclusions of which apply with equal force to both properties. Certain special problems of development and treatment, however, are more limited in their application. Of these points a statement applicable to one part of the ground or to one property may not fit another part at all, and therefore these special problems will be treated in separate memoranda or supplimentary reports as indicated in the introduction.

1. General Statement

a. Location

The Hilltop and Hilltop Extension properties are located in the Chiricahua Mountains in the extreme eastern margin of Cochise County, the last county in the extreme southeastern corner of Arizona. The nearest railroad station is Rodeo, New Mexico, on the El Paso and Southwestern Railway at a distance of about 22 miles by wagon road.

The properties lie along the major mountain ridge which extends in a general N.W. and S.E. direction between Jhus Canyon and Hands Pass, just south of the line between the San Simon Quadrangle on the north and the Chiricahua Quadrangle. The ground thus lies wholly within the Chiricahua toppgraphic sheet of the U.S. Geological Survey near its northern margin at one of the narrowest parts of the Chiricahua Mountain Range.

The top of this mountain range lies considerably above 7000 feet and the property lines on either side in places reach down to about the 6000 foot line. Rodeo, which has a elevation of about 4100 feet, thus lies almost 2000 feet lower than the Hilltop plant. The outlet by wagon road is on an easy and practically continuous grade, a fact of much importance in the further development of the ground to a producting stage.

b. Extent of the Properties

The Hilltop ground includes 35 mining claims, most of which are of standard size. The maximum length of this property lies along the ridge more than seven claims long or about 10,500 feet actual measure in a straight line from end to end - approximately 2 miles. The maximum width is in the central portion where 9 claims cover a width of 5750 feet, or a little more than a mile. At the two ends, however, this property is much narrower, 1375 feet at the extreme northwest and not more than 500 feet at the extreme southeast. The total area

therefore is somewhat more than a square mile but it is stretched out irregularly along a stretch of two miles over and along an exceedingly rugged mountain ridge.

The Hilltop Extension ground lies in two widely separated tracts, one at either end of the Hilltop ground and lapping partly around these ends. The number of claims involved is 36, of which 19 lie along and at the northwest end of the Hilltop ground and 17 at the south end. These claims are more irregularly placed than are the Hilltop claims but together with them the total length of territory covered amounts to 17,250 feet, or nearly 3 1/4 miles. At the same time the claims are located in such a manner as to make the average width more than half a mile.

The total area of both properties is thus considerably more than 2 square miles.

c. Preliminary Condensed Summary

The general geological features of these two properties are practically identical. On this account the whole area covered by the two holdings together with some additional adjacent ground is treated as a single geological problem.

The Chiricahua Mountains represent a partially eroded series of Fault blocks, tilted and crowded against each other, cut by a considerable variety of igneous intrusions, which in places are covered by later lava flows and volcanic tuffs, the whole complex mass standing considerably higher than the surrounding country. The surrounding country, which formerly must have been much lower than it is now, has been filled in by the wash from this and other neighboring masses, - All of the waste from the mountains being deposited in the intervening valleys or basins until these places have become broad and comparatively flat lowlands, above which the Chiricahua mountains stand as a comparatively isolated group representing a series of tilted and injected fault blocks.

The Hilltop properties lie on one ththese series of fault blocks constituting the Chiricahua group. None of the ground of either properties reaches beyond the limits of this single fault block.

The particular block, which might well be called "the Hilltop Block", is made up chiefly of sedimentary rocks formations including quartzites, marble, limestones, sandstones and shales, in a great continuous series which from bottom to top measured at least 10,000 feet of total thickness. These sedimentary beds are cut by numerous intrusives in the form of dikes and larger masses, most or all of which probably are simply the upward or outward extreme reach of off shoots from a still larger bathylithic igneous mass lying beneath the whole district.

Much of the sedimentary rock, especially the shaly limestones, have been metamorphosed by these igneous invasions with the development of great quantities of silicified and silicated rock; but in most cases the original nature of the rock is fairly well preserved in spite of these changes.

This whole series of rocks was badly tilted at the time that the region brock up into blocks, and in subsequent crowding the east side of the block was jammed over to such amount that the beds now stand overturned along this margin. In the middle of the block the beds stand in places almost vertical,

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENT OF THESE DOCUMENTS.

and along this portion the Hilltop Quartzite forms the crest of the ridge for some distance. On the west side of the ridge the beds all dip [illegible] gently to the west or southwest and the dip of them becomes comparatively [illegible] along the extreme westerly edge of the block where the overlying andesitic lavas cover them. Thus the Hilltop block is essentially a mass of bedded rock 3 or [illegible] miles long and close to 2 miles wide which has not only been tilted but has had the edges of its beds overturned and much crowded from one side until they now stand in the form of an unsymmetrical trough.

The crowding of the block resulted in a great deal of small thrust faulting and overriding of competent or hard beds over other weaker ones, to such extent that in some places the succession of strata is very much disturbed. In exceptional places some slipping or small faulting is encountered every few feet and it becomes particularly difficult to follow any but the most massive or most competent beds. The igneous intrusions doubtless added to this disturbance and confusion but the regional crowding seems to have been more disturbing than the igneous invasions in this particular ground represented by the Hilltop block. Toward the end of the series of disturbances small cross faulting developed along the whole ridge, and the breaks of this stage seem to be of particular importance in connection with the ore deposits and in mining operations.

The ore deposits lie in these sedimentary rocks, the principal ones, as far as yet discovered, lie in or are associated closely with the Hilltop quartzite, the bed which forms the highest portion of the ridge throughout most of the extent of this property. These ore deposits are undoubtedly intimately connected genetically with both the igneous and the dynamic history. The chief items of this history are as follows:

1. All of the primary ore has been introduced into and through fractures and bedding planes and other weaknesses during and especially at the close of the contact metamorphism produced by the igneous intrusive masses.

2. All of the valuable deposits as far as yet known were made at the very close of this contact history after most of the silication of the limestones had been completed and most of the rock formations had been so thoroughly transformed that it was not easy any more for the mineralizing solutions to penetrate the average rock. But wherever fractures were developed, especially the cross fractures with small fault movement, or wherever the rock had escaped earlier metamorphism and was inclined to be brittle and form connecting fractures rather than mash into new position, there it was still easy for the mineral bearing solutions to penetrate and deposit this mineral load.

3. Thus it happened that most of the ore bodies, as far as yet developed, are irregular branching and bunchy deposits of chimney like form cutting up through the nearly vertical or steeply tilted Hilltop Quartzite. This quartzite was the most brittle and least affected original member of the series at the time this mineralization began and consequently was formed a good final outlet for the mineral bearing solutions. Many of these cross fractures made especially good outlets and in their vicinity deposits are usually found. But at other places also there are similar results, and at some of these intermediate points, that is between the cross fractures, the form of deposit is even more chimney like than at the cross fractures. But from the nature of the case, with such an origin, the deposit ought to be very irregular and obscurely connected or perhaps in some cases not connected laterally at all. Vertically, however, or downward there must be much better and more continuous connection, and without doubt the mineral deposits can be followed much more successfully either by winzes or raises than be drifts. There is no way of determining where the next

THE ARIZONA DEPARTMENT OF MINERAL R
MAKES NO REPRESENTATION AS TO THE AC
OF THE CONTENTS OF THESE DOCUMEN

mineral chimney is, in exploring laterally, but in the other direction doubtless they branch and connect in a perfectly consistent manner, which the actual working of the mine will not be found very confusing.

4. All of this primary mineralization came from below from igneous sources. The mineral bodies are only the conduits or courses of the escaping solutions.

5. The types of mineralization represented in the primary ore and the related effects include,

a-Silication of the limestones
b-Introduction of pyrite and sometimes other sulphides during silication
c-Replacement limestone and quartzite by other mineral material
d-Vein and cavity and space filling by ore minerals
e-Some silicification or development of quartz filling and replacement.

6. The chief development of valuable deposits belongs to c and d above, i.e., space filling and replacement. The principal primary minerals being sulphides of the common metals. In the workings thus far the principal ones are the sulphides of lead, iron, zinc, copper, molybdeum and arsenic (galena, pyrite, sphalerite, chalcopyrite, molybdenite and arsenopyrite.) Doubtless there are others but they do not appear prominately.

7. The Hilltop quartzite, however, was either not very completely cemented by the mineralization process or it suffered still further disturbance with reopening of fractures, because in much later time, after considerable erosion, surface rain water began to percolate down into and through this same mineralized ground. This began to alter and dissolve and move and reorganize the original ore deposit minerals. Some material has been dissolved and carried away leaving a cavernous habit at some places. In other places, where the structure is still tight and the surface waters did not succeed very well in penetrating, the primary minerals may still be found quite fresh and undisturbed in their original relation to each other and the country rock. In still other places some of the ores have been oxidized, and carbonated and otherwise recombined with portions of free mineral elements forming a whole series of secondary products. Among these are the sulphate and carbonate of lead (anglesite and cerussite), the molybdate of lead (wulfenite), hydrous iron oxide (limonite). Many others are to be found but no others are of equal prominance.

8. As deep as esploratory work has gone, these secondary effects are to be seen; but it is not to be expected that such pronounced oxidation will extend to very much greater depth.

9. The primary minerals, however, may be expected to continue and since they carry the valuable metals in even more recoverable form than do the secondary products, such a change of conditions may be looked forward to with more than usual satisfaction.

10. It is probable than in addition to this change to primary character of the ore, there will also be some change in the mineral mixture or proportions of the chief constituents. Zinc may be expected to increase and also iron and copper and probably silver, but lead may be expected to decrease in proportion with great depth.

11. No very sudden changes of any kind are likely to be encountered but at considerably greater depth than has yet been reached, the mineral bearing solutions must have crossed the underlying limestone beds in order to reach the quartzite and there it may be well that disseminated ore will be found replacing the limestone.

THE ARIZONA DEPARTMENT OF MINERAL RESOU
AKES NO REPRESENTATION AS TO THE ACCURA
OF THE CONTENTS OF THESE DOCUMENTS.

PART 2

Geology of the Hilltop and Hilltop Extension Ground

On account of the complexity of the geological conditions represented in the district it will be advisable to discuss the geological features and conditions under many separate heads. This necessarily leads to some repetition but it cannot be well avoided. The chief large headings are,

A. General Geologic Features
B. Local Geological Detail
C. Special Studies
D. The Ore Deposits
E. Historical State ment
F. Summary of the Geological Conditions

These are taken up in order.

A. General Geologic Features

1. Relation to Older Studied Districts.

Although the geology of the Chiricahua Mountains is not well known, the location suggests a possible similarity to the Bisbee region and districts also within easy reach in New Mexico. Nothing has been studied in detail, however, nearer than Bisbee about 75 miles distant. There it is well known that a great series of sedimentary beds ranging from Cambrian to Cretaceous occur and that igneous intrusives are important in connection with the ores and their origin. It would be reasonable to except that as far as the sedimentary beds are concerned, that a very similar series might be expected here although considering the distance it would be very unlikely that identical formations would be found. As will be seen in later discussion, this expectation has been fullfilled, but there is so much minor difference and so much more metamorphic modification at Hilltop that the general similarity is much obscured.

No other nearby districts have been described in enough detail to be of any particular service.

2. Structural Features of the Chiricahua Mountains

The Chiricahua Mountains are made up chiefly of the eroded remnants of a series of tilted and somewhat distorted fault blocks which have been cut up and injected by igneous intrusions. Some of these individual blocks have been raised above their neighbors and some of their beds have also been indurated (silicified and otherwise hardened) so that they resist erosion with considerable success, where as neighboring ones stand lower and have also been more easily eroded. Thus it happens that the high standing blocks, now cut up by erosion so much that it is somewhat difficult to see their boundaries and the way they are attached to each other, form the more elevated tracts of the Chiricahua Mountains. Still more depressed blocks doubtless lie in the valleys between this mountain group and its neighbors on all sides, and the sediments eroded from the mountains are carried out by the streams and deposited over these depressed areas on all sides, covering them completely. Thus we have a rugged mountain area standing out alone surrounded by comparatively uniform gravel covered country.

The Hilltop Block

One of these very elevated blocks forming a portion of the Chiricahua

THE ARIZONA DEPARTMENT OF MINERAL RESOU
MAKES NO REPRESENTATION AS TO THE ACCUR
OF THE DATA IN THESE DOCUMENTS.

Mountains is the Hilltop Block and on it is located the properties of the Hilltop Metals Mining Company and the Hilltop Extension. This block is more extensive than the ground of these two companies combined although at several points the properties reach the margins of the block, especially at the north and at the east. The block, however, extends much farther west and south beyond any lines of the property. This block is tilted out of its original position by being pushed up on its east side so that as a whole it is tilted strongly to the west. In addition it is cut into by numerous intrusives of igneous rocks and is doubtless underlain and surrounded by still larger masses. This is the general structural setting without which the local geology cannot be understood

3. Rock Formation

The formations of this Hilltop block and its immediate vicinity include a great series of limestones and limy or sandy shales and quartzites and sandstones with an occasional development of less common varieties of sediments. They were all laid down originally on a basement represented by the Pinal Schist, a pre-Cambrian formation of the southwest which is very well known in many districts. The overlying formations begin with a conglomerate and quartzite from 300 to 400 feet thick and this is followed by a great series of limestones and lime shales and somewhat sandy beds to a total of several thousand feet. These beds have been in some cases extremely modified by contact metamorphic influences and deformation producing marble, silicified and silicated beds, and indurated and mineralized rock in great confusion and complexity. In spite of this complexity it is possible to follow certain formations with more or less success from one point to another and determine the principal structural features of the area and, roughly, the age of the formations.

It is sufficient, however, at this point to note that the formations seem to include most of those recognised at Bisbee up to and including the Carboniferous beds. The most highly developed and the most distinct ones at Hilltop are the Cambrian quartzite (Bolsa Quartzite) at the base and the Mississippian and Pennsylvanian limestones (equivalent to the Naco, in part, of Bisbee) higher up in the series. It is sufficient at this point to call attention to the fact that the chief interest in the Hilltop group centers in the beds of the Pennsylvanian series, especially the heavy limestones and one included quartzite bed which will be referred to in this report as the Hillton Quartzite.

Igneous rocks occur abundantly also. They are all later than the sediments and therefore intrude them or cut them or lie beneath and surround them. The chief ones of these in contact with the sediments themselves are the so called Birdseye porphyry, which lies on the east side, and several varieties of quartz porphyries, with less prominately developed representatives of other types.

4. Deformation

Previous to the breaking of the region into these fault blocks all formations seem to have lain in comparatively little disturbed position. At the time of the faulting, however, and subsequently, not only were the strata broken into large blocks, sometimes two or three miles long and of similar width, but they were tilted out of position by crowding one against the other; and the strata have been bent and broken and overturned and faulted and brecciated and slid along bedding planes in a very complicated way. The Hilltop block has been tilted to the west and has been jammed and crowded by another block on the east side in such a manner that the beds along the east margin are not only turned up at a very steep angle but for long stretches are actually overturned. These

ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

beds, therefore, look as though they were dipped to the [illegible], as a matter of fact, the strata of the whole block dips to the [illegible] this local overturning.

This gives a very deceptive appearance structurally to the [illegible] mountain ridge and it is easy to get the impression that the ridge is an [illegible] clinal fold with a quartzite in the middle of it. On the contrary however, it is clearly a tilted block crowded so much against the east side that along certain stretches of the east margin the beds are pushed over beyond the vertical.

This makes a decided difference in the structural makeup of the block and in a good many other ways. Locally these deformation effects give a most complicated structural condition, some beds being almost entirely squeezed out, whereas others are actually thickened and bulged. The igneous intrusives have accomplished some displacement also, of course, but on the whole the deformation due directly to that cause is of little consequence compared to the other. This covers the general deformational habit of the locality.

5. Igneous Encroachment

The Hilltop block is cut by hundreds of dikes and larger intrusive masses and is bordered along the east side particularly, by still more massive igneous formations. Their distribution leads one to believe that there was underneath at the time of the faulting, a large magmatic mass undergoing differentiation which from time to time broke out and penetrated the overlying formations with tongues of fused material. Doubtless this kept on for a long time and it may be that similar intrusive attack took place in more than one geological period. It is certain at least that there were two such periods of igneous activity, one at the time of the faulting and one at a much later comparatively recent date. The latter has nothing to do with the behavior of the block or with its mineralization, whereas the former one has much to do with the geological history of the deposits. In spite of the great diversity of the type of rock represented by these igneous intrusions, they are probably nearly all closely related genetically. It is clear that some have preceeded the others, but it is not certain that there is any great time interval in a geologic sense represented by the different intrusive units of the older series. Also it does not appear that the difference of composition noticeable are of very great consequence. They seem to represent different stages of differentiation rather than important independent difference of source, and altho there is considerable variety of composition there is no important difference of meaning.

The most striking of all of the igneous members is the "Birdseye porphyry" which is heavily developed along the east margin in the vicinity of the plant of the Hilltop Metals Mining Company, where a wedge of the Birdseye cuts into the base of the block for several hundred feet. It can also be followed thence eastward and southward for long distances, but as one goes to the south end of the Hilltop block, the same type seems to change somewhat and in places is more like a diorite porphyry than in the first locality. I judge, however, that they are all of identical origin and that one could find a very large series of different compositions with once leaving the same formation.

In like manner I judge that some of the tongues in the form of dikes and sills that cut into the property and which are themselves very different in appearance from the parent masses that furnish them and from each other are not just on this account of any special or unusual significance or individual importance.

The very latest igneous rocks are of entirely different relation. They are surface flows and tuffs belonging to a volcanic period much later than all of these other features. For the most part these later flows and tuffs cover more or less completely the blocks that have been described and it is

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

only by long erosion that they have been exposed again. It happens that on the east side of White Tail Canyon the country is made up of these later formations and also at the north end of the property the same is true. Some of the claims actually extend across this contact. None of these things, however, have the slightest bearing on the behavior of the Hilltop block itself.

6. Mineralization

The Hilltop block is very much effected by "contact" influences, that is by processes set in operation by igneous invasions and encroachment. Most of the formations are extensively modified, especially along the eastern half or side of the block including the lower third of the series of sedimentary formations. There has been a rather complicated mineralization, most of it of non-metallic character, effecting particularly the former shaly limestones and limy shales, as well as some of the purer limestones. The latter have been transformed into marble on a large scale by recrystallization and the former into hard flinty crystalline silicated rock by the transformation of lime shales into the silicates of lime magnesia and iron by the introduction of silica and the reorganization of the material under igneous influences. Literally thousands of feet have been modified in this way, giving a most complicated series, of more or less completely transformed and modified strata.

The most pronounced type is a grayish dense flinty tough rock which is made up almost wholly of these reorganized silicates with some original quartz and a little of the original carbonates still preserved. Doubtless those beds have been most modified which had, in the begining, either a special composition or a structure that encouraged or permitted abundant penetration of the mineralizing solutions. Increase in temperature, due to the proximity of the igneous masses below, as well as to the hot circulating solutions coming up from them succeeded in transforming the more massive limestones into marble on a large scale while the more shaly and thin bedded layers were changed into these silicate products, building the whole mass into a very resistent crystalline bed of rock strata. Some of it is exceeding difficult to workin because of its hardness or toughness.

Probably the original limestone and shale was all dark colored. The mineralization and recrystallization has made it generally much lighter and in many places almost white. The white streaks ramify thru darker colored beds, and in some places that is elsewhere dark or bluish gray has been completely whitened by these mineralizing process. It is therefore quite difficult to follow the beds on the surface by their color or condition and it is this fact that accounts for much of the confusion in identification of the different strata and for the difficulty of detailed mapping.

This mineralization process has also tended to destroy the more delicate original structure. The fossils are poorly preserved and many forms cannot be identified at all, although it is perfectly clear that fossils were very abundant in many of the beds. This is particularly true of the formations forming the lower members of the series from the Pinal Schist up to or nearly to the Hilltop quartzite, and it is only here and there that beds are preserved in original condition well enough to make use of these finer details.

Along with the mineralization effects already described, there was also some metallic mineralization. Pyrite in particular is very common in minute particles or crystalls associated with many of these products, and occasionally other ore minerals may be found in almost any position from one side of the block to the other and from one end to the other. For the most part, however, these random occurences of ore minerals are in small amount and seem to have too little promise to encourage much more than simple prospecting.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

Along near the top of the ridge, however, outside the belt marked out by the Hilltop Quartzite, there is a much more extensive mineralization. Its most pronounced development at the surface is along strong and old fractures and in bunches in the quartzite, but some occurences of somewhat similar character may be seen in the footwall limestones adjacent to a little distance from the quartzite along fractures and especially along margins of dikes. Mineralization along the quartzite is most pronounced in Hilltop ground proper and can be seen to best advantage from the Blacksmith Shop Tunnel southward for half a mile or more. The other type of mineralization, that associated with dikes cutting the limestone and sometimes penetrating the limestone for some distance, is seen best in the Hilltop Extension ground toward the north especially in Lead Lilly and Eureka claims.

The character of the mineralization in its primary condition is similar in all of these places in a very broad way, but there are local differences of considerable possible importance. It appears, for example, that this metallic mineralization which is represented by considerable variety of the sulphides of the metals and includes ores of lead, zinc, silver, iron, copper and molybdenum came very late in the whole mineralization history, practically forming the end effect. It seems to have been produced by escaping solutions which were comparatively highly heated and were at that time at sufficient depth and under great enough pressure to form some of the standard high temperature minerals. It did, however, find easiest outlets along lines of fracture and bedding planes and doubtless for this reason it chose to follow chiefly the quartzite. This was a brittle formation and in the later deformation adjustments developed a good many cracks, especially cross fractures. These formed a series of cross veins. Most of them are occupied by a very complex type of ore.

The solutions which came up along these lines of weakness alos penetrated other lines of weakness in the rock and were active enough besides to attack some of the quartzite itself and accomplish a good deal of removal and replacement. It is possible at a good exposure such as the open pits or cuts at the Blacksmith Shop Tunnel to see the effects of these penetrating and replacing solutions on the adjacent rock. These mineralization effects branch out and penetrate and die out in the quartzite as they pass toward the surface in a very complicated way. It is perfectly evident in looking at them to see that they could not have been formed in any other way than by rising solutions. Some of these fingers end abruptly and nothing more can be seen above. It is evident, of course, that the activity of the solution was, at such points completely exhausted and nothing further could be accomplished along that particular line of attack or penetration. At the same time, however, at some other point the solutions did continue to escape to higher levels and to produce ores of the same or related type in other more readily available positions.

It is the common observation that these cross fractures contain rather basic and complex ore and that there are other patches more chimney like in their form that have a simpler makeup carrying lead in great dominance. This is probably the result of changing quality of solutions as the process of mineralization continued. The latest products have a composition in which lead is dominant. This is not surprising considering the facts that the whole mineralization process began with the introduction of non-metallics, when the limestone beds were chiefly being transformed, and that it furnished more metallics toward the close of the mineralization epoch as the igneous influences died out.

In some places also there is considerable penetration of the country rock by these later solutions, which carried ore minerals, producing disseminated ore

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATIONS AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS

but that type has not been discovered on a large scale in the explorations, thus far. It can be seen, however, in the Eureka workings of the Hilltop Extension and also in the Kasper Tunnel at certain places in the Hilltop ground.

The mineralization habit and origin together with the bearing of the geologic structure of the block on possible additional distribution is a matter of extreme importance so that these matters are given more extended discussion in a section by themselves under heading Ore Deposits.

7. Present Condition

The rocks for the most part are in about as sound condition as they ever were except superficially. Most of the beds are hard and not much altered. The ore deposits, however, are much effected by secondary processes due to weathering. Rain waters have soaked into the Hilltop Quartzites and have leached some of the ores, others have been oxidized to sulphates and to oxides, part of the material has been dissolved and carried down helping to attack and destroy and modify the material lying still deeper. In some places these secondary destructive effects extend as deep as any of the workings have yet reached. Other spots on the contrary are in much the same condition as when they were first formed. The difference depends largely on their proportions of minerals and the structural condition of the ore and surrounding rocks.

Such secondary attack has resulted in a great mixture of products and prominence of certain typical minerals such as the carbonates and sulphates and oxides of iron, lead, and zinc. Molybdate of lead occurs also and occasionally other less common secondary minerals.

Such conditions are on the whole favorable to secondary sulphide enrichment and perhaps if this had been a copper deposit one might have found extensive secondary sulphide ore shoots but the process does not seem to lend itself so well in the case of some of the other metals to the production of secondary sulphides. As far as the important metals are concerned the ores found in the shoots are either original minerals or else they are the sulphides and oxides and carbonates derived from them. Large quantities of iron have been leached out and probably large quantities of zinc also. Some of this may have disappeared entirely escaping with the circulating water. As deep as the working has gone this condition prevails. It may be, however, that some secondary sulphide is better preserved below the present workings. The present condition of the ores includes primary sulphides and oxidized products chiefly, rather than secondary sulphides to any very great extent.

8. Physiographic Expression

The relief is rugged. The crest of the ridge runs nearly parallel to the beds. The crest is formed by two formations chiefly, the Hilltop Quartzite and a very massive cherty blue limestone lying above it. These are the most resistant beds in the whole series and stand up in greatest relief. Structural weaknesses such as crushed zones and faults have in some places helped to guide the location ravines or small canyons, but on the whole these erosions depressions are not a very satisfactory evidence of structural conditions. There are equally pronounced canyons or gullies where no such structural weaknesses seem to be in evidence at all. All streams are eroding actively and all stream bottoms are narrow. Only White Tail Canyon shows wash deposits.

9. General Historical Statement.

The oldest formation is pre-Cambrian in age, but very little of this is to be seen anywhere. This is the ancient Pinal Schist of the southwest.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS

After an erosion interval a great series of mostly conformable sediments and limestones were laid down on top of the series continuing from Cambrian to Permian time. In this great series the earlier beds are rather imperfectly represented by beds which cannot be assigned with great certainty to any particular time as all of the fossils have been destroyed. From their similarity, however, in character and in sequence to those of adjacent districts, especially the Bisbee area, it is reasonably certain that the Cambrian is well represented by conglomerate and quartzite and striped limestones amounting to several hundred feet at the base of the series.

The Ordivician and Silurian strata are doubtless much less prominently represented and the Devonian is also in this district of uncertain boundaries. No unconformities, however, are noticable at any point. The local representatives of the formations belonging to these periods are followed immediately by very great thicknesses of strata Mississippian and Pennsylvanian age and perhaps also of Permian age, amounting to many thousand feet.

Most of these strata are limestones or shaly and impure limestones and they become much more sandy and shaly toward the top of the series. What happens at the very top of this series is not shown in the Hilltop block because the edges are either covered by later (Tertiary) lava flows or by wash or otherwise obscured by later material.

The geology of the Hilltop district, therefore, is concerned chiefly with strata of Paleozoic age from Cambrian to Permain time. The mineralization history is doubtless connected with the igneous intrusion epoch. Since the intrusive rocks of igneous origin cut thru and modify all members of the series, they, with all their related effects must have come at some time subsequent to the close of the Paleozoic after all of these beds had been formed. There is no direct evidence of the exact age of this development, but it lies somewhere between the Permian when the sedimentation was finished and the Tertiary volcanic outbreak when the outflows of lavas and accumulation of tuffs took place.

No other historical steps are of apparent consequence altho it must not be overlooked that alteration and erosion and secondary changes have effected the ores and that these changes have continued down to the very present time.

B. Geological Detail

The Hilltop and Hilltop Extension ground covers so large an area that locally each of the individual features referred to in the general outline become of some importance.

The properties boundaries actually overlap or extend beyond the edge of the Hilltop block at two or three points and take in some of the adjoining formations.

On account, therefore, of the occasional importance of local geological conditions and features, it is necessary to discuss some of these points in more detail than was possible in the general outline.

1. The Formations.

(A) The Sedimentaries and Metamorphics

Seven sedimentary formations are probably represented although some of them are not distinctly separable. Beginning at the top of the series they are as follows:

1. Possible Permian Beds -

No beds of recognised Permian age occur within the boundaries of the properties and it is not absolutely certain from any fossil evidence secured

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS

that any of the beds belonging to this block are Permian. It is true, however, that along the extreme western edge of this block where it finally overlapped by the andesite flows there is a great thickness of very [illegible] of quite different character from those recognised as belonging to the Pennsylvanian beneath. It is very likely indeed that they belong to the Permian. They are brown and yellow thin bedded shaly sands and in places limy sands that vary in quality rapidly with great numbers of repetitions of similar types. Although accurate measurement was not made, I judge from the dip and distance in the field that no less than three or four thousand feet of these beds are exposed. They are cut by dikes but are not nearly as much modified or effected by igneous influences as are the underlying members of the series and at no place do they carry attractive mineralization although occasionally a fracture is slightly mineralized.

2. The Pennsylvanian Beds

(a) The Upper Sandy Limestones

The Pennsylvanian is represented by a great series of limestones and shaly limestones and sandy beds. At the top there is no way of separating this member from those beds that have been described above as probably Permian. One passes down without any more evidence of a break than is represented by pebbly beds and slight conglomeratic habit into beds beneath that are not decidedly different from those above except that the lime content becomes more and more prominent and occasional good limestone layers are interstratified with layers that are sandy or shaly or sometimes are almost pure sandstone or quartzite. In some these, typical fusulina are found and the beds are, I judge, to be classified as of the Pennsylvanian age.

This succession of alternating sandy and limy beds continues through a great thickness but with a somewhat greater and greater prominence of the lime constituent in the lower beds down to a second conglomeratic bed which lies on top of a very massive blue limestone.

(b) The Limestone Conglomerate

This conglomerate is undoubtedly a break of more significance than any of the others noted in this series, but for all that it does not mark any pronounced unconformity. The general dip or attitude of the beds above are certainly not very different from those below although the obscurity of the bedding in the underlying cherty blue limestone member makes comparison somewhat difficult. The most direct evidence of unconformity in addition to the rather extensive development of the conglomeratic condition is a noticable difference in the thickness of the underlying massive number, the cherty limestone, at different points. Without any doubt, however, the formations on both sides of the break belong to the Pennsylvanian and therefore is not of any large historical importance although as a structural break it is quite noticable.

This conglomerate can be traced along the west slopes of the ridges for a long distance, but it is best developed across Green, Frederick J., Surprise and Ida and is ultimately lost in the crushed zones and thrust faulting of the north end of the block.

(c) The Cherty Productus Limestone (Naco, in part)
(Upper Naco)

Beneath this conglomerate lies an immense massive blue cherty limestone carrying Productus. The bedding in this formation is exceedingly obscure and in most places cannot be determined at all. It is, therefore, not

possible with certainty that the beds of this formation and those beds lying immediately above are perfectly conformative, but in general way they are, although the difference in thickness of the heavy cherty formations at different places indicates that there is at least a disconformity. The massive formation is the chief one forming the top of the Hilltop ridge, but it is associated directly with a bed of sandstones that is now, in part, transformed into a quartzite.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THESE DOCUMENTS

(d) The Hilltop Quartzite

The upper portion of this sandy bed is for the most part nearly a pure quartzite, but the lower portion is much finer grained and inclined to be shaly or limy. A maximum thickness of about 100 feet is exposed in places, but this is almost twice as great thickness as should be credited to the better quartzite quality of the formation.

This is the formation in which most of the ore discovered in the Hilltop ground is found, and, on account of tis importance in this connection, this formation will be referred to as the Hilltop Quartzite.

It should be remarked, however, that it is not everywhere a good quartzite. In some places the binding material is largely carbonate. The lower beds are decidedly red in color and much finer grained whereas the major portion of the formation is only slightly colored and is very granular. Along a portion of the ridge this quartzite forms the crest, but for a greater proportion of the length of the property, the quartzite follows on the east side of the crest while the Cherty Productus limestone forms the crest. At some places, especially far to the south and north on the Hilltop Extension ground, this quartzite is difficult to follow because of the covering of talus and soil. This is a brittle formation and, on this account, suffered considerable fracturing during the time of deformation while the Hilltop block was being squeezed and tilted into its present position. Thus there are many cross fractures running from one wall to the other, usually diagonally and dying out as a rule upon reaching the limestones on either side. Veins have been formed in these fractures. These mineralization relations will be discussed under a different head.

(e) The Lower Pennsylvanian Variable Beds
(Naco, in part) (Lower Naco)

Below the Hilltop quartzite on the east side of the crest of the ridge, is a great series of much thinner bedded bluish and grayish white limestones and limy shales and crystalline limestones and silicified and silicated beds, with occasional thin layers of sandstone and sandy shale especially in the upper portion. The uppermost member is even somewhat reddish in color, being influenced by the same conditions that have given the red shaly portion of the Hilltop quartzite. But beneath that, in those portions of the ground where there is not too much metamorphic modification, the limestones are blue and more or less fossiliferous and are interbedded with thin sandy layers. Some of these sandy layers are prominent enough to attract attention at a few places. At least three or four such layers can be seen on the ridge and to the east of the crest in the vicinity of the Blacksmith Shop Tunnel and along the trail leading northward Hardluck.

Some of these beds are still more strongly developed to the south along the ridge through the Hilltop property toward the Hilltop Extension ground on the Whale group. On the Whale most of the work has been done on one of these interbedded sandstones or quartzites lying a considerable distance below the Hilltop quartzite proper. This particular sandstone bed is not more than 12' to 15' thick, or perhaps a maximum of 20', and the Hilltop quartzite proper lies

much farther up on the side of the ridge. It appears that most of the work done on that ground was in the vicinity of this smaller quartzite layer in the apparent belief that this was the true Hilltop quartzite. It is, however, clearly on one of the other beds, interstratified with the under lying limestones The relations of these sandstone layers to the limestone and to the Hilltop quartzite is indicated on the accompanying sketch. This series of comparatively thin bedded limestone and shaly limestone and much metamorphosed beds is developed to a great thickness. As one passes down in the series, the beds are more and more modified or metamorphosed and their fossil content is almost completely destroyed. Here and there, however, a thin bed carries such large fossils and such resistent types that they serve as horizon markers throughout the property. Thus there are two very pronounced cupcoral beds and two or three very pronounced giant Fusulina beds. The coral beds in particular, even in badly deformed spots, can be recognised without much difficulty. The lowest one of these lies far down on the side of the ridge and crosses the trail between the two lower tunnel portals of the Hilltop workings. Traces of similar fossil content in the rocks are observed to still lower horizons, but for the most part the lower beds are too much metamorphosed to preserve the fossils. How thick thisseries is, it is most difficult to determine because of the distortion of the ground by the crowding to which it has been subjected, some of it being overturned. But probably at least 2000 feet below the Hilltop quartzite should be included with this formation forming the lower formation of the Pennsylvanian. It is doubtless in part equivalent to the Waco limestone of Bisbee.

Below these horizons determinations of age relations and separation into identifiable formations is much increased, but in places enough similarity to the formations described in the Bisbee district can be detected to warrent continuing the geologic column as is indicated below.

3. Mississippian Beds

Crinoidal Beds (Escabrosa Limestone)

The beds lying next below are more massive and in places are extremely crystalline and evidently formerly very fossiliferous. Wherever the beds are not too badly metamorphosed, traces of crinoidal make-up afe abundant, some beds apparently being made up of crinoidalt fragments entirely. Such beds alternate with more or less massive coarsely crystalline and bluish or gray beds. These alterations are repeated a great number of times, but their variability of habit and of metamorphism make it particular difficult to trace their boundaries. These become even more obscure and indefinite as one passes down in the series. It is judged that all of these belong to the Mississippian and probably correspond closely to the Escabrosa limestone of Bisbee. There is no way of determining the exact limits either above or below. The whole is essentially a continuous series and division into separate members of this kind is distinctly for convenience only.

4. Devonian Beds

Heavy Marbles (Martin Formation in part)

Whether or not the Devonian is exactly represented in this district one cannot tell. In Bisbee region the Martin limestone is credited to this position and on the basis of other similarities, already noted, it might be expected that this formation would also be represented here. It certainly cannot be mapped separately, and no importance should be attached to its separation or identification, but that the formation is represented is reasonably certain.

5. Silurian Beds

There is no way of determining whether anything of this age is represented but the fact that the beds appear to be continuous and from the fact that there is no evidence at all of a hiatus, it is likely that at least a small

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

development of this age is present.

6. Cambro-Ordovician Beds.

(a) The Tapestry Limestone (Abrigo limestone)

On the basis of comparison with Bisbee and the similarity of beds represented at Hilltop there seems to be no considerable doubt that both the Abrigo limestone of the Bisbee district and the Bolsa quartzite and their equivalents are both represented, to a total thickness of 800 feet or more.

A thin bedded very peculiar type of banded limestone is developed to a thickness of perhaps three and even four hundred feet. It is very variable and does not exhibit the features described equally well though its whole thickness but it habitually gives a ribbon structure or a peculiarly streaked appearance and when silicified, as it sometimes is, it weathers out very unevenly along the different streaks. This effect is evidently due to selective silicification and subsequent differential weathering.

This peculiar limestone doubtless is the equivalent of the Abrigo of Bisbee. At the very base it is massive instead. of banded and at least 200 feet is of this character.

(b) The Bolsa Quartzite.

Beneath this limestone lies a quartzite and conglomerate from three to four hundred feet in thickness. Perhaps it is variable in thickness, but it is so deformed by the crowding against this eastern limb of the block that measurements are more or less uncertain. At the best exposure there is not much doubt of thickness of about four hundred feet. The basal portion for a few feet is conglomeratic with pebbles two or three inches in diameters, but usually smaller. The quartzite is unusually pure and very obscurely bedded. This is undoubtedly equivalent to the Bolsa Quartzite of the Bisbee district.

7. Pre-Cambrian beds.

Pinal Schist

Beneath an unconformity separating the Bolsa quartzite from everything older, lies the complicated and very badly metamorphosed and little exposed Pinal Schist. It may be seen at two or three places along the east side of White Tail Canyon just beneath the quartzite. It is made up of quartzose and micaceous schists of complicated composition and structure, but apparently of original sedimentary origin, modified by regional and perhaps even igneous metamorphism having gone through a much more comples history than any of the formations listed above. Although it is the basement on which all of the others were laid down and therefore is the most fundamental formation in the district, it is exposed in such small spots and is so insignificant, in the present geology of the district, that it cannot be mapped at all and needs no further attention.

This succession of formations with their age relations and an attempt to indicate the most characteristic members is figured in columnal form in the accompanying sketch on the following page showing relative positions, thicknesses, and sometimes of the quality of the rock.

(B) Igneous Rocks

Although the variety of igneous rocks is very great indeed, in quality and composition of all the various intrusives, they may be classified for all practical purposes much more simply by grouping them according to age. By this method the later flows and surface accumulations, represented by the tuffs and breccias of Tertiary age, fall into the group, while the much older intrusives,

The Geologic Column

Present Erosion Epoch

Tertiary age	Volcanic Tuffs Rhyolite flows Andesite flows

----------Unconformity and great erosion period----------

Mesozoic era	The coarse quartz porphyry dikes Gray porphyries of many varieties Black porphyries The white dense quartz-felsite porphyry Pegmatite dikes cutting the Birdseye porphyry The Birdseye porphyry and related granite porphyries The granites and granodiorites of Jhus Canyon

----------Unconformity----------

Permian (?)	Probably the uppermost brown sandstone beds belong here.
Pennsylvanian	(Naco limestone of Bisbee in part)
Upper	(Very sandy beds (Sandy drab limestone (Conglomeratic beds
Middle	(Massive blue cherty Productus (limestone (The Hilltop Quartzite ("Footwall rock" fine textured rock
Lower	(Fossiliferous blue limestone (Shaly limestones interbedded (Massive marbles interbedded
Mississippian	("Escabrosa" limestone of Bisbee Crinoidal coarse white and blue marbles
Devonian (?)	A very thick series of massive marbles
Silurian (?)	of uncertain correlation
Ordovician (?)	
Cambrian	(Banded cherty limestone ("Abrigo" of Bisbee) (Massive limestones (Massive quartzite ("Bolsa" of Bisbee

----------Unconformity and great erosion period ----------

Pre-Cambrian, The "Pinal Schist" of the Southwest

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

including the large diorite and granite and porphyry masses as well as the hundreds of smaller dikes and sills, inspite of their compositional differences, fall into another group. The still older igneous rocks of pre-Cambrian age may well form another. The first two of these are of importance toward the west and north because they form the boundary of the Hilltop block, but it is the second group particularly that requires detailed attention because of the relation of these rocks to the structural disturbances and mineralization history of the sedimentary series and the ore deposits.

The characteristics of these different groups are given below.

1. Recent Flows and Tuffs.

A great variety of rhyolites and other surface flow types, including chiefly rhyolites and andesites, together with fragmental materials in great quantity in the form of volcanic breccias or tuff were developed, judging from their superficial relations, sometime in the Tertiary. Formerly, doubtless they covered much more territory than they do now because they were thrown out on the top of the surface at that time. Subsequent erosion has stripped them off the higher ground, however, and they do not appear in this study of the Hilltop block at any place except around the north end of the properties. If the study were extended, however, farther to the west and to the southwest they would be encountered on that side also. At the northerly end this group is represented by rhyolites and tuffs chiefly andesites of very massive habit. The rhyolites and tuffs lying to the north limit surface exploration where they cover the older formations. Thus it happens that the Mecville claim belonging to the Hilltop is in large part covered by these formations. On the Hilltop Extension ground. Ida claim is also more than half covered and the Maud claim is wholly covered by these deposits.

2. Intrusives of Intermediate Age

This is the most important and complex lot. It includes both large and small intrusives cutting the sedimentaries of the Hilltop block and therefore certainly represent some age subsequent to the Carboniferous. There is no means of determining their age more accurately by study of this block alone, and it is sufficient for all purposes of the present study simply to refer to them as post-Carboniferous. Most of the coarse large granitic and dioritic and syenitic masses lying to the south and to the east of the Hilltop block certainly belong to this group and I have no doubt myself but that all of the granite of Jhus canyon has the same relation.

As far as the Hilltop block is concerned the most important member of this group is a mass that projects into the block from the east and cuts a considerable distance into the basal beds in the vicinity of the Hilltop plant. It crosses the road just below the power house and occupies nearly the whole area below the road to the east and along the easterly edge of the block for at least a mile. Doubtless it is a closely related representative that occurs much farther to the south in Mackeys Wash and on the Manhattan ground where a dark gray grano-diorite is encountered.

This mass bordering the east margin of the block in the vicinity of the Hilltop plant, however, is distinctly porphyritic. Because of its peculiar appearance, produced by its large bluish quartz phenocrysts, we have called it the Birdseye porphyry. It is essentially a granite porphyry at this place, but abundent evidence of considerable variability in texture and structure can be seen in it without going very far. It is itself cut by two or three varieties of dikes, some of which are similar to and perhaps identical with those which also cut the sediments. But a very acid variety of binary granite pegmatite is common in this rock which has not been observed elsewhere. It is possible,

however, that these also are closely related to the very acid and very peculiar white porphyry dikes which do cut the sediments and which will be referred to later.

A very large and complex area of intrusive rock occurs beyond the limits of the property, toward the south, in Jhus Canyon. There is no doubt in my mind but that this occurence is also connected both in age and in source with the others, and has the same general significance and influence as has the Birdseye porphyry, throwing off dikes and causing metamorphism and also more or less mineralization. Little opportunity was presented for making examination of the Jhus Canyon rocks, but sufficient was done to prove that they are very variable and have a very complex relation. It is my belief that the abundant dikes and intrusive sheets as well as more irregular masses cutting into the ground from the south are thrust out from these large Jhus Canyon masses. There is on the whole, greater similarity between the Jhus Canyon massive rocks and most of the dikes in the Hilltop block than there is between the Birdseye porphyry of the east side and the dikes of the Hilltop ground. It is likely, therefore, it seems to me, that the upper Jhus Canyon masses may be a little later than the Birdseye porphyry proper and that most of the porphyry dikes came from it, or from the same course as it, rather than from the Birdseye porphyry directly.

Small intrusives occur as dikes and sheets or sills and also more irregular masses. They are in places crushed and faulted a great deal showing that they were intruded before the deformation was concluded. The are also of sufficiently different age so that some are more deformed than others, and besides they cut each other. The larger number, however, tend to follow more or less the bedding structure of the series for long distances, although they cut across rather freely and irregularly also, giving a peculiarly difficult course to follow and much uncertainty about their form and possible extent.

The most important varieties of those smaller intrusives are these three:

(a) A very dense, almost white, exceedingly fine grained very acid looking rock looking almost like a silicified limestone. It is always massive, however, and in thin section shows, without any question whatever, that it is an igneous rock of quartz porphyry type. This rock is strongly developed as far as observed, only in the northwest portion of the ground, chiefly in the belt represented by Green Frederick J., Surprise, Lead Lilly. A very extraodinary heavy crushed rock encountered at the west end line of Eureka and which can be followed almost without break from the Ida claim and through claims CB 6, CB 7, I judge represents precisely the same thing where it has been subjected to deformation by crushing enough to have lost nearly all of its usual appearance. Inspection of the map will show that the large mass in Frederick J., is connected with a sill which extends to the north from the center of Frederick J., along the bedding planes of the rock, and it is my belief that this is directly connected with and is the same mass as the crushed rock traceable through Ida and CB 6 and CB 7. This white quartz porphyry is one of the older porphyry intrusions of the series. It is cut by later quartz porphyry of coarser type. It is possible that this fine grained white quartz porphyry is more or less directly connected with the acid dikes of the Birdseye porphyry area but there is no direct proof of this relation.

(b) Coarse quartz porphyry. A comparatively coarse grained quartz porphyry occurs also in this ground. Its heaviest development is in the general district referred to above as occupied by the white dense type but it extends in long stringers and sills in the general direction of the strike of the sedimentary beds to the south and to the southeast, some of the individual sills being traceable more or less continuously for several thousand feet. It is this type that is encountered most prominently in the present workings of the

Hilltop ground. It forms an irregular mass on Green and Hidden Treasure and in very many places on Birthday and thence to the southeast. It is also encountered in large dikes and sills on the east side of the ridge on Portland and Hilltop and Clanse and Alma. In its best development it is a strikingly good quartz porphyry. In its different occurences there is much variability in amount of dark constituents and doubtless some of the dikes are showing very little free quartz, which have very much less striking characteristics and are simply variations of the same thing. This is commonly referred to simply as "quartz porphyry".

(c) All of the others may be referred to as porphyries of minor importance. They vary from quartz porphyry of less pronounced and individual characteristics than those just described, to trachyte porphyries and andesitic porphyries and even to basaltic porphyries of a very limited extent, that is, they vary through almost the whole range from acid to rather basic types, but there is no expecial significance in that point. They simply represent igneous intrusions coming from a differentiating mass somewhere and the particular quality or composition that they exhibit, depends upon the differentiation stage or particular compositional condition of the magma reached at that particular time. They have all been studied and examined microscopically, and descriptions accompany this report as a special petrographic contribution, but geologically they all mean the same thing and should be treated as a group.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

3. Older Igneous Rocks

There doubtless are older formations of igneous origin back in the pre-Cambrian but sufficient work has not been done to throw any light on that problem and it may be that there is not sufficient ground of that type exposed in the district to make a statement possible. There is no problem hinging on that point. They cannot possibly have any bearing on the geology of the sediments or the ir mineralization.

(C) Metamorphic Rocks

Two types of metamorphism are recognisable from the rocks of the district, <u>regional</u>, and <u>contact</u> metamorphism. By regional metamorphism is meant those effects which are produced on a large scale by forces acting on all rocks of a region. By contact metamorphism is meant local modification and it may be confined to the effects induced by the igneous rock proximity.

(1) Regional Metamorphic Effects.

The schistose structure of the <u>Pinal Schist</u> is of regional metamorphic nature. Likewise the distortion, squeezing out, and crowding effects in the overlying series of limestones and shales is also of regional origin. Such crowding and distortion undoubtedly help very much in this kind of a series in the making of a crystalline condition and in the destruction of minor structural features such as bedding and fossils. Because of the fact that these blocks were crowded against each other and suffered a good deal of mashing and distortion, there is considerable accompanying modification.

(2) Contact Metamorphism

It is the contact effects, however, that are most pronounced and important in this ground. Igneous rocks are abundant. The block is almost surrounded by and doubtless is largely underlain by igneous rocks of intrusive relation. Some of these igneous masses probably helped by their intrusion, in the dislocation of the block itself and it is doubtless also true that some of these underlying masses were partly fused while the blocks were crowding one against the other and reaching their new positions of rest. The larger igneous masses seem to have been capable of thrusting out great quantities of material

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OR THE CONTENTS OF THESE DOCUMENTS

in the form of dikes and it appears also that they gave off correspondingly large quantities of similar matters in solution capable of penetrating the beds more intimately, causing internal change both of structure and composition, and introducing matters that were originally entirely wanting.

Under these conditions very striking and characteristic contact effects were produced, some of which one sees more strongly developed. These may be referred to conveniently under the following heads.

(a) Marmorization, the making of marble or coarser crystalline limestones out of beds that were not nearly so crystalline before.

(b) Silicification, the adding of quartz to the rock from the circulation of these solutions, indurating the beds, hardening them, and in places entirely replacing the original rock material by quartz.

(c) Complex silcification. This is the making of mineral silicates by a chemical combination of matters derived from the solutions that came from the igneous rock with portions of the rock materials themselves. Thus the lime and magnesia and alumina of certain beds combine with silica and iron and other constituents coming in solution at high temperature and produce aggregates of entirely new minerals, including diopside, tremolite, zoisite, garnet, etc., transforming the whole mass into a much harder and much denser and on the whole a very different type of thing from what it was before. This process does not usually destroy the bedding or change its position in any way, and it develops most readily in those beds which were originally easily penetrated by the solutions in their circulation and escape toward the surface, and, in those beds also whose composition yielded more readily to the making of new compounds. Apparently those beds which were originally somewhat shaly in structure and somewhat aluminous and clayey in composition, in addition to their lime carbonate content, have yielded most readily to this kind of modification, whereas very massive limestone beds without much structural porosity or bedding structure seem to have resisted the circulation and remain as beds of marble instead of being transformed into these other metamorphic products.

In the Hilltop and Hilltop Extension ground this kind of metamorphism is very extensively developed. Its strongest development, of course, is in the east side of the ridge, especially on the lower two-thirds of the slope in the lower 2000 feet of strata. The reorganization of these beds and the introduction of mineral matters is on an immense scale. It has made some of the beds extraordinarily difficult to work by increasing the hardness and toughness of the rock. It has also, as a final effect, made those particular beds even more dense and resistent to the circulation of water and to possible additional mineralization. I have no doubt whatever but that all of this effect is contact metamorphic in its nature due to igneous relations and influence.

(d) Mineralization. An additional contact effect or product in the Hilltop block is metallic mineralization. There is some metallic mineral development with the silication processes described in the previous paragraph but in those beds it is almost wholly confined to pyrite and only rarely are there other more important minerals. At various places, however, in the series of formations where fractures were produced after most of the metamorphism just described had been accomplished, there is evidence of metallic mineralization more or less closely associated with the development of silicates of complex nature. This indicates reaction between the hot solutions which came up and some of the material of the adjacent wall rock as well as deposition of metallic minerals.

Thus there is in places, more or less development of epidote and zoisite and garnet and tremolite and chlorite and other commonly associated silicates. Metallic minerals include a long list but the chief ones are sphalerite, pyrite, galena, bornite, and molybdenite (?). It is very clear indeed that the best developments of the metalliferous minerals follow weaknesses or actual fractures

where the mineralizing solutions could escape or circulate after most of the other metamorphism was accomplished. This is the reason, I judge, that most of the ore occurences lie along the course of the Hilltop quartzite. This was a brittle formation. It escaped serious metamorphism in the earlier stages because of its position and its composition. Lying as it does between very thick limestone members both above and below, neither of which were so brittle, it was natural that this rock should fracture in the later movements and encourage this line of escape for some of the solutions which were still coming from the underlying sources.

Other weaknesses, however, here and there were also mineralized in a similar manner. Thus it happens that on the Lead Lilly claim the mineralized stringers that have been explored lie along the margins of porphyry dikes. There were the lines of weakness where channels for circulation were formed and therefore it is these places where mineralization developed.

Likewise in many other places such as the eastern margin of the block where copper and molybdenite ores are sometimes encountered and in other places where garnet and magnetite occur on a large scale it is always along some weakness where the circulation of the later escaping solutions could pass at the time of mineralization. On the eastern margin of the block the boundaries of these mineral streaks are not clearly outlined and there is apparently a larger degree of replacement and transformation of the wall rocks perhaps due to the higher temperature of the solutions and proximity to the source of supply whereas higher in the block at places that are now the top of the ridge and especially the west side of the ridge more clear cut veins are the rule.

In the Hilltop quartzite itself there is a very great irregularity. Some of the mineralization very clearly following gash veins (?) whereas at other places the mineralization is very irregular chimney like replacement and penetration. These different effects depend on the condition of the solutions especially the temperature at the time of development at any particular point.

This is the general statement of the mineralization habit and the nature of the mineralization epoch. But there is a much later modification of the ores accomplished by weathering and the downward circulation of meteoric waters produced since erosion has cut down and exposed these ores to the weather. These effects are all secondary and the present condition of the ore deposits is a condition that depends on both sets of factors, the original mineralization and recent weathering alteration.

II. Structural Detail.

(a) Character of the Fault Block.

The Hilltop block carrying the thick series of sediments referred to above is tilted heavily to the west or to the southwest and the east edge is crowded over evidently being pushed over by some block on that side, which is now wholly or almost wholly removed by erosion. In this crowding at many places, and for distances of from one to two thousand feet, the beds are either tilted up on edge or are entirely overturned. Wherever they are overturned the crowding has been excessive and the weakened beds have been squeezed out of position and faulted in a minor way giving and exceedingly complex structure. In such places the bedding is often very obscure and the dip changes rapidly from place to place and wherever the block material is much sheared its original habit and fossil content and other characteristics are badly destroyed.

The beds are shoved over each other along the bedding planes with minor structural drag effects between. Such faulting as assompanies this particular movement is of a thrust nature largely, sometimes almost parallel to the bedding, but most of them are not of much importance within the chief mineralized belts. Along the east margin, however, in White Tail Canyon, fault displacements of

three or four hundred feet may be seen due to this crowding from the east. It is this kind of displacement that brins quartzite into place on the west side of the creek in White Tail Canyon.

Other very flat faults following almost along the bedding but generally cutting at a flat angle through the beds occur throughout the sedimentary series in this block. This is because of the way the beds have been crowded together. Some of the larger ones are marked on the areal map. One of the largest of these which is very obscure in the field on the Whale Group toward the south end of the property. It cuts out some of the beds above the Hilltop quartzite on one locality.

Another occurs on the Hilltop Extension toward the north end on the Eureka claim and adjacent ground where the Hilltop quartzite and adjacent beds are displaced and finally cannot be traced further on the surface because of this crowding over of the higher beds along the series of rather flat faults.

As a matter of fact slips and faults of this type are so numerous that it is impossible to map or to detect all of them and no part of the Hilltop block is entirely free from slight displacement.

On the west side of the ridge the beds lie dipping much more uniformly to the west and in some places a whole group of competent layers has been shoved bodily toward the east overriding and lying on top of beds that they would not normally come in contact with at all. Thus one comes unexpectedly to formations that should lie still farther over to the west. One of the best illustrations of this crowding over on flat thrust planes almost parrallel to the bedding until the rocks ride far up on other members is to be seen on Florence, Frederick J., and Green. All of these cases are quite obscure in the field but they are in keeping exactly with the dynamic conditions effecting the block. It ought to be expected there would be much mashing and complicated displacements with occasional flat faults nearly all of which die out within comparatively short distances

Occasionally a fault is of larger importance and cuts through the beds at high angles. The principal ones of these are indicated on the areal map. Wherever they cross the general trend of the ridge, these faults represent real displacement of considerable consequence. It is one of these that displaces the Hilltop quartzite several hundred feet on Hidden Treasure and Hilltop claims, but even this, inspite of the large throw of the Hilltop quartzite by it dies out to such insignificant proportions both toward the west and toward the east sides that it is impossible on the surface to map it to a considerable distance. There is very little doubt that it merges into a series of flat faults on the east side which sweep more or less into line with the bedding and ultimately lose their identity entirely in the series of small slips that take the place of it. I have no doubt but that practically all of the others do the same thing. Another of these faults which displaces the principal mineral belt seriously enough to show prominently on the surface is on the Eureka Claim already referred to where the quartzite is displaced at least two hundred feet.

Occasionally a fault is of larger importance and cuts through the beds at high angles. The principal ones of these are indicated on the areal map. Wherever they cross the general trend of the ridge the se faults represent real displacement of considerable. It is one of these that displaces the Hilltop quartzite several hundred feet on Hidden Treasure.

These faults are encountered underground also and are even more numerous than they appear to be on the surface but they are the same type including small off sets across the structure as well as many crushed zones and actual displacements of considerable amount along much flatter planes which cuts the beds at a very low angle.

(b) Deflection of the Main Trend at the North end of the Ridge.

Far to the north, beginning in Eureka claim and Meeville and Ida, the crowding and overriding of one bed by another as the beds were shoved together the individuality of the beds is largely lost and they merge into a confused series of these crushed and deformation effects. Enough individuality is recognisable of one of the beds to make certain that the whole series bends to the north rather sharply by this deformation and it appears that the massive cherty limestone member lying just above the Hilltop quartzite over rides everything else so that even the Hilltop quartzite is lost on the surface. It must exist, of course, beneath, but undoubtedly it is faulted excessively in this far north extension. This condition is indicated on the areal map along the margin of the block just before reaching the rhyolite flows beyond which conditions cannot be seen.

(c) Small Cross Faults

The larger cross faults have been indicated above but wherever a formation is of hard brittle character it had at one of the stages of disturbances a tendency to develop cracks cross wise and is likely to have suffered some displacement. All of the brittle beds exhibit this effect to some degree but the most pronounced of these effects is in the Hilltop quartzite. This is a comparatively hard, brittle rock, more brittle than any other of the whole series and not so tough as some of the silicified members of the shale limestone series, and not so easily molded or deformed by mashing as some of the shaly limestones. On account of this physical condition, the Hilltop quartzite, tends to break and more along these fractures.

Fractures of this kind were open at the time of the mineralization and some of them are filled with ore minerals of various kinds. It appears that these channels have been of considerable importance as lines of escape for some of the mineralizing solutions. These cross faults and fractures, therefore, in the Hilltop quartzite have considerable importance in relation to ore developmemt.

It appears also that weaknesses of similar kind, that is, cross fractures and crush effects, through mineralizing solutions could escape have been of importance in some of the other ground and invariably it has been along side of or through some formation which is more brittle than the average and which therefore fractured and kept more open than most of the other rocks.

Wherever such fractures were open, during the early stages of the mineralization history they were healed without development of ore bodies, wherever, on the other hand, they were opened toward the end of the mineralization epoch when the chief ore minerals were being carried, ore deposits of more or less consequence depending on local conditions were developed along these weaknesses.

(d) Brecciated Zones

There are many crush zones. They have the same relation to the dynamics of the district and the adjustments within the block that the faults have. Most of the deformation is a thrust and crowding effect and such movements favor the breaking and crushing of rocks. Wherever the rock is soft it will flow or mash and recrystallize perhaps rather than break or crush; but wherever the rock is very hard and brittle it is more likely to fracture and fault and in such places crush zones are very likely to develop. They always mean displacement and they have the same meaning as faults.

(e) Dikes and Sills

There are very many igneous dikes and sills. They undoubtedly came from the larger igneous masses that lie below and at the sides of the block. They cut the series of formations promiscuously crossing the series at all sorts

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

of angles but still more commonly running somewhat nearly parallel to the beds and cutting across from one to another at low angles. There is no apparent system about them. A sill a few feet wide suddenly expands to many times its normal width or a dike which cuts across the strata for a considerable distance gradually shift into position between the beds and becomes a sill, or pinches out entirely, or yet again into an irregular mass. These changes of structural relation are normal to the area. For the most part the intrusions are long and narrow and some of them can be followed for surprisingly long distances, but the much larger number cannot be traced any considerable distance.

There is nothing peculiar in other respects about their occurence. They simply follow the old weakness lines of the time when fused magmatic material was available and active beneath this block. In practically all cases they are older than the mineralization and are also older than some of the later deformation. They are themselves, therefore, subject to fracturing and faulting and displacement but, because of their more substantial nature than some of the other rocks, weaknesses tend to develop along the margins of these intrusive units rather than through them. Thus one frequently finds crush zones following the margins of an intrusive and in some cases one finds that the fractures and other weaknesses which have developed along such margins are mineralized by the solutions which escaped through these channels.

Although it is impossible, when one encounters one of these igneous intrusions to determine either its extent of form below the surface it remains true, nevertheless, that most of them are comparatively narrow or thin. One particularly irregular and large mass, however, encountered in the Kasper Tunnel, is the best representative of unexpectedly irregular and suddent enlargement.

(f) Blowouts.

At a few places there are special silicification effects in patches or along certain zones. At one place on Alma claim near the Lead Lilly line, a very large patch of quartz and jaspor has replaced the limestone beds of that spot. No other beds in the vicinity are much effected in this way and it is therefore a striking structural feature. Careful inspection leaves no doubt whatever but that the limestone has been replaced along some weaknesses, perhaps a crush zone where escaping waters carrying silica have deposited and exchanged vein quartz and jaspor for some of the lime of the original rock. It is, therefore, a mineralization effect, but it appears to have no metallic mineral content. I see no way of explaining the occurence except as the work of rising solutions escaping at this point. And they were probably related to the solutions which have produced all of the other metamorphism and mineralization effects in the district.

But I see no way of determining how much importance to attach to the occurence from a practical or economic standpoint. Immense quantities of silica, it is perfectly clear, have been added to the whole series of formations in the course of the mineralization history of this whole block of ground, and it may be that this is simply a local escape channel for surplus solutions still charged with silica after reaching such a distance from the primary sources, or at such a late time in the epoch that the solutions passing through this particular spot were not active enough or high temperature enough or under great enough pressure to penetrate and transform the rock as extensively as were some of the silicified and silicated beds at other places. But it was charged heavily enough and was active enough to replace some of the limestone and precipitate quartz in considerable amounts. Whether this solution was carrying ore minerals at greater depth but did not succeed in carrying them to this level I do not know. But the failure of metallics of any description in this quartz blowout seems to me to indicate that these solutions were not much charged with

metallics and were not very intimately connected with the solutions that developed the ore deposits at other points, but were, on the other hand, genetically related to the solutions that silicified and silicified the beds of limestone rock in other portions of the property.

Several other places have similar quartz occurrences, one on the Prince claim and still another on Ida claim still farther to the northwest. These are roughly in line and probably lie on some hidden structural weakness.

A somewhat similar blowout representing the escape of emaninations or thermal waters or steam but which has produced alteration on a considerable scale rather than silicification lies much farther over to the east, in the Tertiary lava flow area, beyond the west end of the Meeville claim. It looks somewhat the same superficially and at a distance but as a matter of fact this one has nothing whatever to do with the true quartz blowouts of the Hilltop Extension ground. It is a comparatively recent affair.

Another patch of white rock looking superficially somewhat similar the dense felsite porphyry that occurs on Frederick J. claim. It has been referred to sometimes, as a blowout but does not deserve classification in this way at all. It is structurally an irregular expansion of one of the intrusive porphyries, in this case the dense white variety, and belongs structurally to the igneous dike series.

(g) Large Intrusive Masses.

Masses larger than a simple dikes or simple sills occur at many places, as described in a preceeding paragraph as local enlargements of the ordinary dikes and sills. Several such occurences are responsible for the large patches marked on the accompanying map on Frederick J. and Green and Alma and in the underground workings of Hidden Treasure. Doubtless there are many others more obscure than these that have exactly the same meaning but they scarcely deserve separate classification from the dikes and sills themselves, of which they are simple local variations.

They are, however, several large intrusives of another class. The one of chief interest perhaps, is the so called Birdseye porphyry which borders the east side of the block in the vicinity of the Hilltop plant and has a very considerable extent both northward and southward along the east margin of the block and may be followed for a long distance to the east as a massive, more or less porphyritic and rather coarse grained rock. That it is a real intrusive with respect to this block, is indicated by the projection of it which cuts far into the margin of the Hilltop block and crosses the road just below the power house of the Hilltop plant. It varies in quality considerably from place to place but its general composition and appearance leads one to the conclusion that it is essentially a single unit and probably is the same also as the dioritic and granodioritic rocks still farther to the south toward Jhus Canyon and Mackeys Wash.

Still mass of somewhat different character or several masses of different character in the Jhus Canyon region cut off the block at the end. In some respects the quality of some of these Jhus Canyon rocks is more like many of the porphyritic dikes than is the Birdseye porphyry. Doubtless some of the porphyry come from still other masses or from the magma lying still deeper which produced these large intrusion units.

The most satisfactory conception of the igneous history of the district is to consider all of these different igneous rocks as varietal expressions or results of the cooling and crystallization and occasional outbreaking of fused material from a single large magmatic mass lying still deeper, and furnishing the material for a much larger region than this Hilltop block alone. Thus it happens, I think, that the granites of Jhus Canyon which form a very striking and a very complex series, one being cut by another in a very complicated way are

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THESE DOCUMENTS

probably derived from the same source also. All are later in age than the sedimentary beds of the region.

These big masses, therefore, are not to be regarded, in my opinion, as a part of the basement on which the sediments were laid down but on the contrary, are to be regarded as intrusives of the same general age as the dikes which cut the sediments. All are later in age than the Carboniferous.

In this view, which I am sure is the correct one, all the igneous intrusive units, both large and small, except Tertiary lava flows, form a single igneous series, genetically related, but not all developed at present at the same time; and the same magmatic source, has also furnished the silica charged and mineral charged and hot metamorphosing solutions which helped modify the stone beds, transforming them into crystalline condition, and making them into different mineral and structural conditions and developing here and there where conditions were particularly favorable, a concentration of the ore minerals, in large enough amounts to form the ore deposits.

Thus the structural geology becomes a sort of key to an understanding of the sources of supply and the lines of attack and the nature of the circulation as well as the reasons for some of the peculiar effects noted in these rocks and deposits.

(h) Later Flows.

The Tertiary flows and tuffs of the north end of the block and the east side of White Tail Canyon as well as the heavy andesitic flows of the southwest side are all much later and distinctly separate from these units just described. They have no relation whatever, to the other structural features or the history of the block leading up to its mineralization. Although some of the finest structural and topographic features of the region depend on these later igneous rocks, they have so little to do with problems of these properties that it is in the interest of simplicity to practically ignore them in any further discussion.

III. Mineralization.

The causes and general nature of the mineralization of this ground have been referred to in connection with some of the other topics. It is necessary now, however, to assemble the points of mineralization separately from the other features.

(a) Impregnation.

There are several different kinds of mineralization effects. The most prominent differences being thought of as Primary effects and Secondary effects.

Primary mineralization has to do with the original developments of minerals from the original sources. This appears as impregnation of the country rock by solutions that carried mineral matter of various sorts. The chief one of these substances seems to have been silica which was added to the rocks in a very large amount at a temperature and under conditions that allowed or encouraged very extensive penetration and impregnation of the rock. For long distances, effects of this kind may be traced in particular beds where complete transformation of the rock has been accomplished while beds on either side are comparatively little effected by any addition of material. Thus there was undoubtedly a very prominent selective control exerted by beds of different quality and the result is that some beds are completely transformed where as others are only slightly effected although they stand side by side.

(b) Replacement.

In some places there is replacement of the country rock, the place of the rock material being occupied finally by other materials. This is also shown on a large scale.

(c) Contact Metamorphism with Silication.

On a still larger scale there has been chemical reaction between the solutions that penetrated these rocks and the mineral matters of the rocks themselves so that new compounds have been formed, using elements from both sources, thus it happens that some of the beds are completely transformed in their mineralogy, minerals being developed that were not there before although they do contain some of the elements that were introduced. This is contact metamorphism of certain type, the type referred to generally as silication. It is the chief course of the excessive hardness and toughness of the formations penetrated by the lower tunnels of the Hilltop property.

This effect is particularly prominent in the beds within the first 2000 feet of the base of the block. The reason for this distribution, is because these lower beds come more within reach of abundant escaping solutions from below and still more within the reach of the high temperature imposed by proximity to the larger igneous masses and the influence of escaping solutions before they become cooled.

(d) Vein Filling.

In other places, farther removed from the larger igneous masses and at such distance that the escaping solutions had lost some of their transforming competents, and at places where fractures or open spaces allowed solutions to escape through the channels without much contamination from the rock formations themselves, veins have been formed. Most of these have been formed at a late stage in the mineralization epoch and doubtless represent the dying out or perhaps the end product of the whole mineralization epoch. They are, in places simple veins, but the fact that they are genetically very closely related to the other types described above is indicated abundantly by the variety of effects and expressions and compositions and form of these mineral deposits. On the one extreme they are very simple sharply defined veins with clear cut walls. From this they vary in the direction of more or less attack on the walls and replacement of some of the wall rock. Then there is penetration of certain beds of the wall rock along lines of weaknesses, and sometimes impregnation of the walls, with development of irregular finger like extensions into the country rock from the main channels of circulation.

These usually are irregular themselves, appearing either as pocket like or bunchy expansions or finger like extensions or chimney like communications extending upward and downward. It is this type of mineralization that has given rise to the irregular ore bodies characterizing the Kasper Tunnel, whereas the surface, five hundred to seven hundred feet above, at many places the vein form of mineralization is more pronounced.

It is entirely possible that these expansions and pockets and finger like chimneys are the latest expressions of all in the primary mineralization history. They have developed wherever it was easiest for the escaping solutions to penetrate or circulate or escape and they extend as far as and accomplish as much as their energy made possible. It is not unusual in the workings to see a small finger like extension die out entirely in its upward extension in the rock. The solutions have gone as far as they could. They dropped their load of mineral matter and nothing more was done along that channel.

These are the forms of the mineralization of the Hilltop ground. The course of circulation of the mineralization solutions, which made them,

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS

reached from the depth toward the surface of that time, but it must be remembered that the present surface is far below the surface of that time, and that now we have only a portion of the original, the upper portion having been carried away by erosion.

Thus at one extreme in these mineralized formations we have a simple clear cut vein or veinlet, as the first step toward complexity we have the irregular enlargement chimney like form, and at the other extreme in the metallic mineralization as to form, we have impregnation of the rock with disseminated deposits. Thus far only the irregular and chimney like bodies have attracted attention. No large beds of disseminated beds have been discovered. The disseminated type of ores, however, are not unknown. How these latter will behave at greater depth it is quite impossible to predict. Some of the ores being taken from the workings of Eureka claim are essentially dissemination deposits rather than chimney ore vein type as to form.

All of these are primary mineralization products and effects but there were recognizable stages in this mineralization and characteristically different effects in the successive stages.

The earliest stage was essentially non-metallic and it produced silicification and silication and recrystallization of the country rock.

The latest was more prominently metallic and it produced in some places metallic impregnation of the country rock because of the tendency to penetrate these beds just as did the non metallic solutions. But toward the close of this stage and especially farther distant from the source or toward the surface the solutions seem to have followed along weaknesses and channels or fractures better. Thus they have produced all of the forms between disseminated deposits on the one extreme and simple vein fillings on the other, the irregular pocket and chimney like replacement forms which are particularly prominent at the levels of the principal workings.

(e) Secondary Changes.

Contrasted sharply with the primary mineralization is the secondary effects produced on the ore. These are chiefly alteration and depend on the ability of air and percolating rain water to transform the primary ores into very different products from what they originally were. The particular processes represented are <u>leaching</u> and <u>oxidation</u> and <u>hydration</u> and the ordinary alteration products. In the case of sulphide ores in particular, some are oxidized and dissolved and carried away as sulphate solutions, others are transformed in similar manner either to sulphate or to oxide or to carbonate condition but resist solution and removal. Some of the metallic content removed in this manner moves down to lower levels and may attach itself to the primary minerals below. This accomplished the so called secondary sulphide enrichment. Some of the material, doubtless, is carried away by erosion and by solutions and is lost entirely.

These secondary effects are very pronounced in this ground. Leaching andoxidation, the formation of sulphates and oxides and molybdates and carbonates are observed as deep as any of the workings have touched and mineralized ground. Not much enrichment has been found although there is some product of this kind; but the ores are changed a good deal from their original condition and association of oxidized ores with remanents of the unoxidized sulphide ores makes a mixture of unusual complexity and a problem of more than usual difficulty in final mining and milling.

This is a sketch of the mineralization condition. I have no doubt whatever, but that the ores come from the below, that they were also connected with the igneous history of the district, especially the closing epoch of that history, and that their distribution is best understood on the basis of

structure and source of supply as indicated above. They have been subsequently much modified by supergene processes and the ore deposits as they now stand in the Hilltop properties are essentially a mixture of primary and secondary products. In the Hilltop Extension, the ores are much more dominately primary with very little secondary effect and at any of the places now exposed in the workings.

IV. Local Differences of Ground.

All that needs to be said on this topic, perhaps, is included in the following points:

(a) Relation to Upper and Lower Beds.

The west side of the ridge is everywhere made up of higher and higher strata coming in as one proceeds southwestward across the series. On the other hand, the east side of the ridge or the northeast side, is occupied by the older or underlying beds passing down to the very base of the series. This is a fundamental difference but a very simple one that holds for the whole area.

(b) Relation to Hilltop Quartzite.

A strip of ground following rather near to the crest of the ridge carries the outcrop of the Hilltop quartzite. The claims there along the quartzite differ materially in their showing of surface mineralization, and as far as explored, also in underground development of ore, from the other portion of the properties. Only locally and at very special places or spots is there mineralization of enough attractiveness to have encouraged prospecting outside of this belt. Therefore the strip following the Hilltop quartzite, is the belt of special interest in this ground.

(c) Relation to Metamorphic Rocks.

Some places are much more effected by contact metamorphic influences than are others in the same belt. Beds of ordinary limestone are marblized at one place and not at all marblized at other places, while beds of shaly character are in some places completely transformed to silicates but retain some of their original habit in other places. Beds also that are blue in some parts of the property are white or gray or yellowish white in others. This makes it very difficult to trace formations accurately but it must be recognized as characteristic of the property and allowance must be made for this local difference of behavior.

(d) Relation to Faulted Areas.

It also appears that the central portion of the Hilltop block is somewhat more prominently mineralized than are the sides or ends of the block. Long strips of ground show practically no metallic mineralization even along the Hilltop quartzite. This is particularly true of the southward extension, judging from surface appearance. Those portions where cross-fracturing have developed more frequently than at other places seem to have encouraged mineralization, especially where the fractures belong to the period of mineralization rather than to a subsequent period. Thus it happens that local structural differences have a bearing on localization of mineralization. These structural features are best developed in the central portion also.

The most important point to note in this connection is the post mineral faulting and the crowding out of the formations is more prominently developed as one passes to the northwest margin of the Hilltop block. Structurally the southeast end of the block is simple and the central portion is more complex but the north third becomes progressively still more complex in structural habit, especially with respect to faulting and crushing. Thus it happens that even

such a prominent formation as the Hilltop quartzite is split up and overthrust and crowded and obscure that it is impossible to trace it on the surface after reaching about the middle of the Eureka claim.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

C. Special Studies.

Three special studies deserve some attention although they have been carried out to very different extent in the three different areas. They are:

1st: In Petrography or the microscopic examination of the rocks and the ores.
2nd: In Mineralogy including a tabulated list of the minerals found, their distribution, and origin.
3rd: In Paleontology or fossil content including the characteristics of the different formations, fossil horizons or horizon markers and their indication of age.

1. Petrography

The microscopic study of the rocks and ores has been based on an extensive series of prepared plates or slides. Most of them are rock thin sections intended as an aid to determination and interpretation of the more obscure rocks of the Hilltop ground. Each one has been described and some have been illustrated so that they may be used as reference and standards for any future work that may be done. The ores have been studied chiefly from the standpoint of genetic relation or origin and the extent to which secondary processes have operated, and the results are incorporated in the explanations and interpretations throughout this report.

All of this field is particularly technical and a part of it involves much description and repetition with so little significance unless interpreted in general terms that it seems inappropriate to insert these notes in this formal report of the investigation at this point. These descriptions, however, will be furnished separately for comparison and for checking purposes and will be referred to as Special Report Z on the Hilltop Petrography.

Only the general interpretation or summary, therefore, needs to be included here as follows:

(a) Petrography of the Rocks.

Although more than one hundred thin sections have been made and detailed descriptions have been compiled for them, it is possible to summarize the essentials of these examinations in comparatively brief space. In fact most of it is involved in other parts of the report with the explanation and especially the interpretations that are given at these places. For example, it is through these petrographic studies that one determines beyond question that silicification and silication and replacement and the introduction of mineral matters wholly changing the character of many of the primary rocks have been so prominent in this area. The most prominent conditions and facts established by the petrographic work are as follows:

1st: The comparatively fresh and unmodified condition of most of the igneous rocks
2nd: The extensively modified and metamorphosed condition of many of the sedimentary beds
3rd: The introduction of immense quantities of material, especially silica from some sources which were not present in the original formations

4th: The development of metallic mineralization and, in places, ore deposits as an accompaniment of the metamorphic transformations referred to in No. 2 above.

5th: Igneous influences and sources for most of the modification and mineralization that has been produced.

6th: Extensive secondary alteration of the rocks and the chief ore deposits wherever the ground is comparatively porous. This alteration involves leaching, solution, oxidization, carbonization, with development of characteristic oxides, such as the iron oxides, and carbonates such as lead carbonate, and sulphates, such as lead sulphate and calcium sulphate, and molybdates such as lead molybdate, and secondary sulphides such as chalcocite, and reaction products, such as gypsum.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS

All of these conclusions, some of which vitally effect the question of actual conditions and processes that have been operating in this ground, are woven into the general explanatory structure of this report and it is simply in the interest of showing their true relation in the investigation that they repeated at this point. These general conclusions are worked into the discussion of rocks and their changes in earlier sections of the report, and, insofar as the ores are affected, these matters are included in the discussion under the topic Ore Deposits to follow.

For the details of description and individual illustration, and interpretation, therefore, the reader is referred to the special petrographic notes forming Part Z of the extra memorandum to be submitted, and the application of the determinations and conclusions reached is incorporated in the general discussion under all of the other headings of this report.

(b) Petrography of the Ores.

The ores yield also to the regular form of petrographic study. The detailed notes are included in the extra memorandum already referred to, but the conclusions and interpretations are all worked into this general report, especially under the topics Mineralization and Ore Deposits.

For convenience of reference the principal conclusions from this special field of study are enumerated here as follows:

1st: The ores are in part primary and in part secondary.

2nd: The primary ores are intimately associated with the typical metamorphic processes especially with complex silicates such as form under high pressure and temperature with addition of silica. Thus they are much associated with silicates in some places.

3rd: They also replace rock directly.

4th: They also penetrate and impregnate the country rock in some places.

5th: They also fill spaces and form veins.

6th: The metallic ore minerals are intimately associated themselves, in some places forming a very complex mixed ore. At other places the ores are more simple. But they all are very closely related, differing in time of development chiefly.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS

7th: Mineral deposition took place during the deformation epoch while movement was in progress. But movement continued beyond the time of completion of ore deposition. Minerals themselves are squeezed and deformed.

8th: The secondary ores are chiefly oxidation and carbonation products, but the results are rather complex.

9th: The secondary minerals of most prominence are cerussite, anglesite, limonite and wulfenite. The zinc constituents have been dissipated more than the lead.

10th: There is a little secondary enrichment, but secondary sulphide enrichment at least is of very little consequence in any of this ground.

2. Mineralogy.

The tabulated list of minerals found in this ground is given below. Nothing further need be said since the table is self-explanatory.

With regard to origin, however, it ought to be said that the larger number of mineral species are essentially primary and connected either with contact metamorphism as an origin or with igneous emanation or with hot water solutions, probably from igneous sources and contaminated by mineral materials from these igneous sources. All of these origins are considered so much alike that they are not differentiated. They form the primary ores and they are widely separated in their meaning from the other important group of ore minerals which must be thought of as due to weathering attack with its tendency to destroy and alter the original minerals. This latter group includes a large number of species but most of them are not present in large quantity.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

List of Minerals.

Primary Mineral List

1. Arsenopyrite FeAsS
2. Bornite Cu_5FeS_4
3. Calcite $CaCO_3$
4. Chalcopyrite CuFeS2
5. Chlorite H8(MgFe)5 Al2(SiO6)3
6. Dolomite (CaMg)CO3
7. Epidote Ca2(AlFe)3(OH)(SiO4)3
8. Garnet Fe3Al2 (SiO4)3
9. Galena PbS
10. Jasper SiO2 with impurities
11. Magnetite Fe3O4
12. Molybdenite MoS2
13. Piedmonite
14. Pyrite FeS2
15. Quartz SiO2
16. Rhodonite MnSiO3
17. Sericitic mica H2KAl3(SiO4)3
18. Siderite FeCO3
19. Specularite Fe2O3
20. Sphalerite ZnS
21. Tremolite Ca(MgFe)3 (SiO3)4
22. Wollastonite CaSiO3
23. Zoisite HCa2Al3(SiO4)3

Secondary Mineral List.

1. Alabandite MnS
2. Anglesite PbSO4
3. Azurite Cu3(OH)2 (CO2)2
4. Calamine Zn2(OH)2SiO3
5. Calcite CaCO3
6. Cerrusite PbCO3
7. Chalcedony SiO2
8. Chalcocite Cu2S
9. Chlorite H8(MgFe)5 Al2 (SiO6)3
10. Chrysocolla CuSiO3.2H2O
11. Copper Cu
12. Cuprite Cu2O
13. Dolomite (CaMg)CO3
14. Gypsum CaSO4. 2H2O
15. Jasper and Jasperoid SiO2 + iron oxide coloring
16. Limonite Fe2O3 .2Fe(OH)3
17. Malachite Cu(OH)2 (CO2)2
18. Psilomelane (?) 4MnO2 (BaK2)O. H2O
19. Pyrolusite MnO2
20. Pyromorphite (?) Pb5Cl (PO4) 3
21. Rhodochrosite MnCO3
22. Ripidolite
23. Siderite FeCO3
24. Smithsonite ZuCO3
25. Vanadinite Pb5Cl (VO4)3
26. Wad MnO2 + H2O (variable)
27. Wulfenite PbMoO4

Paragenesis.

An interesting relation is indicated by the paragenesis of the minerals and this is best represented by a tabulation also. It is not at all easy to indicate which is the earlier and which the later minerals for the district because these relations vary somewhat at different points but in a general way the tabulation is suggestive.

Magnetite	___
Garnet	_____
Bornite	_____
Molybdenite	_____
Sphalerite	_____
Pyrite	_____
Galena	_____
Epidote	_____
Tremolite	_____
Quartz	_____
Rhodonite	_____
Anglesite	_____
Cerrusite	_____
Limonite	_____
Smithsonite	_____
Calcamine	_____
Vanadinite	_____
Wad	_____
Malachite	_____
Gypsum	_____
Copper	_____
Chalcocite	_____

3. Paleontology.

Comparatively little has been done with this special field. In most of the formations the fossils are either completely destroyed or are so badly obscured in their finer detail by the metamorphic changes that have effected the rocks that little can be made out of them. It would be possible, however, to make a much more detailed study than has been done. The higher formations, the Pennsylvanian strata in particular carry a considerable fauna. Many of the forms are microscopic but there is better preservation in the upper formations than in the lower ones. Since there is no economic or practical application to be made of any greater detail at the present time these details have not been followed.

In spite of the obscurity of some of the fossils, however, in the lower beds of the series, certain horizons have such a strong development of fossil content that they have been successfully used as horizon markers. Two or three such beds occur toward the base of the Pennsylvanian one thousand feet or more below the Hilltop quartzite. Another quite fossiliferous bed of very different habit occurs not far below the Hilltop quartzite. From the characteristic fossils in the heavy cherty limestone above the Hilltop quartzite and numerous horizons higher in the series, the age of the series is fully determined. All of the fossils that have been identified could belong to the Pennsylvanian.

The following have been identified, and in the tabulation the age range of them is indicated as recognized by Paleontologists. No further special attention seems to be necessary. Typical specimens to be used as standards have been labeled and left on the ground for comparison.

List of Fossils.

Corals:-

Cammophyllum torquium (Owen) Pennsylvanian
Syringopora multattenuata (McChesney) Upper Pennsylvanian

Brachiopoda:-

Productus semireticulatus (Martin) Pennsylvanian
Productus costatus (Sowerby) Pennsylvanian & L. Permian
Composita argentea (Shepard) Pennsylvanian

Gastropods:-

Loxonema of multicostatum Pennsylvanian
Straparollus subquadratus (Meek & Worthen) Up. Penn. & Per.
Phanerotinus of gyroceras Pennsylvanian

Protogoa:-

Fusulina secalica (Say) Upper Pennsylvanian

D. The Ore Deposits.

The ores of the Hilltop area depend for their chief, value, in the Hilltop and Hilltop Extension ground, on the lead and silver content. The ore minerals are, however, of considerably larger range including iron, zinc, molybdenite and copper with more rarely other metals. None of these, however, figure heavily in the control of values in the ground where explorations are being made unless it is zinc which might be considered with the lead and silver.

The ore minerals are widely distributed and small amounts are found at occasional spots throughout the series of formations. But only those places deserve to be regarded as ore deposits or possible ore bodies where there is appreciable concentration of the metallic minerals.

(a) Types of Deposits.

The following types of deposits should be distinguished:

1. The Vein Deposits.

Some of the ores occupy fractures in the country rock and the occurrence is therefore essentially of vein type. The best examples are the cross fracture veins cutting the Hilltop quartzite as seen on the surface at a good many points from the Blacksmith Shop Tunnel westward, and veins that cut the limestone shale series, both above and below the quartzite, widely separated spots. They usually carry a complex lead zinc mixture especially in the upper beds whereas toward the base of the block such veins carry ore with more or less copper and sometimes a good deal of molybdenum.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS

2. The Disseminated Deposits.

At other places the ore minerals are distributed along [illegible] weaknesses in the rock of too little prominence to appear as veins but still of [illegible] importance in controlling the circulation of mineral bearing solutions to guide the distribution of ore minerals along these lines. This leads to one form of disseminated deposit. It is widely represented but is practically confined to certain beds of the series from the base of the block up to and including the Hilltop quartzite. In nearly all cases the amount of disseminated ore of this kind is very small indeed, and on that account most occurrences cannot be regarded as of any economic importance. But the type is represented and it is possible that a greater concentration ore minerals occurs in other positions where the series may have been subjected to the mineralizing processes under more favorable conditions.

This should be called the disseminated type of ore deposits. It is represented at a good many places but in all cases thus far seen on a comparatively small scale. It is probably best represented at certain points in the Kasper Tunnel, and at two or three points on the Lead Lilly and Eureka claims of the Extension ground. The recent work in the Eureka tunnel has been prosecuted on this kind of deposit.

On the whole this is, it seems to me, a type of ore occurrence of considerable interest in considering the future behavior of the mineralized ground at points not yet opened by exploration. The opportunity for disseminated ore deposits is probably better with depth than under shallower conditions but it is quite impossible to say what the actual prospects are. In a general way, the rule will probably hold in most districts that dissemination, or the introduction of minerals into the body of country rock is improved with depth especially if the deposits near the surface tend to confine themselves to fractures and veins and cavities. On this account a disseminated type is one of the speculative features of exploration in depth. This type may be developed on a larger scale in the deeper parts of the ground than it is in the superficial and shallow workings. If, at the same time, the mineral content is concentrated along certain limited beds rather than promiscuously scattered, it might become a very essential factor in the future behavior of the mine. Considering the fact, however, that the ores are more or less explored to a considerable total depth, the promise of much improvement in this respect does not seem to be very great.

3. Chimney like and Irregular Replacement Deposits.

A third type of mineral occurrence of ore deposit is essentially an irregular bunchy replacement of the country rock not confined to fractures or openings entirely, and also not spreading widely out into the formations but differing from both these two other types in replacing the country rock. The process represented is largely metasomatic replacement.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATIONS AS TO THE COMPLETENESS OF THE DOCUMENT

Such a process tends in this ground to develop irregular and bunchy or chimney like or finger like forms comparatively high in ore minerals. Some of these are almost solid ore, others are much mixed with nonmetallics and other useless gangue material. They seem to have developed chiefly in the Hilltop quartzite and are more or less directly connected with old cracks and other weaknesses of the rock along which the rising mineralizing solutions could circulate comparatively easily. For some reason, however, either because of local obstruction or because simply of the chemical virility of the solutions themselves, the country rock minerals have been destroyed and for the most part removed while other minerals have come in or have formed at their expense. These are the so called replacement ore bodies.

In some cases they seem to have the form and attitude of so called chimney deposits. What they are, of course, is irregular replacements of the country rock forming along the course of weaknesses that form channels of escape for and chemical attack by the escaping solutions.

This type of ore deposit is comparatively common in the Hilltop ground. It is particularly frequent in the Hilltop quartzite where it exhibits every possible graduation in size and form and attitude from simple small scattered bunches that lie in any position to finger like projections and large irregular more or less vertical standing chimney like bodies whose extent is not fully yet explored.

4. Secondary Deposits.

A fourth type of ore deposit is the secondary enrichment and alteration type which depends for its character on the process set in operation by exposure to the weathering, especially the attack of air and water with their tendency to alter the original minerals destroying some of them while developing others. Most of the mineral deposits in the Hilltop quartzite are more or less modified in this manner and show secondary effects to as great depth as any exploration has been carried thus far. In many places, however, the primary ores are structurally too tight to permit easy penetration of surface waters and they therefore resist this kind of secondary change with considerable success. It thus happens that the disseminated ores as a type are not much effected because they lie in a tight crystalline matrix which does not encourage abundant circulation. At many places also the vein types resist these changes with moderate success and are not as much effected as the chimney type. The difference is probably due to the fact that those veins are made up of a closely interlocked crystalline matrix of metallic and non metallic substances whereas the chimney type is more open textured. In some places, therefore, the ore bodies resist the weather and chemical attack so well that primary ore may be secured quite near or even at the very surface.

Wherever the ores occur inporous rock, or wherever subsequent movement has weakened the structure and left cracks so that the surface waters could circulate and wherever the structure of the ore itself was coarse enough or porous enough or of such a composition as to encourage the progress of surface attack, and especially in places where ore deposits of this kind stand nearly vertical so that downward circulation of water would pass for long distances through them, there has been secondary alteration to great depths.

The alteration processes represented may be comprehended under the terms <u>oxidation</u>, <u>leaching</u>, the forming of <u>acid waters</u>, the <u>chemical attack</u> by these waters on underlying ores and rocks, the <u>destruction</u> or <u>removal of some</u> of the <u>ores</u>, the development of <u>new compounds</u> out of part of the material and the <u>replacement</u> of some minerals by others along the course of these downward circulating waters. Thus in some places the ore is porous, more porous than it originally was because of the removal of some of the constituents. At other

places, additions have been made to the minerals that were formerly there in the form of secondary sulphide enrichment. In other places new minerals have been formed such as cerrusite, the carbonate of lead, and anglesite, the sulphate of lead, wulfenite, the molybdate of lead, and other carbonates, oxides, sulphates, and occasionally still more rare substances.

Almost everywhere something of these final changes have materially modified the condition as well as the composition and structure and value of the ore. There is no possible way of avoiding this complication or of eliminating the problems that attach to it from the standpoint of concentration and distribution and milling, in all of the ground carrying the chimney type of ore deposit.

Abundant evidence of secondary attack in the form of gypsum is present in the Gray Tunnel along the entire course of the drifts. The gypsum has undoubtedly been made by the attack of the downward moving acid carrying waters derived from the oxidation attack on the sulphides higher up on the limestone, below, transforming the calcium carbonate of the wall rock into calcium sulphate. This is a soft soapy talc like material found abundantly in the Gray. Some form of secondary attack is certain to extend at least that deep. It of course extends as deep as the surface waters have reached with any considerable circulating success in the mountain.

These four types of ore deposits cover the range of mineralization character in the Hilltop block.

In the present workings the replacement chimney type of deposit is of most consequence, and it is much effected by secondary attack so that with it is associated all of the complexity of the fourth type. But it is certain that at depth these secondary changes will be of less and less consequence and what ever ore is encountered will be more nearly in its primary condition. Also it is entirely possible that the disseminated type rather than the chimney type of ore deposit will become of more prominence with greater depth. It is not at all likely that the vein type of deposit will in any case be of much importance in this ground.

(b) Relations of Ores to Geological Formations.

The disseminated type of ore seems to occur chiefly in the limestones and limy shales, and I judge that this may be true essentially wherever encountered. The vein type is found in any formation that was capable of clear cut fracturing. Thus it is found throughout the series but a somewhat more common in the quartzites than elsewhere. This is doubtless because of the brittleness of this rock while most of the limestones too readily under deformation to form clear cut fractures so easily.

The chimney and irregular body type or replacement type in massive form occur chiefly in the Hilltop quartzite. This is probably because the fractures of the Hilltop quartzite constituted the chief channels of escape during the mineralizing epoch. Perhaps also it is because of the simple mineral character of the rock, the quartz not being so susceptible to a development of complex metamorphic silicates but on the contrary quite susceptible to metasomatic replacement attack.

Thus the chief ore deposits follow certain lines depending on the physical character and compositions of the formations themselves. The controlling factor in largest part is the opening of weaknesses for the escaping mineral bearing waters from below. At the Hilltop ground this has been chiefly through the quartzite, but on the Hilltop Extension ground it has been quite as commonly along by the side of dikes or along more irregular weaknesses that cut the limestone series beneath the Hilltop quartzite.

(c) Controlling Geological Features and Conditions.

A general study of the whole area, but especially the Hilltop block

THE ARIZONA DEPARTMENT OF MINES AND MINERAL RESOURCES MAKES NO REPRESENTATION OR WARRANTY AS TO THE CONTENTS OF THESE DOCUMENTS.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

shows that nearly all of the mineralization is found somewhere in the lower half of the stratiographic series, that is, somewhere in the beds between the Pinal Schist at the base and the top block and the Hilltop quartzite. Very little mineralization reaches higher position than this. It is indeed a striking thing that the lower beds are exceedingly metamorphosed; whereas the higher beds, including the blue cherty limestone above the Hilltop quartzite and nearly all beds still higher in the series are comparatively little or only locally affected.

There must be a good reason for this. A little further inspection shows that wherever mineralization does occur to any consequence higher in the series it is along definite fractures, now in the form of veins, or else in the vicinity of dikes or other intrusive masses, whereas, in the lower part of the series, modification in the form of metamorphic and contact changes as well as the introduction of minerals is a very common effect. Sometimes this completely transforms a whole series of beds for long distances even though there is no apparent relation to any individual dikes or intrusives.

It is evident, therefore, that for some reason the base of the block is much more modified and mineralized than the upper portion. A further inspection of the series fails to show any very good reason for this difference of amount of mineralization in the character of the original beds themselves, that is, in the upper beds as distinguished from the lower ones. It must be, therefore, that the reason for the difference is essentially the fact that the lower beds have been in position to be readily reached by the mineralizing solutions whereas the upper beds were, for the most part, out of reach. This leads to the conclusion that the chief influences and sources of supply were from the lower side. When this situation is examined, it is found that this is also the side where the great variety of igneous intrusives occur. It is the Birdseye porphyry side of the block. There is no escape from the conclusion, it seems to me, that the general distribution, of mineralization, therefore, is controlled in part by the composition of the beds themselves with respect to the source of supply but that the opportunity to be effected at all is due chiefly to the proximity and the influence of the intrusives which have encroached on the block on the easterly and under side.

In the second place it is very noticable indeed even in the lower members of the series, that some beds are much more effected than others. In other words, there is a selective mineralization even where mineralization is the heaviest, some places being mineralized, and others not. In general this is undoubtedly a selective difference due to the structure and composition of the rock itself, those being more readily penetrated and more abundantly mineralized which allowed circulation to pass or allowed solutions to penetrate more readily.

In the third place there is an equally pronounced difference of mineralization, especially development of ores, along still other structural lines. These are deformation weaknesses, chiefly fractures or crush zones developed during and toward the end of the mineralization epoch. It is along these structural weaknesses that nearly all of the ore deposits proper are formed. All of these features, no matter, where they are studied, fall into this conception of genesis and structural relation and are consistent with the conclusions already reached as to the direction of source of supply. The later mineralizing solutions found escape channels along structural weaknesses, and such deposits as formed from them are necessarily formed along these lines or are connected with them in some structural way.

For example, the types of ore deposits described in the previous section fit exactly into this conception of structural relation. The vein deposits are those which have formed in the most sharply cut fractures where the mineralizing solutions have not penetrated much into the wall rock or have not materially enlarged the openings. The disseminated ore deposits are those

which have developed sidewise from these chief channels by reason of the somewhat easy penetration of certain beds by the mineralizing solutions, but they are intimately connected with the whole system of escape channels and rising and circulating solutions just the same. The replacement deposits of irregular or chimney like form are all developments along such channels where some of the wall material has been more or less completely replaced for these deposits have been developed to a size greatly exceeding any possible original fractures or openings in the rock.

If this is the proper explanation then the more brittle members of the formational series, beds which were brittle enough to fracture abundantly rather than to squeeze into new position when deformed should be the places where these escape channels would develop in greatest abundance. Thus the Hilltop quartzite which is the most brittle member in the middle portion of the whole sedimentary series is the chief home of most of the deposits, especially the vein and replacement deposits. But certain other places are favorable also for circulation or escape of these solutions, such for example, as the margins or contact between the sedimentary rocks and some of the dikes especially those dikes or small intrusions which have a general linear extent across the formations rather than parallel to them. In a number of places like this, small deposits have been formed. The best examples may be seen on the Lead Lilly claim but they are not confined to this location.

How these weaknesses have been entered from below is a matter of considerable importance but entirely within the realm of speculation. The beds do not extend directly to or directly toward the ultimate source of the mineralizing solutions themselves. In other words, the beds do not extend to the end at the igneous intrusive masses lying below and cutting slightly into the nase of the block. The Hilltop quartzite, for example, which dips steeply at first, dips more gently and gently toward the southwest and must everywhere be underlain by great thicknesses of limestone between it and the igneous masses from which, it appears the mineralizing solutions must have come. The mineralizing solutions must have had to traverse some of these underlying formations, therefore, for considerable distances before reaching the Hilltop quartzite at all.

What these circulation courses looked like, no one could form a very conclusive image of. They probably were not opened and simple as were the cracks in the Hilltop quartzite at higher levels nearer the surface. But the solutions must have come through in some way and if they followed along any particular courses rather than by soaking promiscuously through, it may be that important mineralization is developed along these courses at greater depth.

In any case conditions are certain to change and structural behavior is certain to change somewhat at great depth but it is not clear at all whether the mineralization channels will become dissipated as if representing thousands of seepages, or whether in contrast they will appear as a very few main penetration channels along which considerable mineral concentration ought to be accomplished.

This is one of the uncertain sides about the behavior in depth. If there were main trunk circulation channels rather than widely distributed seepages, I think that such conditions would be favorable to a larger mineralization development in depth and possibly more easily followed ore deposits than in the higher levels. And if, on the contrary, the other form of penetration or circulation from the igneous sources to the Hilltop quartzite is the proper one, that is by seepage or soaking, then I think that the chances of workable mineralization are less favorable.

On the whole, it seems to me, that some evidence favors the conception of a branching out more and more and to greater complexity as the near surface was reached or approached.

The behavior of the ore deposits in the higher levels, it seems to me suggest certain centers of maximum mineralization as if they were branches from the feeders of these rather broadly distributed deposits. Thus on the Kasper level, for example, that the most prominent mineralization belt lies in the Galena Queen and Hilltop line (claims-?). [illegible] the largest bodies are found there.

If solutions were rising through grot[illegible] the Hilltop quartzite, as we now know it to be, they ought to spread out [illegible] all of the broken ground within reach as the supply continued to come [illegible] below. Thus, even if there was only one point of entrance at depth, they would reach, ultimately, hundreds of places at higher levels with a corresponding [illegible] mineralized ground as these higher levels are reached. The upper levels, therefore, would exhibit the phenomenom of numerous and widely scattered veins and replacements deposits with very imperfect connections laterally but with better connections vertically, all tending to converge downward rather than upward.

At lower levels, therefore, it would be normal for the ore deposit occurences to be more restricted in extent and it might very well happen that still lower one might find very few courses mineralized. This need not be considered a discouraging circumstance or condition. That matter, on the whole, depends on the amount of mineralization actually developed along the principal feed channels.

One of the practical difficulties with the ore deposits of the higher levels is its scattered distribution laterally. It would be an immensely advantageous thing if the same amount of mineral were concentrated along a very few zones or chimneys. My conception is that in depth this condition may obtain, and if so, this condition would be an advantage rather than otherwise no matter whether it is heavily mineralized or not. Still it would be a greater advantage if it proves to be heavily mineralized. In either case it would require less work in exploration than a more scattered type and the deposits are workable or not workable dependent upon the concentration of the ore minerals.

It may be that this is the chief explanation of the fact that the fractures in the quartzite on the Gray Tunnel level show so very little mineralization. I note that the principal mineralization areas on the surface are not immediately over the position of the Gray Tunnel workings, but that on the contrary mineralization is much more pronounced both to the northward and to the southward along the strike of the quartzite bed. If, therefore, this conception of the vertical connections and relations of the feeding channels and the known ore bodies of the upper workings is essentially correct, one ought not to find much ore developed in this particular region where the Gray Tunnel struck the vein but rather to the right or to the left at a great enough distance farther to get under the chief mineralisation bodies of the upper workings.

This is a vital question in connection with the prospects and plans of development and possibilities of the property. It is essentially a structural question or feature but it has to do directly with a working conception of the origin of the ore and its possible distribution. On any other conception than this, one would certainly be discouraged with the showing of the Gray Tunnel because fewer bodies of mineralization appear there for the distance covered than in any other portion of the ground or at any other level. But on this conception of structural arrangement it may simply mean that a lean stretch has been encountered between two widely spaced feeding zones or channels or groups of such channels and that the actual behavior or meaning of the ground at the Gray Level will not be indicated at all until those portions are explored which lie beneath the principal mineral bodies of higher levels.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS

(d) Depth and Primary Change.

The most important problem in connection with the primary mineralization is the question of behavior in depth. Explorations thus far have shown the behavior to the depth of the Kasper Tunnel which cuts the ore deposits at a maximum of 700 to 800 feet below the surface although the lower tunnels will ultimately cut these same beds approximately 300 and 600 feet deeper, neither of them have reached a position or have encountered the proper ground from which to judge the primary ore deposits behavior of those depths.

The only means of judging, therefore, about the behavior at depth is from the condition seen at the surface and at the Kasper Tunnel levels. In this distance no striking or important primary change seems to me to have come in. The primary ores are essentially the same and I see no ground for concluding whether the mineralization is increasing or decreasing in importance and value. On the whole if there is any conclusion to draw at all in comparing the surface outcrop conditions with the Kasper Tunnel it seems to me that the deposits are somewhat larger on the Kasper level and also more prominent in content at this level. Whether this curve will be maintained with still greater amount of mineralization at greater depth I cannot tell, but there seems to me to be no evidence whatever for any marked change one way or the other, and if there is any tendency indicated at all it is slightly in the direction of increased mineralization with depth.

This question is a vital one in the prospects of the company. The deposits already opened are rather widely scattered and many of them are comparatively small. Any improvement in size or richness or in the prominence of connections between them would greatly improve the mine and increase its prospective value. The best that I can say is that there is thus far no evidence of material change. But under liberal interpretation of the conditions shown in the upper workings there is some encouragement toward improvement in this respect. There is some theoritical support for believing that replacement ought to take place some what more readily at greater depth so that the replacement type of ore deposit would have a better chance to develop. Greater depth is also favorable to the development of the disseminated type of deposit as pointed out in the discussion under Types of Deposits. If, therefore, the metallic minerals are abundant enough to maintain themselves at all both of these types of deposits might very well be somewhat better developed at greater depth than they are at the present working levels.

There is no way that I know of to determine whether mineralization continues abundant at depth or how much it changes in character but such evidence as there is in the district, indicates that copper is likely to increase in great depth and lead to decrease as much greater depths are reached. Moderate distances of a few hundred feet have thus far shown very slow or insignificant changes. This sort of a curve will probably be maintained in going deeper and therefore sudden changes to very markedly character are not to be expected. The fact that on the Gray Tunnel level not much mineralization has been encountered has very little bearing on this question since the work along the quartzite at that level is in an intermediate stretch between two principal mineralizations. It will not be until the workings penetrate the ground beneath the larger deposits of the Kasper Tunnel that one will have sufficient evidence of behavior of the ore deposits at this level to base any judgement on.

(e) Secondary Changes and their Depth.

The nature of the secondary modifications of the ore due to leaching and oxidation on the one hand and secondary enrichment modifications at a little greater depth on the other hand have been discussed under the heading Types of Deposits, especially under type 4. The larger replacement ore deposits are

effected extensively, the chief changes being represented by alteration of the ore in its composition and removal of some of the material. There has been very little actual enrichment such as was found in many other districts. Judging from the condition of the ore as now exposed in the workings, I am of the opinion that there is probably comparatively little enrichment to be expected, but it is certain that the secondary effects will ultimately die out, leaving only the primary ore conditions as greater depth is reached. How much farther it will be necessary to go to reach entirely unaltered conditions, it is impossible to say.

A good deal of secondary attack is noted at the Gray Tunnel level but it is chiefly represented by gypsum and the small amounts of metallic mineralization encountered gives comparatively little to draw sweeping conclusions from. The striking thing however, at that level is the development of gypsum, a sulphate of lime, formed by attack of the descending sulphuric acid bearing waters on the lime of the country rock. It appears, therefore, that the secondary attack is largely expended in this level in reaction with the limestone and other constituents of the rock. It is certain also from this occurrence, that the sulphuric acid produced by oxidation of the sulphides higher up in the deposits reaches abundantly to this level, but as far as observed these oxidation processes themselves are not prominent at this level. I would be inclined to think, therefore, that extensive secondary modification of the ores will not carry to any consequence lower than the Rehm Tunnel and that by the time this tunnel level is reached essentially primary conditions will be encountered in practically all of the deposits.

It would be some advantage, of course, and encouragement if one could count on extensive secondary enrichment somewhere in this zone between Kasper level and the Rehm. Of this I have not seen sufficient evidence, however, to warrant expressing any confidence in such an occurrence. Copper is the chief metal to attach itself readily in this way and copper is not abundant mineral in the upper portions of these deposits. The opportunity, therefore, in this direction for much enrichment does not seem to be very good from the mere question of supply. This conclusion is borne out also by the behavior at places where the ore can be studied below ground. In the case of the other metals it appears that they yield less readily anyway to secondary sulphide enrichment than copper, and I have not detected any evidence of that kind of enrichment at all in this ground.

On account of these conditions, I do not believe that secondary enrichment can be figured on as of any economic importance in these deposits. On the other hand, with greater depth, the ordinary alteration type of secondary changes will undoubtedly become less and less pronounced. On account of the effect of this change on milling and mining the change will be an advantage, because some of the secondary products are very difficult indeed to handle. Beyond these sorts of changes, I do not think that any striking differences of a secondary nature are to be expected in the deeper workings.

(f) Present Conditions of the Ore Deposits.

Little need be said in connection with this matter in addition to what has already been given under the other headings in explanation of the ore deposits. It is perhaps sufficient to point out that practically all of the deposits exposed in the present workings are likely to be reached in the upper three levels are essentially mixed deposits carrying both primary and secondary ore. Very locally ore masses may be found now which are an essentially primary condition because of the close texture of the material or other conditions giving them protection from the downward circulating waters. They have not succeeded in penetrating. Very locally, also in other situations ore minerals of wholly secondary character are detected in more or less abundance. Good

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS

illustrations of this condition may be seen at places such as the wulfenite occurrences or in places where the carbonate of zinc is developed. These, however, are apparently not very extensive in the district and in the great majority of cases are closely associated with still unoxidized remnants of primary ore. In spite of the fact, therefore, that simple oxidation, either of one sort or another can be found it is still true that the ore deposits as a whole in the part of the ground within reach of the present exploration carries mixed primary and secondary ore.

This is of chief importance because of its bearing on the problem of mining and milling and marketing of the product. Whatever methods are employed must be based on these conditions looking to the successful handling of a very variable and very mixed type of ore. Even the primary ore itself is exceedingly mixed and variable and this is immensely complicated by the variable secondary modifications and products. The only ore type which does not fall under this generalization is the dissemination type of ore, such as that represented in some of the Eureka and some of the Lead Lilly ground and occasionally in the Hilltop ground and at other places where the ore is so closely involved in the modified limestone that it is protected from most of these secondary changes. The disseminated ore, therefore, can be figured on practically as a primary ore wherever it is formed. Methods that will handle it will undoubtedly handle the primary condition of the other ore bodies as they reach greater depth beyond the reach of secondary attack which is so prominent in the upper workings.

(g) Origin of the Ore and History of the Deposits.

The origin of the ore has been referred to repeatedly in connection with other topics, practically in connection with the discussion of the Types of Deposits. It is possible, therefore, to condense this statement somewhat.

There is good internal evidence, which is supported also by the conditions noted in the general geology of the field, that the ores have been furnished in connection with and probably derived from the igneous intrusions of the district. It is perfectly certain that the metamorphism and the general non metallic mineralization which has modified the strata so extensively are connected with contact metamorphism produced by these intrusives. It is equally clear that metallic mineralization is intimately connected with this same series of processes and differs from it only in a change in the contact of the mineral bearing solutions so that sulphides of the metals were developed more extensively after that change came toward and practically at the close of this contact metamorphic history.

There is further evidence that the ore minerals have come in in solution at a comparatively high temperature because they penetrate rocks of very substantial character and replace minerals characteristic of comparatively high temperature, and high pressure. The combination of evidence, therefore, favors disposition from hot water solutions controlled by igneous influences and precipitation out of solution while in its escape or circulation upward through the formations forming the Hilltop block.

Because of the fact that the chief metallic substances were carried most abundantly at the close of the general mineralization history, the other effects, such as the marblization of the lower beds, the silicification of some of the strata and the development of silicates in other beds was practically before that time. These transformations had made the lower members of the series exceedingly tight and tough and almost impermeable wherever these metamorphic effects were developed. As a consequence, the mineralizing solutions of the final stages found their escape and circulation considerably obstructed or disturbed in those very places which had been formerly the chief zones of mineralization. Instead of following the old lines, they had to find new channels of escape and circulation through other beds which had either escaped the earlier

attack or were so different in physical character as to behave differently and allow new courses of circulation to be opened. It was under just such conditions, I am sure, that the metallic deposits forming all three of the primary types have been made.

Development of these deposits may have taken considerable time and while it was going on there was continuous deformation, represented by the crowding of the block and the additional fracturing and faulting of some of the beds, and these new lines of weakness furnished additional lines of circulation for the later continuing solutions. Thus it happens that the deposits of one type sometimes differ materially from those of another type immediately adjacent, but this difference is not of large significance. They represent different types of mineralization characterizing different stages in the mineralization history rather than any important difference of a more fundamental sort. Undoubtedly also there is overlapping of mineralization in the form of replacement and exchange, as the temperature of these solutions changed and finally died down to extinction.

From the nature of the origin, considering the structural condition of the country rock in which the deposits had to be formed, one can readily see that a variety of deposits ought to be formed and that mineralization might very well be widely scattered. The essential practical consideration is the fact that the mineralizing solutions were rising and escaping solutions and that there channels are chiefly vertical with many lateral subdividings as they pass toward the surface. In this way they spread out probably to long distances laterally wherever weaknesses of sufficient importance were encountered to allow the waters to penetrate. The ore bodies, therefore, are upward branching and spreading bodies, not exactly chimney-like, because too many branchings were possible, but more like the branching of a tree with an occasional marked spreading laterally in any weakness along vein like courses or porous layers.

This conception of the form of the ore deposit has been referred to in another connection. Its importance lies in its bearing on methods of exploring and working such ground, evidentally the easiest courses to follow ought to be those same branches reaching downward toward the main feeding channels or sources. Lateral exploration is much more hit and miss work. There is comparatively little lateral connection in most cases on any particular level but vertically these connections are undoubtedly more continuous.

Toward the close of the mineralization epoch still larger dynamic disturbances gave rise to the larger faults. In many places the ores are cut off and displaced and otherwise deformed in a way that shows beyond question that they were formed before that movement took place. Some of these movements took place so late in the history that they are not now healed up at all. Indeed some of these breaks and displacements may be of an entirely different and subsequent time, not connected with the mineralization epoch at all whereas others, notably those which carry some ore along their courses certainly developed during and toward the close of the mineralization epoch.

Thus it happens that some of the cross fractures are completely filled with ore, some are only partially filled with ore, and others have no minerals along them at all. More of these displacements belong to a period subsequent to the mineralization epoch than before, and, as a consequence, they are not very profitable structures to follow. A streak of weakness, however, which shows some characteristic mineralization along its course, as if it had partially healed up by mineralization of the right type, are profitable lines to follow in exploration because they normally tend to lead in the very courses that the solutions themselves have followed.

It is very noticable in the workings that most of the so called ore bodies follow at no great distance from the hanging wall of the Hilltop quartzite.

This is in keeping with the principal, already emphasized, that the solutions were rising and escaping in their nature and because of the tight character of the hanging wall, could go no farther in that direction. Being held back somewhat in their circulation by that condition, they have been encouraged by this stagnation to drop a part of their mineral load in the most available places in the upper portion of the quartzites.

This has some bearing on the question of depth behavior for example:

1. Has most of the metallic load escaped to this and higher levels, and

2. What are the structural conditions governing the distribution in those parts of the block traversed by the escaping solutions before reaching the Hilltop quartzite. These are discussed below.

(a) The Question possible escape of most of the metals.

Most of the ore deposits are developed far up in the series, above the chief mineralization of metamorphic sort, and in many cases as far up in the series as could be reached, that is, in the Hilltop quartzite because the next overlying member is almost inpenetratible limestone. It looks, therefore, as though the mineral carrying solutions had a very strong tendency to rise and escape. The same impression is gathered from the appearance of some of the structural detail of certain of the ore deposits, for example, the mineralization at the Blacksmith shop Tunnel. In these places the finger like projections, marking out the course of the mineralization even in the dense quartzite, practically always extend decidedly upward instead of extending prominently side wise. Yet the rock appears to be the same or approximately the same in one direction as in the other, and in many cases the bedding weaknesses certainly extend laterally quite as well or better than in the other direction. The fact that these fingers stand so prominently upward leads me to believe that there was a strong rising tendency in the solutions and a very decided attempt to escape to the surface. In some cases they have expended their energy in the work of reorganizing the rock that they penetrated, and have, therefore, deposited all of the mineral load that they carried. In other cases, they seemed to have reached to the hanging wall and on account of that obstruction they followed the weaknesses of that vicinity but hampered by this confined condition they have been encouraged to leave part of their load there along the course of escape. The fact that there is more lead on the Kasper level than on the surface does not favor the idea of large amount of loss through this tendency to escape.

Lead, which is one of the chief valuable metals in the deposits is regarded as having a tendency to carry far from the source of supply in mineralization of this kind. This does not apply so directly, however, to the other minerals. Although there is this tendency to rise far in the series it is noticable also that there is a great deal of replacement of the rock along the way, developing considerably more ore than could possibly have gotten into the simple spaces at any time open for its reception. This replacement tendency, therefore, modified the tendency to escape. Reaction with the walls also must have had some precipitating effect. On account of this replacement and precipitating tendency which may be even stronger at deeper levels where pressure was greater and original temperature was higher, I see no reason for arguing any striking reduction in the amount of mineralization with depth. As far as I can tell, the metal content continued to be furnished in the solutions practically to the close of the mineralization history, and therefore, metallic mineralization ought to appear as the final healing of all of the circulation channels down toward the source of supply. It may be, of course, that the feeding channels were exceedingly finely distributed amounting to a soaking through the rock until openings such as these in the quartzite were encountered to give better outlet.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

(b) Structural Conditions and disturbances of channels for the quartzite.

The quartzite dips down as a layer of rock toward the west. The igneous intrusive masses which were probably the source of the mineralizing solutions lie below and beneath one or two thousand feet of rock strata lying the quartzite. Through this intervening series the mineralizing solutions must have passed to reach the quartzite bed. Since these strata are of different quality from the quartzite doubtless the mineralization behavior in them is different. Perhaps it follows fractures or weaknesses like those in the Lead Lilly ground. Perhaps on the contrary, it simply penetrates these beds, soaking through them in a much more intimate way. It is probable indeed that there is something of both structures. This is an interesting speculation. It is the ground particularly favorable to development of dissemination deposits rather than simply vein fillings or to replacement deposits on a more elaborate scale perhaps than appears in the upper ground. Whether or not this is true I do not think can be proved by any means at hand. The only reason for raising the question is to point out two things:

First, it is not at all likely that the mineralization stays in the quartzite at very great depth, but, on the contrary, it probably swings into the foot wall strata and,

Second, when the mineralization does have the quartzite it must lie in strata where the solutions have had very different and physical and chemical conditions in control of them, and those conditions would seem to furnish greater opportunity for the dissemination of ore minerals and to replacement.

The thing that is not at all certain and that I know no way of getting conclusive evidence on, is whether the type of mineralization or the quality of ore represented is likely to be good or not or to be developed on a larger scale at this depth. This is one of the normal risks of the operations of this ground.

Nothing of any consequence has happened to this ground since the deposition of the primary ores except three things:

1st: Some deformation subsequent to ore deposition appearing in faulting and cruching and this location of the ground producing most confused structure in some places. This is much greater in some parts of the ground than in others and is particularly prominent and confusing at the north end. But it is also prominent in all of the ground to the northward of the Kasper Tunnel. Undoubtedly, also this deformation is emphasized in the upper portion of the mine a great deal more than in its deeper extension. This is because of the crowding of the block with overturning of the upper edges of the strata. As the workings extend deeper this condition will be found undoubtedly very much simpler. Furthermore if the structure can be worked out on the surface, the same principals will apply throughout. These distrubances simply become less and less complicated in depth. The deformation difficulties therefore, are of no very great consequence compared to the whole question of mineralization at depth. Although the ground is much distrubed to the north it undoubtedly can be solved if there is occasion for solving it when the character of the mineralization at depth is solved.

2nd: The whole block has been much eroded. How much has been removed by erosion I do not know but perhaps several thousand feet in places has been cut away. This has not only exposed ground which was formerly at great depth but undoubtedly has carried away deposits that formerly existed in the strata removed. This erosion history has given the ruggedness and form of the present topography and has permitted the secondary and weathering changes that now effect the ores in the upper workings.

3rd: The only other subsequent movement of any consequence is the weathering and leaching and oxidation and other changes of secondary sort produced by supergene agencies. These have been discussed in other connections and require no other statement. The whole combination of subsequent changes due to dynamic

processes and erosion and weathering together gives a great variety of effects in a minor way but they may all be understood readily on the basis of these three conclusions.

E. Summary of Local Geological History.

Although it would be possible to write a comparatively extensive discussion of the geological history represented by this complex district, the essential facts about it can be stated rather simply and briefly as follows:

1st: The whole series of sedimentary formations involved in the block and associated with the mineralization range from Cambrian to Carboniferous in age. They represent a practically continuous series of plastic and organic deposits. They are strongly bedded and fossil bearing and undoubtedly represent a series very similar in its fundamental features to that of the Bisbee Quadrangle.

2nd: At some time perhaps long subsequent to the deposition of the strata, the region was broken into a series of blocks which were crowded one against the other and into new position. This was aided much by igneous intrusion from below and the welling up of great masses of molten igneous material which probably made it possible for the different members to be floated and depressed quite differently one from the other. Thus such a block as the Hilltop block was tilted to the southwest and also jammed over from the east side by the pressure of the block crowding on at that side, which has since been entirely removed by erosion. The base of it probably rests on some of the igneous members just referred to. Projections or intrusions of a similar sort extend out from the principal masses of igneous rock penetrating portions of the blocks themselves, developing dikes and sills and more irregular forms. As time went on, the outer portions of these large masses which had become solidified were cut through by still other igneous material welling up from below and adding further to the complexity under additional disturbances or deformation.

Perhaps there was a time when block faulting was the chief form of development and the time following when igneous activity was dominant in the district but the two effects were more or less tied up together, one being somewhat related to and dependent on the other. The time when these geological changes were developed cannot be determined very accurately but it was at least Post-Permian.

3rd: The chief mineralization accompanied and followed the igneous invasion. The earlier part of it was essentially non metallic, developed as a product of the cooling of the igneous material.

The chief metallic mineralization seems to have formed the closing stage of this epoch and this probably concluded the whole igneous history. It is, therefore, to be attached to the same historical period as the igneous activity itself and represents only a stage of the closing phase of that activity. It came after the chief block faulting and also after some of the cross faulting and deformation but preceeded still another abundant faulting and dislocation that characterizes certain parts of the ground.

4th: Subsequent to these developments erosion developed a surface not now easily reproduced because, on top of it after a long interval of time, a great thickness, lavas and tuffs, were accumulated from a revival of igneous activity in some Tertiary period. There is no means at hand of determining this period accurately, but it is the most recent of the large developments in the district. It is represented by the rhyolites and andesites and tuffs of very large areal extent to the north and west of this ground.

5th: Subsequent to the pouring out of these lavas, and the throwing out of the materials forming the tuffs, erosion began again to cut down the rocks and develop a new topography. Lavas and tuffs may have covered up some of this ground but in large areas it is now stripped off and cleared of this covering.

Th topography is, therefore, not the topography of the time previous to the Tetiary volcanic outbreak. In places it may have a good deal of the same heit where the stripping has exposed some of the higher ground, but, taking th district as a whole, the present topography is a complex of new and mdified older forms.

6th: Secondary modifications represented by leaching and alteration and enrichment of the ores are effects that have been produced in caparatively recent time as erosion proceeded. These changes are going on ns, but the process is slow and no changes of consequence are likely to be noiced in moderate length of time.

Ne York City,
ay 21, 1920.

Charles P. Berkey
Geologist.

PHONES: OFFICE - MUTUAL 4830
RES. - LAFAYETTE 8276

FRANK R. WICKS
CONSULTING MINING AND INDUSTRIAL ENGINEER
315 WEST FIFTH ST., LOS ANGELES 13, CALIF.

Copy

THE HILLTOP GROUP MINES.
Cochise County, Arizona.

GENERAL DESCRIPTION, and
PROGRESS REPORT OF CURRENT OPERATIONS.

Date of this Report: November 3, 1948.

Dates of most recent examination: Oct. 29—Nov 1, 1948.

Preliminary Statement: The information contained herein is based on personal knowledge of the property and its development since June 11, 1947, including five months of resident supervision as engineer management in 1947.

Type of Ores: Lead, zinc, copper, tungsten and silver minerals; named in the order of their importance. Base metals

Location: In the east-central portion of Cochise County, Ariz., which is in the southeast corner of the State. 26 miles south of San Simon, Ariz., and the same distance northeast of Rodeo, New Mexico. In Sections 32 and 33 of T-16-S:R-30-E:Gila & Salt River B. & M. Approximately adjoining the easterly boundary of the Wonderland of Rocks National Monument. In the Chiricahua Mountains.

Holdings: 26 claims in original group, mostly full sized, 600' x 1500', all of which are unpatented lode locations, as one contiguous group. 20 of these have been mapped and surveyed, and were all located prior to the year 1920, and the identity of each one has been maintained since that year.

6 additional claims approximately adjoining, but of more recent location, which have not been surveyed. These have some overlap with claims of other ownerships, but are mostly off of the main structure.

19 other claims of recent location covering ground that was formerly contained in the original group, upon which titles had lapsed prior to 1947, but relocated and joined to the group.

Area: Combined area is almost 1,000 acres, covering about three miles in length along the main ore zones.

Titles: Under purchase lease to Gould & Watson, and being operated by Piedmont Mines, Inc., an Arizona company controlled by them. Chain of titles has been well established and is of record and all title papers are in escrow pending completion of purchase payments.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATIONS AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

Roads: Paved highway to San Simon, Route #86. Thence graded, gravelled, road south 20 miles on slight grade. Thence 6 miles westerly on mountain road with moderate to steep grades to camp buildings at lower edge of property on the Empress and Empire Claims. Additional side road about five miles up Whitetail Creek Canyon to upper workings on Hilltop and Hidden Treasure Claims.

Post Office Address: Portal, Arizona. Reached by RFD daily mail deliveries to Hilltop, Arizona. Former postoffice at Hilltop could probably be reopened if desired. Telephone line to headquarters house on properties, but nearest present phone service is about two miles.

Shipping Points: San Simon, on the main line of the Southern Pacific R. R., where there is an existing lease for a loading ramp and where local freight and express can be sent and received. San Simon is about 200 miles from the El Paso smelting works.
Concentrate mill products and ore can be shipped by truck from the properties to a milling plant at Lordsburg, New Mexico, a distance of 50 miles, of which 30 miles is on main paved highway. This is referred to later in this report.
Rodeo, Hidalgo County, New Mexico is also an alternate shipping point, being the same distance from the mines and slightly nearer the smelter.
Willcox, Arizona is an alternate shipping point for ores from westerly portals of the property, a distance of about 40 miles. A loading ramp there is available on rental if ever needed.

Supply Points: San Simon, 26 miles for camp supplies. Tucson 150 miles; El Paso 200 miles; Phoenix 265 miles. Lordsburg 50 miles.

Elevations above sea level:

San Simon 3611 ft.	
Hilltop Townsite 5840 ft.	
Rhem tunnel 6050 ft.	
Gray tunnel 6450 ft.	
Blacksmith workings, east portal	7200 ft.
Blacksmith workings, west portal	7130 ft.
Apex above Blacksmith workings	7300 ft.
Highest point on property	7550 ft.

Mining District: California. Forest Reserve: Coronado.

Timber: Small timber for camp fuel and ties on the ground. No large timber. Nearest saw mills at Duncan or nearby on the Arizona-New Mexico line, northerly from Hilltop.

Climatic Conditions: Properties can be operated all year from lower tunnels; upper workings are frequently snow bound for short periods in winter.

Power: Deisel and gasoline engines now in use; probability of obtaining government single phase power at an early date, as it is understood that a projected line will cross directly over the claims. May and probably will be converted to a three-phase power line soon thereafter. Transcontinental compressed gas line passes within 10 miles of the properties. It is believed that gas for both power and furnace processes could be obtained therefrom at prices that would make the consideration of local smelting and local power development attractive.

Present Operations: Now in operation with a small crew on opening, sampling and repair of main workings and on the installation of equipment. No ore shipments or direct ore mining has yet been attempted but preparations for doing so are nearing completion.

Total Underground Development: These are approximate but conservative estimates, showing the magnitude of the development and mining program that the properties have experienced:

Main cross-cut tunnels and adits, in excess of 12,250 feet or about 2½ miles.
Main drifts on ore zones and now accessible, in excess of 10,000 feet.
Main drifts now not accessible, but most of which can be reopened if desired, about 2500 feet.
Stopes, raises and chutes open for use about 2000 feet.
Stopes, raises and chutes closed by caving, about 3000 feet.
Shafts, winzes and miscellaneous about 1,000 feet.

Deepest underground penetration on ore: 1350 feet below the outcrop on vertical line, equalivent to about 1700 feet on the dip of the vein.

From the above it will be noted that almost five miles of underground workings are now open for examination and use. Nearly all crosscut workings stand and are in good condition without timber.

Water: About 125 gallons of water per minute natural flow from the lower, or Rehm tunnel, though this varies slightly from season to season. All the remainder of the mine is dry except for an underground spring on the main intermediate tunnel, the Kasper, where a small basin is provided for use on that level.

ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

Mining Equipment: 3 to 4 miles of mine track underground and on mine dumps, installed and in use.
About 20 mine cars, of which most are servicable.
One Deisel driven air compressor on wheels.
Air tools for two mining crews, drills, hose, tanks, steel and miscellaneous items.
Two trucks, both late model and in good condition.
Electric lighting plant 15 k.w. gasoline portable type.
About 1½ to 2 miles of water and air piping.
Miscellaneous stock of small tools and parts.

Milling Equipment: One Universal semi portable crushing plant complete, with extra coarse crusher, extra Deisel drive for same, and with two two-compartment roughing jigs for making bulk, rough concentrate, installed below lower mine workings.

Surface Equipment:

There is one steel building, 40 x 60 in area, 20 feet high for power plant and shops, with heavy overhead crane. There are 29 additional buildings of frame construction, comprising a 8-room headquarters house and office, warehouse, store, laboratory, cabins ranging from two rooms to four rooms each. Nearly all are in usable condition and many have recently been partially overhauled. Water system in townsite and lighting system to most of the buildings.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

General Description of the Properties:
These Hilltop properties taken as a whole, form one of the largest all-tunnel development projects in Arizona.

The principal claims, on which the outcrops are found, lie along a high ridge of the Chiricahua Mountains, and the bordering claims cover areas on both sides of the steep slopes of the Range. Thus, to get from the camp on the northeast sideline to the Kasper portal, near the southwest edge of the property means a climb of 1500 feet by road or trail and a descent of 900 feet.

To illustrate the mining problem and mineralization graphically in terms understandable by persons not versed in mining terms, it is best to picture the section of the mountain under discussion as a tent-shaped structure, with a ridge of the tent, along the outcrops of the vein, nearly two miles long, and the width 3/4 of a mile.

The mineral zone can be represented by a partition, roughly 100 feet thick extending from the ridge downward through the workings for 1700 feet to the lowest of the three tunnels and probably far below. This partition-like ore zone leans or dips southwesterly at about 15 degrees from the vertical in the upper sections but gradually flattens to 18 or 20 degrees

on, in and immediately above the lowest workings.

To continue the illustration in similar terms, the mineral zone, or partition, is made up of a series of up-and-down bands, like vertical stripes in an awning. The whole of the zone is mineralized, but only certain bands contain enough mineral to be of commercial value. These are called ore shoots. They may be wide or narrow horizontally, and they may continue for long distances up or down, or they may be relatively short lenses.

Extensive crosscutting was done in order to get at the ore bodies without hoisting. In retrospect this seems to have been ill-advised, but from the present standpoint it is certainly of primary importance for immediate and future operations. It makes for very low-cost operations as compared with conventional shaft mining with the result that much lower grade ores can be considered commercial than would otherwise be possible.

History: It is reported to me that the original discoveries of lead and silver in the District were made near the present Blacksmith or upper workings, on this property in the years of 1880 to 1890. Some mining was done then. The main interest appears to have been in the high grade silver sulphide minerals. There are many shallow shafts and other hand drilled openings along the outcrops where ore was mined and sorted.

Subsequently, a discovery of copper ore on what is now the Birthday Claim, caused the Kasper tunnel to be driven from what is now the southwest portal. The Kasper was later driven 1800 feet to the main ore zone and extensive mining was begun, with almost two miles of drifting and miscellaneous work. A further extension of the Kasper crosscut was eventually made, 1500 feet beyond the ore zone, to an opening on the easterly side above the present townsite.

Two long crosscuts below the Kasper were driven later and used for main haulage ways for Kasper ore in addition to serving for more limited mining operations on those levels.

The Blacksmith property with its upper tunnels and workings comprising the Hilltop Claim and those immediately adjoining, was under separate ownership for many years. It was inactive and did not become a part of the project until later years. Thus substantially all of the past production of ore came from the Kasper workings or immediately above and below the 6750 elevation.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

The old company which owned the group, comprising 38 claims at the time, in 1938, spent huge sums on development. That company mined only about 12,000 tons of ore. The production was limited mainly to hand sorted clean lead sulphide and to oxidized lead-silver ores which had relatively high silver value and little of no lead. The remainder of the ores encountered during that work was not attractive to them because of the lack of processing equipment and because of very low metal prices.

The average price of lead bullion at New York, upon which smelter settlements are based, during the 11 year period of 1928 to 1938, inclusive, was under five cents per pound. This is equal to about 3 cents per pound at the smelters and not more than two cents for contained lead in the ore at the mines. Silver prices during the same period were approximately half of the current price per ounce. Thus this is one more instance where conditions quite apart from the mining property itself determine the difference between success and failure, or determine when and if a property may be operated.

After the original company abandoned the property, there were numerous sampling and examination programs by others. One complete survey and sampling project is reported to have cost $14,000. Excellent maps and assay records from this work are now available to us and have proven quite accurate. Reports were generally unfavorable as to the shipment of crude ore but favorable as to mill processing even in the face of much lower metal prices than are now in effect.

This means that it is necessary to recast the calculations as to commercial value of remaining ores, based on current prices for metals and current operating and supply costs. In doing so, it is realized that the huge amount of prior development which was theretofore unprofitable, is now of very great importance from the standpoint of both time and production costs.

Metallurgical Discussion: First it is well to know that the Hilltop Mines ore carries but little gold; no pay quantities are present in the general run but gold does occur in spots in connection with copper ores. I have the impression that there is a definite tendency for increase in gold content with depth but data are too limited as yet to be definite.

INTERIOR DEPARTMENT OF MINERAL RESOURCES
MAKES NO REPRESENTATIONS AS TO THE ACCURACY
OF THE CONTENTS OF THESE DOCUMENTS.

The main mineralization is in lead, as galena, the sulphide form and as cerrusite or sand carbonate, with a lesser proportion of anglesite, the sulphate of lead. The two latter minerals can of course be considered as results of secondary alteration in place or as secondary re-precipitation after alteration of galena.

After some months of experience with these ores, I have developed the theory that the mineralization of the Hilltop structure had best be considered as representing three separate phases, or perhaps separate periods of mineralizing influences, in such manner as to present for consideration at least three main types of ore:

1. Banded or ribbon like agglomerations of mixed sulphide minerals, representing primary unaltered ores shown in the lower levels, principally in the Rehm tunnel workings. In this ore, the lead assay runs from 10% to 15% lead, somewhat less in zinc, about 1 to 2% copper and a silver content of almost an ounce per unit of lead. In this ore the gold content seems slightly higher than elsewhere.

2. Replacement types of lenticular deposits of mixed sulphides, wherein the minerals are relatively coarse crystalline, where the ore is partly oxidized throughout, and where we find ore of this type in silicified limestone bedding as well as in and along transverse lines of weakness near cross dike-faults. In these ores we find sulphide minerals at and near the surface and in the outcrops, but we also find oxidation products more than a thousand feet below the surface.

3. Massive or nearly solid oxidized mixed minerals of lead carbonate, lead sulphate and zinc carbonate which appear to be replacement lenses and shoots of great size and length. Herein we find oxidation extending from the surface down to as deep as present workings extend. These are in siliceous gangue or silicified limestone and occur as parallel deposits along the same bedding planes as the banded primary ores.

In the replacement type lenses of the #2 class the silver content is extremely high in spots but averages low. In the #3 class the silver is somewhat less than the primary ores, averaging perhaps half that in the banded type.

All the ore seems to contain a more or less constant iron percentage of 8% to 10%. The gangue minerals in the ores are varied. Free silica prediminates in ores along the contact zones. Calcite, kaolinite, barite and flourite are noted in decreasing proportions in the order named.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES DOES NOT REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS

In recent months, mainly because of intensive investigations made by Dr. Watson, it has been shown that the primary ores carry substantial amounts of tungsten, mostly as scheelite but also as wolframite. Information on this subject is not yet complete, but the tungsten minerals appear to be directly associated with the banded ores as a part of the original mineralization and also occur separately in places quite apart from the sulphide zones. No definite percentages can be stated as yet, but the wide distribution of these minerals in the lower and second tunnels indicate that tungsten may be a very important product in mill processing.

Much of the zinc mineral in the ores is marmatite, which is a black zinc sulphide with varying proportions of iron sulphide in solid solution. A limited amount of the normal zinc sulphide, sphalerite is noted in the primary ores. There is no definite relationship as to proportions of lead and zinc minerals. It is significant to note however, that the zinc minerals carry very little if any of the silver or gold. The silver seems to be associated almost entirely with lead minerals.

From this metallurgical discussion, it will be seem that mill processing, for the separation of the several useful minerals is paramount. No revenue whatever can be realized from either zinc or tungsten if ores containing these metals are shipped to lead smelters even though they may and probably do represent at least half of the theoretical assay value. Likewise, lead smelters and processers do not like to handle high zinc crude ore at all, and apply direct or indirect penalties accordingly. Hand sorting of crude ore, such as was formerly tried, is now more or less out of the question because of high labor costs for so doing.

Milling Program: In order to take care of this problem, and to make it possible to get into early production, a plan has been worked out, for at least temporary operation, whereby crude ore can be given a preliminary or rough concentration at the properties; the product resulting from this roughing operation will then be trucked to a flotation, concentration plant at Lordsburg where separate products of lead, zinc and tungsten minerals will be made for shipments to suitable finishing plants.

Some of the highly oxidized ores can and will no doubt be shipped direct because of high silver contant, but these must in most cases be mined at the same time that the mill ores are taken out, so that for the most part the whole program hinges on mill processing.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES MAKES NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

The Lordsburg milling plant, is 50 miles from the Hilltop properties, and is not a part of the Hilltop holdings but is under lease by Watson & Gould as a separate property. This plant is a very important factor in the proposed program; it was operated for many years as a fluorspar concentrator, and will need some remodeling for adequate selective flotation of mixed sulphide ores. It is now equipped with a crusher, a ball mill, two batteries of flotation cells, an excellent assay plant, and numerous items of equipment necessary in connection, including electric power. It is alongside of the railroad on a separate siding, with loading bins for carlot shipments. I understand that additional ground has been acquired for tailing storage.

Ore showings in the Hilltop Mines: It must be understood that while many places in the mine workings have been extensively mined, the total tonnage of ore removed is but a fraction of the ore in sight and available based on current metal prices and assuming that mill treatment will be available.

The most notable feature may be described as a single ore shoot which may be followed from the surface down through the workings of each of the main levels for a total distance of almost 2,000 feet on the westerly rake of the shoot, and which appears to be wider, stronger and thicker at the lowest known point than in workings above. This shoot which is well over 100 feet in width and 30 feet in thickness in a raise just above the Rehm or lowest tunnel, was extensively mined from the Kasper level to near the surface and from the same level downward for about 100 feet. It was somewhat less mined from the intermediate Gray level but has only been tapped by the Rehm workings. At this point the primary, banded ore is over 20 feet thick and a few feet above there is a parallel deposit of 8 to 9 feet of oxidized ore such as previously described.. This showing is at the head of a raise 178 feet above the Rehm tunnel. Further extension of the main adit will almost certainly show this same chute at the tunnel level, but it has not yet been opened at that point.

Roughly paralleling this huge shoot, and apparently almost adjoining it at the lower level, is a similar but smaller shoot. Extending both ways from these main showings throughout the mine, and particularly on the Kasper level there are many ore shoots on which extensive mining was done during early operations but very little ore was taken below the Kasper, leaving some 900 to 1,000 feet of ore on the rake of the shoots that is open and ready to mine.

THE ARIZONA DEPARTMENT OF MINERAL RESOURCES HAS NO REPRESENTATION AS TO THE ACCURACY OF THE CONTENTS OF THESE DOCUMENTS.

At the time of my original examination, it was my guess that we would find approximately 200,000 tons of ore of one kind or another in workings above the Rehm level, of which perhaps 40 to 50,000 tons would be represented by broken ore, stope fill and by-passed pillars from the former operations. I see nothing in subsequent exploration of old workings to substantially change that original estimate. I was particularly pleased, however, to be able to observe during my most recent trip to the properties, that the primary ores were so much in evidence in lower workings heretofore inaccessible for examination.

On the Kasper tunnel level there are at least 20 places where relatively small amounts of ore can be taken, and from this level upwards to the Blacksmith property it seems evident that a large amount of ore is in place that is well shown by wide vein in the Blacksmith east winze but which has never been followed up from the Kasper level. Each of these shoots can reasonably be expected to continue down into and through the lower workings, as some are now know and identified but others await more extensive development from below.

Recommended Program: The Hilltop properties have great merit. At current prices and with reasonable expenditures for equipment and facilities, a profitable project can be developed in a few months. Some small shipments for revenue can be expected in the meantime. The ultimate program and the overall production can not be predicted. Metal prices will determine this to a considerable extent and of course, the general trend in such prices is and has been upward for some months.

ARIZONA DEPARTMENT OF MINERAL RESOURCES
NO REPRESENTATIONS AS TO THE ACCURACY
OF THE CONTENTS OF THE DOCUMENTS.

The mineral content and characteristics of ores below the present workings will have an important influence on the future production, and the main features of this phase lead to most optomistic conclusions.

Taken as a whole, I strongly recommend the Hilltop and the project as now outlined. In making these recommendations, I am fully aware that there are certain metallurgical problems to be met and that mine-labor costs are extremely high, but these are conditions that can be successfully met. I recommend the acquisition of certain outlying claims and properties, particularly on the easterly side of the Hilltop holdings, not only as sources of additional ores but for convenience in providing space for waste disposal and townsite areas. These things have been verbally discussed in detail.

Respectfully submitted,

Frank R. Wicks

Consulting Mining Engineer.
Registered engineer #2370, Calif.

PHONES: OFFICE - MUTUAL 4830
RES. - LAFAYETTE 8276

FRANK R. WICKS
CONSULTING MINING AND INDUSTRIAL ENGINEER
315 WEST FIFTH ST., LOS ANGELES 13, CALIF.

Copy

January 20, 1949.

Dr. E. W. Watson,
Hilltop Mines,
Portal, Arizona.

(Progress Report.)

Dear Dr. Watson:

Since the completion of my rather lengthy report, dated November 3, 1948, in which the main features of the Hilltop Mines were discussed, it has been suggested by you that periodical progress reports should be submitted from time to time as a matter of record. Accordingly, I was at the properties and in the mines during the period of Jan. 10th to Jan. 13th. This report covers briefly the matters of main interest which have developed during the six weeks interval since the previous examination.

During the last few days of December and the first part of January, exceptionally severe weather forced an almost complete suspension of activities. In due time, when equipment is placed under cover and proper preparations for winter conditions have been possible, delays of this kind are not likely to be experienced.

Early in November, bad air prevented adequate access to the outlying portions of the Rehm, or lower level, and the Gray or #2 level, so a fully satisfactory study of the workings could not then be made. Since then, the fresh air circulation in the mine workings has been substantially improved, so that essentially all of the Rehm workings and all but the southerly drift working of the Gray are now accessible. This was accomplished by clearing ore, waste and debris from the main vertical raise connecting these levels that was formerly used as an ore-transfer chute from upper levels to the main haulage facilities on the Rehm. This raise is well opened but has not yet been retimbered or reconditioned for manway use. It can, however, be used as an emergency exit if necessary until better arrangements are made and is of very great importance in the control of mine ventilation.

The opening of this main raise was an exceedingly difficult undertaking, requiring some three months during which some 700 mine carloads of material was removed, and while this work was in progress very little other constructive work could be done. The useful results accomplished are worthy of special comment.

On January 13th the work of laying 3,000 feet of 4" pipe in the Rehm tunnel had been completed, or nearly so. An additional 3,000 feet of 3" pipe had been delivered to the portal of this tunnel and made ready for distribution in the workings. These two sizes of pipe are to be used for compressed air lines to mine workings for operating drills and mine equipment.

In addition, about 2500 feet of 1¼" new galvanized pipe had been laid in the Rehm tunnel for a water line, leading from clean underground springs to the townsite water system. In this manner good domestic water for camp use and fire protection is being provided. Storage tanks needed for this system have been purchased and are at the freight station for delivery to the mines as soon as roads conditions permit.

During the disturbed condition of water supply while the clearing of the raises was in progress and while the Rehm tunnel was being reconditioned for use, it was not possible to supply steady flow of clean water for the milling plant, and cold weather also made it impossible to operate the plant staisfactorily, so no serious attempt was made in the production of jig concentrate from either dump ore or mine ore from the main raise.

The diesel driven air compressor which had been previously used at the upper or Blacksmith workings has been brought down off the mountain and reset at the Rehm portal. This is to be used to furnish compressed air for mining until delivery has been obtained on a large 10-drill compressor recently purchased from a nearby property. The present compressor will serve very well for a month or two until the larger one is ready for use.

A 300 h.p. Fairbanks Morse vertical diesel and electric generating plant has also been purchased for installation in the main power plant building at the townsite. It will likely require three months for moving and setting this power unit, and perhaps somewhat longer to get transformers that are needed in connection, but eventually this will provide ample and economical power for sizable mine and mill operations. A smaller power unit for lighting purposes and numerous other items of equipment have been purchased but can not now be listed in detail.

During my most recent trip, it was possible to study the conditions in the Rehm and Gray levels in greater detail than has heretofore been possible, and to plan a more or less definite immediate and long range program for mine operation. After considerable discussion with you and your superintendent, it was determined that mining could be begun in the No. 1 and No. 2 ore raises from the Rehm level soon after the large compressor is in use, but in the meantime it seems best to concentrate mainly on an access raise starting near point #115 in the westerly Rehm workings. This raise will be headed about N-40°W on an angle of about 57 degrees of slope, to connect with the Gray workings and subsequently to continue in more or less the same line to the Kasper and Blacksmith workings.

This planned raise will start in ore, will continue in or near ore in one of the best developed and best known ore zones, and will come up under known ore of good grade on the Gray level. The most important feature, however, will be that it will serve as a transfer chute from the upper levels to the main haulage point on the Rehm and will avoid immediate installation of extensive trackage and air piping, etc. on the upper levels, such as would be needed if we attempted to use the old transfer chutes.

I strongly recommend that this new access raise be begun as soon as possible and driven with all reasonable speed without side stoping therefrom until it is connected with the Gray workings, a distance of about 440 feet. However, in connection with this work, it will likely be advisable to run an auxiliary raise about 50 feet to the west or thereabouts, on ore. This auxilary raise need not be kept straight but can follow the ore body, and by making cross connections at intervals, it will serve for safety and ventilation purposes as well as being a source of ore. This secondary program may require some alteration as the work progresses.

We also discussed a general but limited program for further extention of the main Rehm workings to get under and into other known ore bodies that were mined on the upper levels but not yet encountered in the Rehm. Am inclined to recommend that this development work be deferred for a time, at least until my next examination trip. The work definitely planned will fully employ all facilities now available.

I am much pleased by the accomplishments in recent weeks.

Yours very truly,

Frank R. Wicks

PHONES: OFFICE - MUTUAL 4830
RES. - LAFAYETTE 8276

FRANK R. WICKS
CONSULTING MINING AND INDUSTRIAL ENGINEER
315 WEST FIFTH ST., LOS ANGELES 13, CALIF.

March 18, 1949.

Dr. E. W. Watson,
Piedmont Mines Inc.,
Hilltop Mines,
Portal, Arizona.

(Progress Report #2.)

Dear Dr. Watson:

During the period of March 7th to 11th, I was at the Hilltop properties on a routine trip to follow up the work at the properties that was discussed in my report of January 20th, 1949, representing an interval of some two months.

Exceptionally severe winter weather conditions during February interfered seriously with all outside work for a time, even to the extent of blocking main highways in the valley areas and along the railroads at both San Simon and Rodeo. That this situation was exceptional is evident by the fact that the total precipitation, as rain and snow, is said to have exceeded that of the previous five years combined. Reasonably good weather has prevailed in March to date.

Since the previous report, essentially all of the existing workings of the lower, or Rehm tunnel have now been cleared, drained and made ready for inspection and for use. Minor caving had occurred at some points during the 20 years since serious work had been done, but only 12 or 15 timber tunnel sets were required to recondition and safeguard 1½ miles, which is a rather remarkably good situation. Inspection of the two vertical raises near the inner end of the Rehm, which extend up into the No. 3 ore zone, shows that these workings are in good condition except for water control and can soon be made ready for use.

The work of laying 3,000 feet of 4" pipe for compressed air was nearly completed two months ago but some of it had to be reworked because of having developed air leaks. It is now in good shape. An additional 3,000 feet of 3" pipe has now been laid extending out to the No. 1 ore raise and out near working faces in the northwest arm of the Rehm workings. From these points 2" lines will be used as needed, which will consist of some old pipe that is already in place and 400 to 500 feet of new pipe which has just been purchased and delivered.

The 1¼" pipe line for domestic water for camp use has been placed in service; some of the surface lines required renewal but now appear to be in quite good condition. The water for this system is taken from underground springs in a now-mineral area and is not contaminated in any way by the water flowing from the main workings.

Generally the flow of water from the Rehm tunnel is on the increase, partly because of better drainage brought about by the work that has been done and partly because of the heavy precipitation during recent months. Water in ample quantity is now available for the operation of the jig plant that has been placed at the foot of the Rehm dump.

Electric motors have been provided for the driving of the two jigs and accessory apparatus at this milling plant and these were being installed during my visit. To drive these motors and to furnish power for lighting and for shop needs, a 25 k.w. diesel electric generating unit has been purchased and installed in the main power house building. This is a very good unit; it will be ready to run in a few days, as soon as the wire lines can be run from the main building to the mill.

Considerable ore of various kinds and grades has been accumulated at the Rehm dump ahead of this milling plant which can now be run through for metallurgical testing and for production of coarse jig concentrate, which will likely be of direct shipping grade as a rougher concentrate. What degree of separation between lead and zinc minerals can be accomplished in this jigging plant remains to be seen, as we do not yet have sufficient data upon which to base an estimate of results.

Weather conditions prevented the moving of the large air compressor and the 300 h.p. electric generating plant that was purchased a couple of months ago; however, arrangements for this work are now being made. An additional truck of the 4-wheel panel body type was purchased and placed in use at the properties during the past month.

The old powder house near the Rehm portal has now been reconditioned and brought into required, standard use for storage of explosives and numerous other surface jobs have been completed. These jobs, in addition to the laying and relaying or rebuilding of much mine track in the workings have amounted to an enormous amount of detail work, necessary but troublesome because of the time and attention involved.

During this recent inspection tour, it was possible to give closer attention to the mining program on and above the existing Rehm workings and the methods required to reach the ores in the levels above. It had not been possible to begin the work recommended in my last report, for raising from near point #115 as shown on the main maps, to connect with the Gray level in the No. 1 ore zone, but piping and preliminary work has been completed to this end. As an alternative to this, consideration was and is being given to a proposed raise from a point known as "D", somewhat farther in on the northwest arm of the workings where ore is in sight for a distance of some 100 feet along the drift and where it is thought possibly a quicker connection to the Gray level might be accomplished. While I prefer the original plan, it seemed best to do some preliminary work at point "D" to break into known ore and see what the exact situation is.

In this connection, it is well to bear in mind that all existing faces and walls of the Rehm workings have been exposed for 20 to 25 years and partly under water at times. Thus it is difficult to distinguish ore zones, formations or typical rock structures without considerable time and work to freshen up old faces. The is being gradually worked out.

The far heading of the northwest arm of the Rehm near point "E" has just been cleaned out in such manner that the ore zone at that point could be examined and sampled. The showing is quite good; do not have assay results as yet; after some work along the zone, from point "B", "D" to "E", then I would recommend the extension of these workings from co-ordinates 25-43 to 26-42, southwesterly about 100 feet but following ore. This will furnish some production and will be important in certain geological analysis work.

There are three jobs that are of paramount importance in the vicinity of the No. 3 ore zone at the end of the main Rehm crosscut adit. These can be carried on simultaneously if men are available:

1. The main heading should be extended straight ahead for a distance of about 400 feet, or until the overlying blanket ore-structure is exposed and cut through to the hanging wall. Minor cross faulting may bring this ore into the main adit somewhat less than 400 feet from the present face. This is very important as it will likely afford a main working point for large scale and economical mining in the near future.

2. Ore raise No. 1 needs minor work, ladder repair and some means of diverting ground water to keep it away from ladders and out of the ore bin section of the raise. Temporarily, this raise will serve as an access to good mill ore, but eventually should be used only for selected high grade.

3. Ore raise No. 2 also needs laddder repair, water diversion and a little timber work. When this is completed, then the southerly face of the drift at the head of this raise should be extended southerly or southeasterly to a connection with the existing workings in No. 1 raise. This is necessary for safety, for ventilation and as a means for getting at exposed ores at this point. Until this connection is established, it will not be safe to begin actual stoping in either No. 1 or No. 2 raises. Approximately 60 feet of driving is necessary at this point. Most of it, and probably all will be on ore.

The whole situation in these mines has now reached the point where definite and careful consideration must be given to the installation of a complete milling plant on the properties. The work accomplished during the past few months has quite definitely proven the former estimates of 200,000 tons of available ore is conservative and well founded. It will be possible

$50,00 ore. from all reports + findings.

and quite advisable to ship a few cars of crude ore direct to smelters in the near future, but it must be fully realized that crude ore shipments will net less than half of the profit that could be realized by mill processing of the same ore. Likewise, it is uneconomical to attempt to extract specially selected, higher grade ores for direct shipment unless and until the mill-grade ore can be taken at the same time from the same locations.

The present jigging plant will serve very well for a brief time, but this plant will not and can not be expected to make a high extraction or a satisfactory separation of minerals. Likewise, I am not too sure that the operation of the Lordsburg mill for a finishing separation plant will prove to be profitable, or will show enough improvement over the work of the jig-roughing plant to justify the expense of retreating at Lordsburg. It will of course serve its original purpose of working out metallurgical problems and furnish some commercial product for a time, but it will not replace or obviate the necessity of having a complete plant on the properties. At least that is my present analysis of the subject until more data are available.

In the meantime, some preliminary flotation concentration tests made in the Terry laboratory have shown quite well that we can expect an excellent recovery of all sulphide minerals and a very fair separation into several products, but the work also shows a reasonably good extraction of the lead carbonate and lead sulphate minerals found in some considerable proportion in the principal ore zones. This work should be continued on a systematic basis, as an aid to ultimate mill design although I do not anticipate any real serious metallurgical difficulties.

Taken as a whole, I am very much impressed with the progress that has been made in the work during the past four winter months, accomplished under difficult conditions and at a very considerable personal risk to yourself and your men. That these results have been accomplished without injury to anyone is worthy of special commendation.

Yours very truly,

Frank R. Wicks

Consulting Mining Engineer.

PHONES: OFFICE - MUTUAL 4830
RES. - LAFAYETTE 8276

FRANK R. WICKS
CONSULTING MINING AND INDUSTRIAL ENGINEER
315 WEST FIFTH ST., LOS ANGELES 13, CALIF.

April 20, 1949.

Dr. E. W. Watson,
Piedmont Mines Inc.,
Hilltop Mines,
Portal, Arizona.

(Progress Report #3.)

Dear Dr. Watson:

For record purposes, this letter is submitted as a review of my observations and our mutual discussions during my most recent visit with you at the Hilltop properties, during the period of April 11th to the morning of April 14th.

There are as yet no new developments that would tend in any way to modify the various suggestions and recommendations embodied in my previous progress reports, and thus it is not necessary to review these.

Essentially all piping for compressed air supply in the Rehm workings is now in place to the headings where immediate work is contemplated, except that which will ultimately serve the No. 1 main raise and the main adit heading. This portion is partly in place but not yet connected for use.

No actual mining has been done during the interval since my previous visit, because the original air compressor available for this purpose took fire and partially burned when placed in service. Immediately after this occurrance, a substitute air compressor was located, brought in and installed in the main shop building, and this was about ready for use last week. This unit is an old type straight line Diesel driven, plate valve single cylinder compressor capable of furnishing air for about four machine drills, and when adjusted properly, it should serve for all necessary purposes until the larger unit can be set up. Old type compressors like this one may not be quite so economical on fuel, but they are much less trouble to maintain because of relatively slow speed and heavy build.

Substantially all of the parts have now been delivered to the property for the large two cylinder air compressor and the 300 h.p. Diesel electric plant referred to in my previous reports. These units were so heavy as to require dismantling for transportation. It will take at least two months to place foundations and reassemble the equipment for use. In the meantime, mining work can proceed without delay.

It was decided to move the 25 k.w. semiportable Diesel electric generating unit, mentioned in the previous report, over to the jig-milling plant for greater operating convenience while mill tests are underway, and this has been done.

The jig-mill and accessory equipment has been in operation intermittantly. Changes in jig speeds, screens and

the like were necessary as might be expected during test work. Samples of products from the mill have been submitted for analysis. This plant is now ready to run. I suggest that the first shipments be made direct to the smelter without further mill treatment, at least one or two carloads in order to definitely determine what net returns can be obtained in that manner, before expending any considerable amount of money for regrind and flotation finish concentration.

In connection with the latter problem, it might be well to look into the possibility of running some flotation tests on both ore and jig plant concentrate at a custom mill that is now operating at Tombstone, Arizona. That plant is now treating lead-zinc ores and is equipped for selective flotation, as well as being able to receive and grind crude ore. Tests there would have to be made in lots of not less than 150 tons and would require complete clennout of tanks and bins before and after test runs and would require a truck haul of some 70 miles from Hilltop to the mill, but even so, it might be worth considering in lieu of preparing the Lordsburg plant, as originally proposed. This Tombstone plant has been equipped for some months but has not heretofore been available for such test work.

Also, I suggest that investigation be made as to the proposed custom milling plant which I understand is to be installed at or near Deming, New Mexico, by the A.S.&R.Co., on which work is expected to start shortly. If the preliminary information is correct, this might obviate the necessity of any milling at Hilltop. I was unable to get any information as to type of equipment proposed for that plant or the terms upon which custom ores would be taken. Am advised that all such information will be made available soon and may then be obtained either at the smelter plant at El Paso or at the Ore Purchasing office at Tucson.

Before this information came to me, I made a study during this last trip, concerning a plan for locating a milling plant on a very suitable site on the Hilltop properties, in a canyon immediately northwest of the portal of the Rehm workings. If a large and permanent plant is found to be required on the property, then this proposed location seems best for many reasons, even though it would involve the driving of a 350 ft. tunnel through the hill, from a point near the present Rehm ore bin to the new mill site.

This suggested plan would place the new plant entirely out of the way of waste dump storage at the Rehm portal; it would make possible the continued operation of the temporary jig mill for dump ores; it would facilitate tailing disposal and water recovery if such should be needed, with many other advantages. It would add about 500 feet to the ore haulage distance, as compared with a site near the portal of the Rehm tunnel, but this is not a serious matter as compared with the distances otherwise involved. Careful consideration of the plan is recommended.

Coincident with the study of the tunnel work required to reach the proposed mill site, some data on surface geology became available for future use in the study of regional fault movements which will be of great importance in due time. The proposed ore-haulage tunnel may quite likely cut through an ore zone that is related to the zones known in the upper workings on the Hilltop property, but upon which very little work has as yet been done at lower horizons comparable to the elevation of the Rehm tunnel. The strike of this possible ore bearing structure places it entirelynorth of the ground penetrated by any of the Rehm workings, and while the immediate problem is not one of developing additional ores or ore zones, this situation is well worth serious consideration on a long range basis.

In connection with this general investigation, we had intended to further explore ore showings in the northwesterly portions of the Grey tunnel, but found that a small cave-in had closed the Grey at a point about 1400 ft. from the portal, where three sets of old timbers had fallen. This is not too serious as the timbers can be replaced when convenient.

A small cave also occurred at the east portal of the Blacksmith tunnel, similar to the one that came down during the previous winter and which was only partially cleared at that time. However, the new cave has exposed a sizable amount of good ore at the surface that is now in view and adjacent to very old workings about which very little is now known. This is not of great importance at this time, but will be of use eventually after the proposed raises underground reach the upper workings.

The whole property is now at the crucial stage, at the beginning of production when the immediate problems become those of ore processing and marketing. The long program of underground preparation and underground equipment and mine planning has been accomplished and for the most part completed. The beneficial results of this work should soon become quite apparent to all.

Yours very truly,

Frank R. Wicks

Consulting mining engineer.

COPY FROM ORIGINAL

COPY OF R. F. C. LETTER
Phoenix, October 4, 1946

Mr. G. T. Humphries,
Hilltop Mines,
Portal, Arizona,
View House, New Mexico

Dear Mr. Humphries:

I am returning your tracing of the California Mining District along with one white print.

The samples which we took assay as follows:

No. 1	9.58%	Lead	9.6	Zinc
2	13.63%	"	14.3	"
3	15.69%	"	17.2	"
4	13.91%	"	4.45	"
5	20.98%	"	8.10	"
6	24.93%	"	7.95	"
7	19.25%	"	3.95	"
8	22.67%	"	5.50	"

Thank you for all your courtesies.

Yours very truly,

(Signed) Charles A. Rasor
Supervising Engineer

CAR:GMK

3

THE HILLTOP MINE

Hilltop, Arizona

Harrison Schmitt
Aug-Sept, 1950

THE HILLTOP MINE

Hilltop, Arizona

CONTENTS

	Page
INTRODUCTION	1
Geography	1
General Description	2
Ownership	3
Former Shipments of Ore	4
Equipment on Ground	4
Old Data Available	4
GEOLOGY	5
Sedimentary and Metamorphic Rocks	5
Igneous Rocks	6
Geologic Structure	6
The Mineralization	8
The Localization of Ore	8
THE ORE RESERVES	12
Recapitulation of Ore Reserves	15
POSSIBILITY FOR ORE IN ADDITION TO THAT OF THE ORE BLOCKS	16
RECOMMENDED DEVELOPMENT	16
Possible Rehabilitation Needed	18
MINING AND MILLING	20
COSTS	20
Equipment	20
Repairs and Installation	20
Cost of Preliminary Drifting	21
ESTIMATED OUTCOME ON ORE	21
Outcome	21
Direct Cost	21
SUMMARY	22
CONCLUSION	24

September 27, 1950

To: The American Zinc, Lead, and Smelting Company
Paul Brown Building
St. Louis, Missouri

From: Harrison Schmitt

Subject: Appraisal of the Hilltop mine, Hilltop, Arizona
Pb, Zn, Ag

INTRODUCTION

I herewith submit the results of my examination of the Hilltop mine, Arizona made during the period of August 10 to September 27. My instructions essentially were to appraise the mine. This required emphasis particularly on the underground geology, the distribution of, amount of, and cause for the localization of the ore formerly mined; the grade and quantity of the ore in place, and the collection of data pertinent to the prospects for and search for new ore.

The field work was done during the period of August 10 to September 9, 1950. A surface transit survey was run for the control of a surface reconnaissance. The geology of several miles of underground workings was mapped. Seven underground samples were cut in order to check samples taken by F. H. Lerchen. These had been obtained for the Eagle Pitcher Company. The period September 11 to 28 was spent in drawing maps and writing this report.

Geography.

The Hilltop mine is located in the Chiricahua mountains about 23.5 miles west of Rodeo, New Mexico on the Southern Pacific railroad and about 27 miles south of san Simon, Arizona which is on another branch of

the Southern Pacific. The claims comprising the property lie across a major northwest trending limestone mountain ridge which has a relief of about 2000 ft. The roads from the mine on the northeast side to the railroads are down-grade and are usually in good shape except for periods of a few days or hours during the summer and winter rainy seasons. In the vicinity of the mine the altitude varies from about 5600 ft. to 7300 ft. above sea level. The principal mine buildings are located near the northeast base of the mountain ridge at an elevation of around 6000 ft.

A fine climate is found at such altitudes and at similar latitudes in the Southwest. The mean annual rainfall is around 18 inches. The vegetation on the lower slopes is largely bear grass, oak, pinon, juniper, cedar, and mountain mahogany. On the higher slopes ponderosa pine is prominent. There is fine range grass at most altitudes. This all adds up to an attractive country.

General Description.

The mine is developed by one minor and three principal adits. There are no important shafts. The upper principal adit, the Kasper, was driven from the southwest side of the mountain and was the first important development of the mine. This was finally pushed through to the northeast side. The early camp was on the southwest side. Later the Gray and the Rehm adits were driven from the northeast side and all three were connected by a through-going raise or ore pass. The elevation of the Rehm is 6055.5 ft., the Gray 6465.1, the Kasper northeast portal 6757.5 ft. The Blacksmith adit is at 7220 ft. At present the only way to get to the upper workings on the northeast side is by foot or horseback. The southwest Kasper adit entrance may be reached by a 26 mile good road around the mountain ridge via Paradise and Piney canyon. A seven mile short-cut on the northwest is at present passable by jeep only. The main plant, just

below the Rehm adit, includes a number of dwellings, a large power house, and a manager's quarters and office.

The property at present is supposed to be controlled by a company called Piedmont Mines Incorporated. The claims (Map D) said to be held by them include the following list submitted by L. K. Diffenderfer, the present manager.

"The following (are the) described unpatented mining claims, situated in the California Mining District, in Cochise County, State of Arizona:

Name of Claim	Record of Mines Book	Page
Empire	30	593
Empress	30	595
Imperial	30	594
Enterprise	31	330
Portland	31	328
W. G.	39	108
Galena Queen	39	114
Spar	49	595
Hill Top	39	113
Hidden Treasure	39	109
Florence	45	241
Birthday	52	172
Hard Luck	14	324
Surprise	39	112
Tunnel	49	597
Outlook	39	106
Four Point	49	599
Victor	39	110
Rocky Ford	49	598
Long Dump	18	194 "

"Right to obtain title to the following unpatented mining claims not yet conveyed to the corporation:

Name of Claim	Book	Page
Alice M. No. 1	75	381
" " 2	75	382
" " 3	75	383
" " 4	75	384
" " 5	75	385
" " 6	75	386
Hilltop Lead No. 1	75	287
" " 2	75	288
" " 3	75	289

Name of Claim	Book	Page
Hilltop Lead No. 4	75	290
" " 5	75	291
" " 6	75	292
" " 7	75	293
" " 8	75	294
" " 9	75	295
" " 10	75	296
" " 11	75	305
" " 12	75	306
" " 13	75	307
" " 14	75	312
" " 15	75	313
" " 16	75	331
" " 17	75	332
" " 18	75	333 "

The first group of claims when plotted seem to adequately cover the important and critical ground (See map D).

Former Shipments of Ore.

Records of ore shipments summarized by F. H. Lerchen are as follows:

Year	Tons	Ag	Pb	Cu	Ins	Fe	CaO	Mn (?)	Sul
1924	4377	5.5	24.0	.25	27.0	12.5	4.0	7.0	3.0
1925	4105	5.0	23.0	.40	32.0	10.0	2.5	9.5	2.5
1926	2890	4.5	20.0	.55	32.0	12.0	4.0	8.0	1.0
	11372								

These are supposed to be nearly the total shipments. All the ore was oxidized. My measurement of the accessible stopes give a minimum of 9000 tons.

Equipment on the Ground.

At the Rehm adit there is a welter of old and new equipment, including a 300 HP diesel electric plant said to be in fair condition, a battery locomotive, an underground loader, compressors, miscellaneous electrical equipment, drilling machines, etc.etc. An inventory may show some useful material, but much of it has been badly used.

Old Data Available.

Data presently available on the mine include: A composite plan of the entire mine nearly up to date and apparently accurate but with no

accompanying survey notes, sample locations and assays by the Eagle Pitcher Company, a geological report of good quality by Dr. Charles B. Berkey with several scattered maps belonging to it, various notes and sketches by Ira B. Joralemon, surface topographic and claim maps and a map of the now caved Blacksmith adit workings by Charles A. Rasor. My office files contain notes taken in 1944 on the Blacksmith workings.

Check for notes

GEOLOGY

The purpose of this report does not appear to require an extended discussion of the general geology. My observations, limited on the surface, but extensive underground, largely confirm Dr. Berkey's conclusions as to the age and character of the rocks and their broad structure.

Sedimentary and Metamorphic Rocks.

The rocks of Hilltop mountain are largely limestone and shaly limestones with a stratigraphic thickness of around 5000 ft. They may vary from lower Mississippian or even Devonian on the northeast side of the mountain to upper Pennsylvanian or even Permian on the southwest side. The first beds with conspicuous fusulina come in about 200 ft. northeast of the Gray adit. This point, then, could be near the base of the Lower Pennsylvanian since these forms are not found lower than upper Mississippian, although rocks of this age may be present locally. A Permian (?) brachiopod is prominent at the top of mountain ridge in the massive limestone with accompanying pink chert just above the Hilltop quartzite. Limestone conglomerates can be observed on the southwest slope. The general character of the upper beds with their thin sandstone and quartzite members and limestone conglomerates resembles the upper Pennsylvanian or Magdalena limestone in southwestern New Mexico.

The Hilltop quartzite is around 65 ft. thick. In general it is a hard dense quartzite, but in places is limy. The lower half, when not greatly

metamorphosed, is a sandy limestone with reddish and greenish phases. Just above the quartzite is the massive gray cherty limestone. Just below the quartzite is a soft marly phase about 60 ft. thick and below this occurs massive to medium bedded gray limestone. In the lower part of the section from about 800 ft. inside the southeast portal of the Kasper adit to the massive marbles at the entrance to the Gray adit, a stratigraphic distance of around 1400 ft., there are thick massive porcellanites (hornfelses or hornstones). Porcellanite is perhaps the preferred term. These presumably are baked shales and shaly limestones. Thick coarse marbles are prominent from the Gray adit entrance on toward the northeast.

Igneous Rocks.

In the mine workings small exposures of igneous rocks are seen in the form of dikes and possibly sills. The commonest type has been called locally "birdseye" porphyry. This may be a quartz monzonite porphyry or a granodiorite porphyry. Northeast of the Rehm adit a large mass of similar porphyry outcrops. In the Hard Luck claim area a large dike of fine grained, dense, nearly white rock is exposed in the workings. This appears to be a rhyolite (felsite). It may be or may have been largely composed of glass and is doubtless related to the late volcanic rocks prominent just southwest of the area.

Geologic Structure.

The fossil and lithologic evidence indicates that the oldest part of the sedimentary section is on the northeast. Since on the lower northeast slopes the beds dip northeast they are overturned. At and near the bottom of the valley still farther northeast there is a mass of birdseye porphyry at least 1800 ft. wide in the northeast direction. The intrusion of this porphyry may have been responsible for the crowding and overturning of the sedimentary beds that occur toward the southwest.

On the Rehm adit level there is much evidence, such as folds and flat faults (Map I), of an active overriding thrust movement from the north-northeast. Indeed, it is probable that this same general thrust has resulted in the Blacksmith fault for the latter shows a predominance of horizontal striations and the northwest wall has moved southwest about 600 ft. The strike of this fault is S75W and the dip around 70° southeast. On the Rehm adit there is evidence that it merges with a flat thrust fault. It is apparently wholly pre-ore in age. There is little if any evidence of post-ore character. It appears to be the principal mineralizing channel as will be discussed later.

The bedding, as disclosed on the surface and underground, dips southwestward from a point about 300 ft. inside from the portal of the Gray adit. From this point to the southwest side of the mountain the dip is always southwest with increasing flattening southwestward. As one proceeds in this direction in the Rehm adit the flattening reaches zero and even shows a few degrees of reversal (Map I). For this reason the Hilltop quartzite does not reach the level in this area. It was cut by a 136 ft. raise and a 144 ft. raise near the end of the Rehm adit (Map I).

Just northeast of the ore bearing areas "heavy" high-angle faults that bear parallel to the mountain range are seen. They cut the adits nearly at right angles. Their significance is obscure at this time, but they must have had an important effect on the regional structure.

Bedding-plane faulting is characteristic. Many small faults that localize ore cut the quartzite. They do not appear always to cross into the limestone beds but may curve and join the bedding faults at the quartzite contacts. The quartzite seems to have been faulted, broken, and brecciated between massive limestones that underwent plastic flow, much like a quartz vein, before sulfide mineralization, may be shattered between less brittle walls.

The Mineralization.

The Hilltop mineralization is characterized by an early pyrometasomatic or high temperature phase indexed by high temperature silicates, recrystallized limestones and porcellanized shales and shaly limestones, and a moderate temperature phase indexed by high-galena sulphide deposition, chlorite and secondary carbonates including calcite, rhodocrosite and dolomite (?). There seems to be little secondary or introduced silica. Quartz is sparse as a vein mineral. The thick beds of shale and shaly limestone were presumably porcellanized ("silicified"), without the introduction of silica. Recrystallized or marbleized limestones are prominent.

Garnet and epidote occur in moderate amounts particularly along pre-ore faults and more particularly along the Blacksmith fault. There is some rhodonite. Berkey also reports magnetite. (See Berkey in appendix P for extensive mineral lists).

The moderate temperature or ore phase is concentrated along the pre-ore faults and fractures particularly where these cut or disturb the Hilltop quartzite, although along the Blacksmith fault, which appears to be the master mineralization channel, this phase is moderately well developed in limestone walls particularly at the lower elevations.

The ore minerals are galena, sphalerite, pyrite and chalcopyrite in order of importance. The chief gangue minerals seem to be the quartz of the quartzite, carbonates, chlorite and epidote, rhodonite, and rhodocrosite with very minor quartz. In the sulphide ore on the north Gray level, as disclosed by assay, there is a moderate amount of silver, up to five ounces in some of the ore, no gold and no appreciable tungsten or bismuth.

The Localization of the Ore (Maps G, H, I and J).

The factors influencing the localization of the known ore in this mine seem clearer than is usually the case. In a broad way most of the ore mined

has been near the intersection of faults with the Hilltop quartzite and most of this has been mined from the intersection of the Blacksmith fault with the quartzite (Map G). In the vicinity of this broad intersection ore may occur along the fault itself, on auxiliary fault intersections and along the bedding and bedding-plane faults adjacent to or close by cross-faults. On the Gray level, as will be noted later, a small ore body lies between limestone walls on a strand of the Blacksmith fault.

On the Hard Luck claim on the Kasper level there has been a moderately important production of oxidized lead ore 1600 ft. west of the principal ore at the Blacksmith fault intersection. This ore also is largely on fault intersections with the Hilltop quartzite. To the southeast 1000 ft. from the main ore some production of oxidized lead ore was had from the Kasper level from the Galena Queen and Spar claims and about 1000 ft. farther southeast on the same level from the Outlook and Four Point claims. The ore at these places is largely on bedding planes and/or bedding-plane faults near cross-faults.

On the southeast Gray level (Map H) there were several small oxidized ore bodies in the quartzite where this bed is cut by cross-faults.

On the Rehm level two raises, Nos. 1 and 2 (Map I) were put up to the quartzite and disclosed minor showings of oxidized ore and scattered patches of sulphides. The localization appears to be caused by a wide northwest bearing shear zone (Map I).

On the Long Dump claim along a bedding plane near a cross-fault in the Hilltop quartzite there has been some minor production of oxidized lead ore said to amount to about 20 tons. The vein is up to 6 in. wide and looks unimportant besides being on the nearly inaccessible main mountain ridge.

The Blacksmith adit, 460 ft. above the Kasper adit, is said to be the place of discovery of Hilltop. The "ore" is mixed sulphide and oxidized

and contains oxidized copper minerals. Obviously it would be difficult to mill. It is of a good grade (See section No. 1). It follows the contact of the hanging wall limestone and the Hilltop quartzite at the intersection of the southeasternmost strand of the Blacksmith fault, the same intersection that is the most important on the Kasper and Gray levels. The strike length is 35 ft., the width 4 to 6 ft. and it has been followed down the dip from the adit level by a winze for 50 ft. The probable relationship of this "ore" to the main ore on the Kasper level is shown on section No. 1.

The only important exposure of millable sulphide ore is on the north Gray level. Here most of the ore replaces beds in the Hilltop quartzite adjacent to the southeasternmost strand of the Blacksmith fault. There are at least two mineralized beds and probably a third. A fourth ore body occurs in the above mentioned strand of the Blacksmith fault in limestone walls.

The apparent preference of the ore for the Hilltop quartzite at least in the upper levels is of critical interest. So far as can be observed now, except along the Blacksmith fault, the exposures of metallic mineralization in limestone in the Hilltop mine proper are subordinate in quantity. On the Kasper level spots of sulphide, often high in galena, occur on the various strands of the Blacksmith fault within limestone walls for a known horizontal distance of 1000 ft., but little if any of this "ore" has been or can be mined. On the Rehm level, roughly below the ore on the Gray level, a 12 in. vein of high grade sulphide in limestone on one of the strands of the fault has been followed by a 17 ft. raise.

In most districts ore prefers limestone as a host, although not too uncommonly some other rock is preferred. Since the possibilities for ore along the Blacksmith fault have been adequately tested on only one level, the Kasper, it may be premature to say that considerable ore cannot occur in limestone at Hilltop. Away from the Blacksmith fault the relatively

extensive exploration in this mine has not found ore in limestone, though indeed, not much in any kind of rock.

The opinion has been expressed at the mine that a massive limestone bed lying just above the quartzite was probably the ore carrier and had not been adequately explored. I have seen no facts in the field that support this opinion, although perhaps it may be justly argued that not enough cross-cuts have intercepted this bed for a real test. Most of the development has been confined to the quartzite. This may have been overdone.

The Blacksmith fault zone seems to have been the principal ore channel. Ore bearing fluids were able to move along this fissure, for it was reopened many times, and while doing so replaced some of the limestone with silicates and then with sulphides, chlorite and carbonates. Where the Hilltop quartzite is in contact with the fault a moderate number of small ore bodies (Map C) were formed as bedding-plane deposits and as irregular pods at the intersection of smaller faults with other faults including bedding-plane faults. The influence of the Blacksmith fault zone on ore localization on the Kasper level extended 500 ft. southeast from the intersection. The southwest segment and intersection of the Hilltop quartzite can be observed 600 ft. southwest on the southwest side of the mountain. Here on the Hidden Treasure claim are workings called the West Blacksmith. There is some minor mineralization at this point. A few tons of ore may have been produced. On this segment of the quartzite the only important production to date has been on the Hard Luck claim as previously noted and small workings still farther to the northwest on outside ground.

As seems usually the case, openings or broken ground was needed for the deposition of ore. This seems to have been available in the crushed and broken quartzite adjacent to the fault zone and in the fault zone itself. The massive limestones adjacent to the quartzite, but not actually along the

Blacksmith fault, usually appear tight and uncrushed with evidence that a plastic condition was common as revealed by flow structure.

The great mass of, and excess of, limestone, around 90 per cent of the mountain, may have neutralized the ore bearing fluids and saturated them with carbonate by the time they reached the upper part of the mine where carbonates were abundantly deposited at least during the time of sulphide deposition. This suggests that in the upper levels the fluids at this time could not easily replace limestone even when this rock walled the channelways. Along the Blacksmith fault ore seems to have replaced only quartzite and early silicates.

The first explorations at least should be concentrated near the intersection of the quartzite with the Blacksmith fault, on the southeast side of the fault, and in the quartzite. Certain possibilities favor certain unexplored ground. The flattening of the quartzite on the southeast side of the fault zone introduces a new factor. The fairly good showing of two and probably three beds of sulphide ore in the north Gray may be the top of better ground unexplored down the dip of the quartzite and along the fault. The flattening could have promoted a greater crushing and drag of the quartzite.

Another possibility is along the Blacksmith fault. On the north Gray level is the first disclosed important showing of ore on the fault. This is fine sulphide ore of good grade. Silver and copper are higher in proportion to the lead than they are in the ore in the quartzite along the bedding. Conditions may improve in depth on the fault possibly because the solutions were not so inert to limestone at the greater depth for presumably they had not passed through so much of this type of rock.

THE ORE RESERVES

The locations and assays of samples taken by F. H. Lerchen for the Eagle Pitcher Company are available. These samples were marked on the ground.

Many were improperly taken. For example, some were cut along the veins or along veinlets. Nevertheless, others were cut across the veins with deep, regular channels. A certain number of these were selected, after careful inspection, as being representative of the ore (Map K). Seven were recut as checks by me personally and were kept in a locked bag until assayed. As will be noted on the assay plan check samples 501-504 inclusive closely correspond to the old assays. The assays of samples 505-507 differ from the old samples. These descrepancies are because my channels were not as wide across the vein as Lerchen's, as well as because the fissure ore from which they were cut contains some high grade bunches or kidneys up to 2-3 ft. in diameter.

The assays and mapping revealed four mineable showings of ore on the north Gray level (Maps K and H). These have been numbered blocks 1 to 4. Block 1 appears to be the replacement of a bed of quartzite. The positive section of this ore is 35 x 3.8 ft (strike length by true vein width) making 10.2 tons per dip foot, but the strike length may be 55 ft. greater (Maps H and K). The grade averages Ag 1.39, Pb 11.14, Zn 3.54, Cu 0.19. It is clean sulphide ore.

Block 2 is the replacement of a second bed of quartzite next toward the hanging wall. The positive and probable section is 100 by 4 making 30.7 tons per dip foot. This ore averages Ag 0.49, Pb 9.9, Zn 6.59, Cu trace and is clean sulphide ore.

Block 3 appears to be the replacement of a bed farther toward the hanging wall, in fact at the contact of the top of the quartzite with the hanging wall limestone. This contact is favored by ore at several places higher in the mine such as on the Blacksmith adit level and on the Kasper level; nevertheless, since the ore is adjacent to a mineralizing strand of the cross-fault and is not exposed for more than a few feet along the strike

of the bed, only a few tons per dip foot can be called positive, say not over 15. The "bed" appears to be 12.5 ft. thick. The grade is Ag 1.44, Pb 8.8, Zn 6.2 and Cu .09. Such a grade, since it is low in silver and copper, is more comparable to the bedded than to the fissure ore. Thus compare Blocks 1 and 2 with Block 4.

Block 4 is ore along strand G-1 of the cross-fault (Maps H and K). The positive section is 80 by 3.27 making 20 tons per dip-foot. The average grade is Ag 3.00, Pb 12.2, Zn 10.3 and Cu .40. It is clean sulphide ore. The vein stands nearly vertically, the walls are limestone and a raise of unknown height has been put up on the southwest end of the shoot.

A showing of ore can be seen at point "R" (Map H), but it does not seem important.

The total positive tons per dip-foot of blocks 1, 2, 3, and 4 is 76. The average grade of the exposed sections of blocks 1, 2, and 4 is: Ag 1.45, Pb 10.85, Zn 7.32 and Cu 0.15. The average width is 3.7 ft. The assays of Block 3 were not averaged in because only three samples were useable. The average assay, however, is nearly the same as the average of the other three blocks. It should be fair to take an up and down dip extension on these ore blocks of 100 ft. and calling this positive and probable ore. This amounts to 7600 tons of the above grade and width.

The Blacksmith adit was inaccessible to me at this time, but some old notes by C. A. Rasor in addition to some of my own show that the "ore" lies along the top contact of the Hilltop quartzite. It is 35 ft. long and 4 to 6 ft. wide. One end abuts a strand of the Blacksmith fault zone. The tons per dip foot are around 13. A winze has followed this bed down 50 ft. so there is a positive tonnage of 650 and say a like amount of probable tonnage. Cross-section No. 1 suggests that on this intersection this ore may extend to the Kaspar level for a similar localization occurrence is found on the latter level (Map F). At the bottom of the winze Lerchen's sample

No. 28 assayed as follows: 6.5 ft., Ag 6.00, Pb 21.30, Zn 12.60. As before noted this "ore" is strongly oxidized and contains oxidized copper minerals. The metals probably cannot be separated and concentrated by known methods. The copper also probably precludes its use for paint at Coffeeville.

The tons of ore per dip-foot of the north Gray area (76) is nearly the same as on the corresponding area on the Kasper where the tons of oxidized ore per dip-foot were around 80. This comparison, the appearance of mineable ore on a fault strand in limestone and the more favorable structural conditions due to the flattening of the dip of the quartzite I think justifies optimism as to the geological possibilities for additional ore in the category of "geologically prospective". At least 300 ft. of extension on the dip can be expected for the quartzite. Assuming the bedded ore would extend that far we have 8200 tons for blocks 1 and 2 in addition to the positive-probable category. If block 3 is in fact a bed we can add ~~12,300~~ 16,500 tons assuming a section of ~~6~~ 7.5 x 100 equivalent to ~~20~~ 60 tons per dip-foot.

I am especially optimistic about the fissure ore. Just below block 4 on the Rehm level a new 17 ft. raise on a strand of the cross-fault has exposed one foot of high grade sulphide ore. I think we are warranted in assuming a 300 ft. up and down dip extension for block 4. This adds 4000 tons to the "geologically prospective" category.

Recapitulation of Ore Reserves.

	Positive & Probable	Geologically Prospective	Total
Block 1	1,000	2,000	3,000
Block 2	3,100	6,200	9,300
Block 3	1,500	16,500	18,000
Block 4	2,000	4,000	6,000
Totals	7,600	28,700	36,300

The average grade of positive and probable of Blocks 1, 2 and 4 is width 3.7, Ag 1.45, Pb 10.85, Zn 7.32, Cu 0.15. There is no appreciable tungsten or bismuth. This is all clean sulphide ore.

The weakest item in the above tabulation is block 3, one of the largest.

Throwing out the geologically prospective tonnage of block 3 would leave a total tonnage of only 19,800. This comparison indicates about the magnitude of the risk envolved. In other words, the size of the ore reserves is critically contingent upon the outcome of certain development work.

POSSIBILITIES FOR ORE IN ADDITION TO THAT OF THE ORE BLOCKS

There seem to be three principal geological possibilities for ore in addition to that given in the ore blocks. (1) The extension of the bedded ore downward may improve in volume. (2) The strands of the Blacksmith fault zone seem to have been inadequately explored considering the good ore exposure on strand G1 on the Gray level and the wide distribution of spots of sulphides on the fault zone. (3) As previously noted there is a geological reason for hoping for more extensive replacement of limestone in depth. Affirmative outcome of these three prospects could double or triple the tonnage available. The development of the fault strands may encounter heavy ground in places although the known fissure ore has good walls.

No other good prospect for clean sulphide ore in addition to the two given above seem to be indicated by the geological facts and their interpretation. It may be that the southwesternmost segment of the quartzite where it abuts the Blacksmith fault zone on the Hidden Treasure claim should be given some attention, possibly by diamond drilling. Here the ore would presumably be oxidized for some hundreds of feet of depth.

Blocks of clean sulphide ore might be encountered along the intersection of the Blacksmith fault with the hanging wall contact of the quartzite as shown on section No. 1.

RECOMMENDED DEVELOPMENT

Where possible, of course, development for new ore should be laid out with an eye to the dual use of the openings for extraction so far as that

is possible. Some preliminary short hole diamond drilling might be done while rehabilitation work was going on, but compressed air must be brought in in any case. With the market as it is I assume speed is critical so as to get into early production. This will be served by subordinating preliminary drilling in this case; although some drilling will be needed if a winze is finally decided upon. Projects "A" and "B" and raise projects "D" and "E" level (Gray adit) will be needed first so as to confirm and prepare the ore for extraction. At the extraction stage additional raises, of course, will be needed. At first at least Raises No. 4 ("C") and No. 5 ("D") will be retimbering jobs.

Should the above work totaling about 250 ft. of drift further confirm reserves, grade, beds, etc. production could start at about this stage or even earlier. The winze should be started as shown, project "E". This should be preceeded by a few short diamond drill holes at stations S1, S2, and S3 so as to locate the horizons and the ore in depth if possible. About 750 ft. of hole would be needed and the winze might be 350 ft. deep at around 35 degrees of dip. Should this project be successful the winze then should be tapped by a vertical raise from the Rehm. This would take around 150 ft. of drift and 225 ft. of raise. The ore then could be scraped or dropped into this raise for transport to the Rehm adit portal.

Longer range development should include drifts and raises on the most favorable strands of the Blacksmith fault. Thus a 125 ft. cross-cut (Map H, project "F") could be driven on the Gray to reveal the full width of the Blacksmith fault zone and additional mineralized strands if any.

The raise on the Rehm adit, project "G" should be extended. As before noted there is a foot of high grade sulphide with 4 ft. of high temperature silicates in the top of this raise in limestone.

Possible Rehabilitation Needed.

The rehabilitation needed and machinery and equipment required for the minimum re-entry of the mine - say the development work recommended in the north Gray level - of course needs a special study that did not seem pertinent during this particular assignment. It would seem, however, that the mine should be worked from the Rehm level as the main haulage level. This level is around 400 ft. below the Gray which, of course, poses special problems; including the difficulty of carrying raises through to completion for such a height, and the problem of getting men back and forth to the Gray. For men and material the only facility for access now is a trail. Then the length of the Rehm adit and the branch drift to under the ore in the north Gray, a total distance of 3600 feet, raises formidible questions of pipe line, track and haulage. These problems would be unimportant should there now be a large reserve of positive ore, but they look serious for an enterprise not far beyond the prospect stage. The scale of the mine is appropriate more for a large going mine than for a prospect.

The track in the Rehm is, I believe, of 12 lb. weight only. It could be reconditioned so as to carry the battery locomotive at moderate speed. The grade is not too bad, around .7 per cent, it is said. There is a 4 in. air line on the same level, but a test is needed to reveal its true condition. No one seems to know the condition of the ore pass to the Gray. Most of the timber has probably fallen out, which if so is a good thing, since it would in any case be rotten. The first cars of waste should knock out any remaining timber. Once the raise is cleaned out, it would appear that a bulkhead with a chute could be built and the base of the raise allowed to fill in with waste to the angle of repose. Then, later, the ore could be passed through and the waste then taken out the Gray adit by mule drawn trains. There is 12 lb. rail throughout most of the Gray level, but no air line.

The question of getting compressed air to the north Gray seems difficult. Possible alternates include: (1) A pipe line up the slope to the Gray portal and along the level to the north end, a total distance of 4900 ft. This would be expensive and require hard-to-get pipe. (2) If the four inch line on the Rehm can be used, possibly a large diamond drill hole put up to the Gray should be drilled and used to connect the air lines between the levels. Or a line could be installed temporarily in the ore pass with or without special protection. (3) A power line could be run up and into the Gray and an underground compressor installed, but this is with the difficulty of getting the equipment up the hill. (4) A portable compressor could be installed at the Gray portal and pipe laid to the face, a distance of 3300 ft. but this would save only 1600 ft. of pipe compared with alternate (1). The above are the possibilities that occur to me. Since air may be eventually needed in the Rehm anyhow method 2 may be the best. The first methods used, it goes without saying, may very well be provisional. The men may need to walk or ride up the hill.

If the property finally justifies it an interior shaft doubtless would be raised from the Rehm to the Gray. The hoist would be set on the Rehm. This shaft might well be used for lowering separate classes of ore and waste to avoid dividing the main ore pass. The present ore passes are said to have off-sets in them or at least are variously inclined. If so they cannot be used as a shaft.

There are enough houses and buildings near the Rehm adit portal to take care of fairly large operation.

As the exploration is advanced considerable underground and surface surveying will be needed. More geological work should be done and a survey and appraisal of bordering and outlying mines and prospects should be made. In some of these ore replaces limestone. Some are near large intrusives.

MINING AND MILLING

The milling of the ore on the north Gray should present few difficulties. The ore is clean, no oxidation of consequence was noted. The fissure ore contains copper but this is largely in the form of sulphide.

In most cases the mining can be done in open stopes with or without stulls. The walls are good in most of the ground.

COSTS

Let us assume that if any action is taken only the preliminary development work will be authorised and that more extensive plans will hinge on this. In this case my suggestion is that the Rehm 4 in. air line be tested and repaired, the ore pass raise cleaned out and a two inch pipe be installed in it and then carried on to the area of interest in the north Gray. 2,000 ft. of 2 in. pipe will be needed. If we further assume that we cannot use any of the equipment at the entrance to the Rehm then a diesel compressor unit, say of 420 cu. ft. capacity will need to be rented or purchased. The cost of starting up then would be about as follows:

Equipment

2,000 ft. of 2 in. Galvanized pipe @50¢	$ 1,000.00
1 Catapillar Diesel Compressor, skid mounted, 420 cu. ft. (sea level), plus freight	10,000.00
1 lyner (3")	850.00
1 stoper	650.00
1 sinker	330.00
Miscellaneous equipment, tools, etc.	3,000.00
	$15,830.00

Repairs and Installation

Preliminary clean up repairs, installation estimated 200 shifts @$12.00	$ 2,400.00
Supervision, engineering work, etc.	1,500.00
Contingencies	2,000.00
	$ 5,900.00

Cost of Preliminary Drifting

250 ft. of drift equivalent to 500 shifts @$12.00	$ 6,000.00
Supplies, diesel oil, etc. (These two items are equivalent to about ~~$20.60~~ 33.60 a ft., which seems ~~all right~~ high.)	2,400.00
Supervision, overhead, etc. for three months	5,000.00
Contingencies	5,000.00
	$18,400.00
Total for 5 months period to do 250 ft. of work	$40,130.00

N.B. Most of the equipment would be only slightly used after this work was done and 75 per cent of the original price should be recovered.

ESTIMATED OUTCOME ON ONE

Mr. J. H. Taylor says that ore of the average grade and character of Blocks 1, 2 and 4 (Ag 1.45, Pb 10.85, Zn 7.32 and Cu 0.15) would give about the following outcome where 80% of the silver, 85% of the lead, and 90% of the zinc is recovered by milling and prices are 17.5 cents for zinc and 16 cents for lead.

Outcome

	Cr.	Dr.	Bal.
Silver	$ .98		
Lead	20.18		
Zinc	10.81		
Milling		$ 3.75	
Freight from San Simon		±2.50	
			$25.09

N.B. To take advantage of lower freight from San Simon, Arizona as against Rodeo, New Mexico a loading platform would need to be built at San Simon. This would cost about $500.00.

Direct Costs

Small scale mining costs should not exceed $10.00 a ton for the breaking can be done in open stopes with only stull and plank timber needed. The 27 mile, down hill, truck haul to San Simon at 8¢ per ton mile would be $2.16. Royalties could be 10% of the net mill return or $2.50. Several additional 100 ft. raises in ore will be needed when mining starts but these should pay their way.

Mining	$ 10.00
Truck haul	2.16
Royalties	2.50
	$ 14.66

Thus there is a balance of $10.43 for profit after the rehabilitation and development (capital charge ?) is subtracted. If this early capital (?) charge is distributed to the 7600 tons of positive and probable ore it amounts to $5.28 a ton leaving $5.15 for profit. This, of course, would be of little interest on such a small tonnage considering the risk. But obviously it could be larger per ton if the "geologically prospective" ore is confirmed because of the better economy in larger production and the smaller capital write-off per ton. This will depend somewhat on a difficult factor to estimate; the cost of development of new ore.

SUMMARY

1. The Hilltop mine formerly produced a little more than 11,000 tons of oxidized lead ore averaging about 23% lead and 5.0 oz. of silver from ore bodies scattered over several miles of mine workings. Few stopes exceeded a thousand tons of production and most produced under 500 tons. Most of the production was from the Kasper adit level.

2. An extensive examination and appraisal by me indicates that the general geology is about as outlined by Dr. C. B. Berkey in 1920. The ore so far produced and in sight replaced quartzite in a 65 ft. bed of quartzite where this is cut by cross-faults and disturbed by bedding-plane faults. Most of the ore mined and in sight is in the quartzite adjacent to the southeasternmost strand of the Blacksmith fault. This intersection is favored by ore from the Blacksmith adit down through the Kasper adit level and down to the Gray adit level. The intersection is not present on the Rehm or lowest level because the bedding there flattens to zero degrees. The Blacksmith fault, however, cuts the Rehm level and there it is still

mineralized by sulphides and is in limestone walls. The Blacksmith fault is the main mineralizing channel.

3. The ore on the north Gray level occurs as a replacement of two or three beds in the quartzite and one ore body replaces limestone along a strand of the Blacksmith fault. Four small ore bodies show a total positive exposure or section of 76 tons per dip foot. The grade of this averages around Ag 1.4, Pb 10.8, Zn 7.3 and Cu 0.15. Assuming a 100 ft. up and down dip extension for all four ore bodies we have 7600 tons of positive and probable ore. I estimate that an additional 28,700 tons may be put in the category of "geologically prospective" and geological conditions suggest that still more ore may be found on the basis of a favorable risk of development work. The grade was determined by using old assay data checked by me by re-moiling the former sample channels.

4. I am moderately optimistic about the probable outcome of new development work. This is based on the apparent better and more clear-cut concentration of the ore on the Gray level, the probability of improved breaking and brecciation of the quartzite in depth due to the flattening of the dip, and the probability of improvement of limestone as a host in depth, although this could be offset by the quartzite becoming more resistant to replacement in depth. Further, I think that since the Blacksmith fault zone contains ore type mineralization for a strike length of at least 1000 ft. in the Kasper level and a dip length of at least 1200 ft. it has not been adequately tested by the present workings. Several large ore bodies on this fault could have been missed by the present workings.

Against undue optimism is of course the fact that extensive development has revealed only small ore bodies to date. Nevertheless, I think the total potentiality of the mine for new ore may be estimated at 100,000 tons.

5. Preliminary work needed for confirmation of some of the ore in the probable category is estimated at 250 ft. of drift. The cost of doing this with necessary equipment and rehabilitation is estimated at $40,130.00. In case of an unfavorable outcome some of this expenditure could be salvaged by selling the equipment.

6. On the present market of 16 cents lead and 17.5 cents zinc the ore is worth approximately $25.09 F.O.B. cars at San Simon, Arizona. This is on the basis of milling at Deming. If the positive and probable ore is charged with the rehabilitation, equipment, development, stope preparation, royalties at 10%, and mining costs there is left a net of around $5.15 a ton. If a larger tonnage can be developed a larger net should be realized. This might amount to $7.50 a ton.

CONCLUSION

I think everything considered at this time, and assuming an arrangement can be made with the owners that would mean a commitment not exceeding an equivalent of a 10 per cent royalty on say the 36,000 tons of the ore estimate, that is to say, not exceeding $100,000.00, that the property is worth controlling for a time at least, and that the minimum development work should be done as outlined.

Very truly yours,

Harrison Schmitt

HS:ejc
cc: 1 and 3 extra
in file

THE HILLTOP MINE

Hilltop, Arizona

APPENDIX

A. Samples taken by F. H. Lerchen for Eagle Pitcher Company, their location and assay results.

B. Assays of check samples taken by H. Schmitt.

C. Geological report by Dr. C. B. Berkey, 1920.

D. Claim map by G. L. Schmutz, 1919, with property boundary.

E. Topographic map, 300 ft. equals 1 in., 50 ft. contours.

F. Legend for geological maps.

G. Geologic plan of Kasper level, 1 in equals 50 ft.

H. " " " Gray " " " "

I. " " " Rehm " " " "

J. Geologic section No. 1, 1 in. equals 50 ft.

K. Sample and assay plan, north Gray level, 1 in. equals 20 ft.

C O P Y

Assay Results
of
Cut Samples Taken in West Workings Gray
Tunnel-Hilltop Mines February-March-April 1936
by
F. H. Lorchen
(Sample cuts surveyed and mapped and marked in workings)

Sample No.	Description	Sta. No.	Ft. Cut	Ag. Oz.	Pb. %	Zn. %	Cu. %
201	Horizontal S. Side 15' S. W. Sur	0212	4.09	3.90	15.80	1.00	....
202	" " " 9' " "	"	5.10	1.00	3.60	2.80	....
203	" " " 4' " "	"	5.70	0.30	11.40	9.80	....
204	" " " 16' S. E. "	0211	5.00	2.80	5.50	1.00	.06
205	" " " 12' " "	0212	5.00	0.02	8.10	1.10	.05
206	" " " 15' " "	"	5.00	Tr	0.40	0.60	Tr
207	" N. " 15' S. W. "	"	5.20	1.00	20.40	9.20	.....
208	" " " 12' " "	"	5.00	0.50	11.00	11.80	....
209	Across Back 13' " "	"	5.20	Tr	5.20	3.40	0.08
210	" " 9' S. E. "	"	6.00	0.10	2.20	2.40	Nil
211	Across ramp floor Raise #3N.		4.00	2.00	17.20	3.80	1.38
212	" " 5' above Sam. #211		3.00	0.50	6.20	3.40	0.36
213	" Face above 9(S.E. #212)		2.90	0.05	11.20	4.80	Tr
214	Back cutwidth ore Sur	0212	3.90	0.70	12.80	8.60	Nil
215	" " " 19' S. E.		4.70	Nil	1.00	13.30	Nil
216	Horizontal W. Side 20' S. E. Sur	0212	4.90	0.30	1.20	0.40	Tr
217	" " " 25' " "	"	5.70	0.30	3.60	0.60	Nil
218	" " " 30' " "	"	5.10	1.10	16.90	4.10	0.37
219	" " " 34' " "	"	4.10	1.20	7.10	3.60	Tr
220	" " " 38' " "	"	5.10	2.30	28.80	3.40	Tr
221	" " " 42' " "	"	4.60	1.40	23.10	7.00	0.10
222	" " " 47' " "	"	5.40	0.20	4.80	2.70	Tr
223	" " " 52' " "	"	5.00	0.60	6.60	7.60	Tr
224	Across Back 42' " "	"	6.60	1.00	5.70	0.60	Tr
225	" " 27' " "	"	4.40	0.20	5.10	2.30	Tr
226	" " 55' " "	"	4.90	0.10	1.10	0.40	Tr
227	" " 19' S. W. "	"	4.20	0.10	0.50	0.30	Tr
228	Horizontal E. Side 10' S. E. "	0211	5.00	0.60	4.30	7.10	Tr
229	Vertical N. " 24' S. W. "	0208	5.80	2.30	1.70	0.70	Tr
230	" E. " 17' " "	0210	5.00	1.60	1.30	0.20	Tr
231	" S. " 15' " "	0205	5.10	0.80	3.80	0.40	Tr
232	" E. " 12' " "	0210	4.90	1.90	0.60	0.50	Tr
233	" N. " 18' " "	0206	4.80	2.30	1.50	0.40	Tr
234	" E. " 25' " "	0210	5.60	10.80	7.90	0.50	Tr
235	" S. " 20' " "	0206	5.40	5.90	9.90	1.60	Tr
236	Across Back 3' S. E. "	0210	5.00	2.10	1.80	1.30	Tr
237	" " 16' S. W. "	0208	6.00	0.40	0.50	0.60	0.64
238	" " 13' " "	0210	5.50	2.30	2.40	0.30	Tr
239	Brow Back Dr. Raise 4n. "	0213	4.00	1.30	9.60	5.40	0.46
239	Check Out		4.00	2.70	11.20	2.40	0.83
240	Vertical S. side 9'E (near)	0215	5.70	3.60	6.30	2.60	0.64
242	Across back Spad #1 37' E.	0215	3.40	4.00	3.70	1.80	0.64
242	" " 31'E.	0215	3.00	6.60	5.70	2.40	0.28
243	Vertical S. Side 25' E. "	0216	3.30	4.80	8.90	5.80	0.36
244	Across Back 18' E. "	0215	3.50	2.90	10.40	6.30	0.20

None of these samples give more than a trace of Gold.

Gray Tunnel, Hilltop Mine. Assays Feb.-April 1936

Sample No.	Description	Sta. No.	Ft. Cut	Ag. Oz.	Pb. %	Zn. %	Cu. %
245	Across ramp Raise #4N. 42'E	0215	2.00	1.20	12.60	11.90	2.12
246	Across back and Vert 43'E	0215	3.70	5.50	20.00	23.60	1.54
247	Across Back 52'E	0215	3.10	3.10	1.50	0.03	0.08
248	Vertical E. Side 15'E	0215	3.10	0.60	8.80	5.50	1.28
249	Vertical S. Side 3'S	0215	5.00	0.90	9.20	1.10	0.01
250	" " " 9'W	0213	5.60	1.20	5.50	1.00	0.54
251	" " " 12'E	0215	4.00	0.90	9.00	5.50	0.18
252	" " " 21'E	0215	5.40	3.50	6.10	2.50	0.01
253	" E " 15'W	0213	3.10	1.60	7.10	0.90	0.10
254	" " " 20'W	0213	3.40	1.40	11.80	1.30	0.08
255	" " " 1'W	0216	4.10	0.60	6.40	3.60	0.41
256	Raise #3 N up 13' N. side		4.00	0.80	13.80	7.90	0.10
257	" #5 N up 15' N. side		4.20	3.10	13.70	21.00	0.15
258	Vertical and back E. side 25'W		3.10	1.90	13.90	1.70	0.14
259	" S. Side 11'E	0219	3.00	1.20	12.50	9.80	0.13
260	Across back 6'E.	0219	2.50	1.00	13.90	7.30	0.15
261	Horizontal S. Side 12'E	0215	5.00	0.60	7.60	5.20	0.82
262	Vertical S. side 1/2'	0219	5.10	9.10	8.20	0.90	0.07
263	Across Back 5'E	0215	3.10	1.00	7.80	7.10	0.27
264	" " 6'W	0219	2.80	1.30	3.40	0.30	0.08
265	" " 30'W	0213	3.60	1.80	2.50	0.20	0.06
266	Vertical W. Side 35'W	0213	3.70	1.70	8.60	0.50	0.14
267	Across E. Side Raise #5 N up 20'		3.80	3.00	21.80	27.80	0.64
268	" N. " " #3 N up 18'		2.00	0.90	12.20	11.80	1.66
269	" W. " " #5 N up 20'		2.90	2.30	20.40	12.70	0.17
270	Horizontal N. side 1' E	0212	1.02	8.20	8.20	3.80	0.10
271	Vertical S. Side 30' S	0202	6.10	0.80	6.60	7.00	0.06
272	" " " 35' S	0202	5.20	2.60	1.40	0.50	0.11
273	" " " 25' S	0202	5.00	2.70	11.20	6.00	0.09
274	" " " 20' S	0202	2.50	0.50	9.60	4.60	0.08
275	" " " 13' W	0206	5.60	1.80	14.50	12.70	0.80
276	Across back 46' S.	0202	4.90	1.00	5.40	5.20	0.05
277	Vertical S. Side 6' W.	0206	6.70	0.80	7.50	9.40	0.05
278	" " " 1' W	0206	6.20	1.80	6.20	8.70	0.04
279	" " " 6'E	0206	5.10	2.80	19.30	17.00	0.31
280	" N " 1'E	0206	2.60	0.80	3.90	5.50	0.06
281	Across back 5'E	0206	4.60	2.40	6.00	14.20	0.08
282	Vert. & across back side 10'E	0206	5.10	2.00	5.90	6.20	0.10
283	Vertical S. side 15' E	0200	5.20	0.90	5.60	3.60	0.06
284	" & back 10' W	0219	4.80	0.50	0.30	0.50	0.05
285	Across back 65' E	0217	3.60	5.00	6.40	11.00	0.05
286	Raise 5' N. up 27' N side		5.10	1.60	14.50	12.30	1.36
287	" " " " 27' S. "		2.70	1.60	4.80	4.00	0.94
288	Ore selected from gob from R. 1 N course			12.00	27.90	0.80	Tr
289	" " " " " R. 2 N "			3.50	14.40	2.10	0.07

Note: Average of 87 cut samples 1.78 7.56 5.22 0.24

Samples 293 "Check cut" and 288 and 289 were excluded in determining average above.

By F. H. Lerchen, May 20, 1938

C O P Y

Assay Results of Channel-Cut and Stope-Fill (gob)
Samples Taken in the Kasper Tunnel Workings of the Hilltop Mines
Cochise County, Arizona, March-April 1938
By - F. H. Lerchen

(Samples cuts surveyed, and mapped, and marked in workings; stope-fill (gob) samples consisted of selected coarse ore and "grab" fines.)

Sample No.	Description	Ft. Cut	Au. Oz.	Ag. Oz.	Pb. %	Zn. %	Cu. %
301	Across vein bottom winze Sta. 0314	5.10	Nil	2.40	10.80	8.60	0.09
302	" " 25' W(winze) " "	3.00	"	9.50	20.50	0.70	0.14
303	" " 20' (winze) " "	2.00	0.02	12.20	20.60	0.30	0.47
304	" " Collar winze 17' W "	1.50	0.02	7.40	33.00	0.30	0.03
305	Back cut 19' S. Station 0327	3.00	Tr	2.80	11.60	5.50	0.13
306	Horizontal " " "	3.00	Tr	3.80	19.80	6.40	0.10
307	Selected ore from Stope #4 N.	[illegible]	0.02	37.40	43.70	0.02	0.15
308	" " " " #2 "	....	Tr	6.40	20.50	7.50	0.27
309	" " " " #3 "	....	Tr	11.20	36.20	0.40	0.10
310	" " " " #5 "	....	Tr	11.80	39.80	0.40	0.16
311	Horizontal-wall 10'E old Sur. Sta. 86	5.00	Tr	2.40	13.00	0.60	0.06
312	" " 15'W " " Sta. 86	5.00	Tr	5.40	18.30	0.50	0.42
313	Back cut 3'W Sur. Sta. 0328	3.00	Tr	3.20	11.80	0.20	0.11
314	Horizontal Wall 16'W 0328	5.00	Tr	0.40	8.40	3.10	Tr
315	Pace drift 37' W. 0329	2.00	Tr	4.80	18.40	0.30	Tr
316	Back out 15'E Sta. "	3.00	Tr	9.60	27.10	0.40	0.05
317	" " 5'W " "	3.00	0.02	6.80	35.40	0.30	0.10
318	Horizontal 36' W "	3.00	0.04	23.40	38.10	0.80	0.06
319	Back out 12' N old Sur. Sta. 84	3.00	Tr	5.00	21.80	1.00	0.33
320	Fines from gob in #4 N. stope	....	Tr	2.80	8.10	0.40	Tr
321	Vertical cut south W. 110' Sur #7	1.00	Tr	0.30	7.70	10.80	0.07
322	" " S. W. 3' Sur. Sta. #6	1.00	Tr	3.60	20.10	14.60	3.41
323	" " " 12' " " #6	1.00	Tr	3.80	20.40	24.10	4.21
324	" " " 157' " " #7	1.00	Tr	0.30	13.40	1.90	1.58
Average 19 cut samples per assays above				5.67	19.96	4.23	0.60

Control assay certificates of Hawley and Hawley, Assayers, Douglas, Arizona, in the files in the office of the Hilltop Mines, Hilltop, show shipments of 231 cars of ore, principally from the Kasper Tunnel workings, made in the years 1923-25-26, show, for the tonnage of 11,424 tons shipped:

	Ag / Ton	Pb / Ton	Zn. %	Cu. %	Fe. %
Note: The average of 87 "cut" samples in Gray workings give shipments of 231 cars of ore	Tr.	5.24	23.06	8.06	0.347
	1.78	7.56	5.22	0.24	
(11,424) tons mainly from the Kasper workings 1924-1926	5.24	23.06	5.06	0.35	16.20
Blacksmith workings The average of 19 cut samples in Kasper workings	5.67	19.96	4.23	0.60	

Memo. by F. H. Lerchon, Tucson, Arizona, May 21, 1938

C O P Y

Assay Results of
Character Samples Taken in Hilltop Mines by F. H. Lerchen
From December 14, 1937 to April 19, 1938

Sample No.	Description	Ag. Ozs.	Pb. %	Zn. %	Cu. %	Fe. %
1.	In place 1st E. Dr. Kasper tun.	16.00	65.80	0.20	0.18	4.80
2.	Buried in Kasper Tun. West side	9.00	32.10	28.60	0.09	3.00
3.	Sulp. dump Rhem audit Garnet	34.00	9.60	0.40	0.08	20.10
4.	Base ore, garnet gangue Gray D.	3.00	15.80	3.30	2.36	11.18
5.	Heavy black sulphide Gray Dump	7.60	35.00	21.10	0.50	2.30
6.	Float red, above Kasper tunnel	0.50	9.10	—	—	—
7.	Ore in place 29' (E Sample #1)	1.20	10.50	0.90	1.00	—
8.	5.5' cut NW face Blacksmith Adit	5.60	40.00	6.00	0.20	8.70
9.	6.0' cut continuation Sam. #8	0.30	16.00	4.50	0.60	3.40
10.	5.0' cut back Dr. 6' Se 8 & 9	2.10	22.30	7.10	0.07	2.40
11.	14" cut H. W. 22' SW from 8 & 9	1.70	14.60	10.30	0.08	3.30
12.	Chute 5N. NW. Dr. Gray Audit	1.40	23.30	10.00	0.12	1.70
13.	Near raise extreme NW. Dr. Gray T.	1.40	29.00	13.20	3.26	3.10
14.	3' cut outcrop surface Blacksmith	1.40	16.30	9.00	0.10	—
15.	Selected dumps surface	2.60	28.30	6.10	0.08	—
16.	Ore dump Fife audit	6.50	43.80	3.10	Tr	—
17.	Chutes G. 1 & 2 S, SE, Dr. Gray Audit	0.30	9.60	0.90	Tr	29.10
18.	Carbonates red H.W. below Gray Audit	1.80	40.60	1.30	—	—
18A.	10" cut base raise NW Drift Gray	Tr	30.40	10.70	2.30	3.20
19.	Blotches side Dr. 150' NW #18 A	1.60	20.30	10.54	5.60	—
20.	Disseminated ore in dump Rhem Adt.	0.80	7.00	1.10	Tr	0.50
21.	Confirmation rejects Sample #3	2.30	1.80	—	—	—
22.	Confirmation rejects Sample #5	7.20	32.00	—	—	—
23.	Coned fines ceib plat. Rhem Dump	9.00	4.30	1.00	—	—
24.	Broken (over) from above, coarse	15.80	0.20	1.20	—	19.20
25.	Fines loading platform Rnds Pase	10.30	34.40	9.60	—	— ?
26.	Coarse ore " " Hands "	5.80	23.90	25.20	—	— ?
27.	10th shovel Sam. base ore Rhem (workings - - - out in dump)	10.00	5.40	0.60	0.25	9.90
28.	50' depth winge Blacksmith 6 1/2' (across SE face and winze)	6.00	21.30	12.60	—	—
29.	Boulders ore in muck Chute #5 Sun Sta No. 23 SE, Kasper Drift	3.60	35.00	5.90	—	—
30.	Ore in place NW Winze Chute #1 Station #12 SE, Drift Kasper	2.20	24.40	2.30	—	—
31.	From muck in Chute #2 North	41.00	48.10	0.40	0.18	— ?
32.	Massive Pyrite bedding plans top 165' raise No. 1 Rhem tun.	3.20	?	?	?	?
33.	Selected ore place raise No. 1 165' Rhem tunnel	16.40	21.00	9.30	?	?
34.	6" ore in place back stope near raise From Gray Adt. Kas. Lvl. Se.	8.40	36.80	17.00	0.12	

Sample No.	Description	Ag. Ozs.	Pb. %	Zn. %	Cu. %	Fe. %
35.	Under outcrop. Long Dump N. shaft	35.20	41.60	--	--	CHECK -
36.	8" cut ore N. side shaft Long D	41.40	57.00	0.20	Tr	CHECK
37.	Asstd. ore dump long Tun. Claim	27.20	43.60	0.50	--	CHECK.
38.	Outcrop Sur. Above SE. Dr. Kas. T.	0.50	7.70	0.20	--	
39.	A selected ore in place Sur. Sta. 0113 NW Drift Rhem Tunnel	24.40	19.90	4.90	--	CHECK
40.	Bedded ore in place, 18" cut extreme NW. Workings Rhem Tun.	1.80	14.60	0.40	Tr	CHECK
41.	Dumps old Workings W. side along trail above camp-shallow workings	8.20	36.50	2.70		
42.	Shallow shaft Sur. Sta. 18, Blacks,	13.00	54.70	0.60	- - -	CHECK
43.	5' open cut Sur. Blacksmith	3.20	16.10	17.70	- - -	CHECK.
44.	Open chute and shaft dump ore Sur. Stations 14-15-16 Blacksmith	7.60	41.30	11.00	- - - -	CHECK
44A.	18" cut Oxi. S. side XO.SE Gray Wrk. Sur. Sta. 216 55 Deg. W. 29.00'	5.60	39.80	17.20	1.20	
45.	Narrow high G.S. side Xc,SE Gray Wk Sur. Sta. 216 S.30 Deg. W. 39.00'					

Control assay certificates of Hawley & Hawley, Assayers, Douglas, Arizona in the files in the office of the Hilltop Mines, Hilltop, show shipments of 231 cars of ore, principally from the Kasper Tunnel Workings, made in the years 1924-25-26, show, for the tonnage of 11,424 tons shipped:

	Ag. Ozs.	Pb. %	Zn. %	Cu. %	Fe. %
Shipments of 424 cars of ore (11,424) tons mainly from the Kasper workings 1924-1926	2.96	12.25	7.40	0.25	(Gray)
	5.24	23.06	5.06	0.35	16.20
The average of 87 "cut" samples in Gray workings give	2.00	8.35	5.90	0.49	
	1.78	7.56	5.22	0.24	
The average of 19 cut samples in Kasper workings	5.67	19.96	4.23	0.60	

Memo by F. H. Lerchen, Tucson, Arizona, May 21, 1938

APPENDIX B

Samples by H. Schmitt and Assays by A. Veeder

No.	Gold oz	Silver oz	Copper %	Lead %	Zinc %	WO_3 %	Bi %
501	trace	0.52	0.25	13.30	11.05		
502	"	2.72	0.30	14.95	1.60		
503	"	2.80	0.10	10.70	8.00		
504	"	1.06	0.15	9.05	6.20		
Composite of above samples						0.05	0.08
505	trace	2.00	3.45	14.60	16.60		
506	0.01	4.60	0.30	15.90	12.85		
507	trace	2.40	0.20	6.15	4.80		
		10.10	4.75	84.65	61.10		
		2.3	.6	12.1	8.7		

LEGEND FOR HILLTOP MINE

Mine Workings

Shaft

Winze

Raise

Chute

Workings back of, or below section or plan

Workings in front of, or above section or plan

Adit

Prospect

Rocks

Ls	Limestone (undifferentiated)
Qt	Quartzite
Sh	Shale
Pp	Porphyry (undifferentiated)

Minerals

Ga	Galena
Sp	Sphalerite
Py	Pyrite
Chal	Chalcopyrite
G	Garnet
E	Epidote
Ch	Chlorite
Crs	Carbonates (not lead ore)
Min	Mineralization

Alteration Symbols

Mbl	Marble
Sls	Secondary silicates

Alteration Symbols (Cont.)

Hn	Porcellanite (Hornfels)
MT	Metamorphosed
Ox	Oxidized
Sl	Slightly altered
Gs	Gossan
Md	Moderately altered
ST	Strongly altered
FeO	Oxidized iron minerals
CuO	Oxidised copper minerals
	Low grade ore mineralization
	Sulphide ore
	Oxidized ore

Structural Symbols

Gg	Gouge
Br	Breccia
Flt	Fault
	Fault showing dip and with 2' of gouge
	Dip and strike of beds
	Broken ground not breccia, i.e., fragments not rotated
	Jointing "shear" or fracturing with dip
	Direction and dip of striations on faults
	Known contact
	Inferred contact
	Angle away from plane of section

N.B. When above symbols are orange read pre-ore: when red, undifferentiated; when green, post ore.

Some abbreviations are formed by dropping consonants of the words

AMERICAN SMELTING AND REFINING COMPANY
EL PASO SMELTING WORKS

ORE SETTLEMENT

EL PASO TEXAS 6/11/47
SMELTER LOT 1415
SHIPPER'S LOT
CLASSIFICATION Ore
NAME OF MINE Hilltop

BOUGHT OF G. T. Humphries, R.F.C. Acct.
ADDRESS c/o Southern Ariz. Bank & Tr. Co., Dockett #6166
SHIPPING POINT San Simon, Arizona Tucson, Arizona

CAR No.	Initials	Gross	Sacks No.	Sacks Weight	Net Weight	Moisture %	Dry Weight
39965	SP				113580	1.4	111990

Final Settlement

ASSAY METAL CALCULATIONS
Assayed Date 5/27/47
B/L Date 5/24/47
Silver 90.0 Oz per ton
Fine Silver 70.75
Lead $ 15.00 Per cwt lb
E & M 1
Copper Oz per lb

PREMIUM METAL CONTENT
Lead 20480 lbs
Copper lbs

PAYMENTS FOR METALS

Elements	Assay	Ton	Deducted	Payable	Price	Per	Value	Deductions	Amount Total
Gold		Oz				Oz			
Silver	4.2	Oz	1.0	3.2		3.2	Oz	.885	2.83
Lead	19.25	%	1.5	17.75	355	90	319.5 lbs	.1329	42.46
Copper	.08	%	No	Pay			lbs		

TOTAL PAYMENTS FOR METALS 45.29

DEDUCTIONS

		Debits	Credits
Base Charge: 1 @ El Paso, for Metal Payments not exceeding 15.00 per ton		4.50	
10 % of $ 30.29 exceeds over $ 15.00 per ton		1.50 Max.	
Grading Sch.			
Copper Deducty			
Balance Freight Due 319.5 @ .00024		.08	

Analysis		Deduction	Net	Rate				
Insoluble	51.2 %	40.0	11.2	%	@	5	Cts	.56
Silica	32.2 %			%	@		Cts	
Iron	3.5 %			%	@		Cts	
Mn	%			%	@		Cts	
Lime	.1 %			%	@		Cts	
Zinc	5.8 %	5.0	.8	%	@	30	Cts	.24
Sulphur	.2 %			%	@		Cts	
Alumina	8.0 %			%	@		Cts	
As	.15 %			%	@		Cts	
Sb	.32 %			%	@		Cts	
Bi	%			%	@		Cts	

TOTAL DEDUCTIONS 6.88 6.88

38.41

	Debits	Credits
Total Value of 55.995		2150.77
Less Freight on 56.79		
Dry Tons @ 38.41		
Wet Tons @ 3.24	184.00 & 5.52 Tax	189.52
~~Trucking Charge~~ Demmurage	9.90 & .30 tax	10.20
Switching 3.10 & .09 Tax		3.19
Umpire		
Custom Assay Co.		6.00
Amount withheld pending receipt of Silver Affidavit (10% -3.24)		34.16
Royalty 10%		191.37
BALANCE DUE SHIPPER		1716.33
Deduction for Freight per wet ton $ 37.87		2150.77 2150.77

Checked Verified Approved

E. W. Watson
Hilltop-via Portal
Arizona.

July 13, 1948.

Mr. Joseph T. Terry
1318 So. Ivar Ave.
Rosemead, Calif.

Dear Joe:

Please accept my apologies for my delinquency in answering your letter but I have been so busy putting things together with the usual uncertainties. These are now being resolved into a definite line of proceedure.

Please let me know at your earliest how soon you can come up here and how much money you will need to have to bring your equipment or at least the essentials of it along with you. Now, Joe, I am in a tough spot for the moment but I need you very badly and if you can come at once we can provide accommodations for Mrs. Terry and yourself and we will get together and fight this thing into production as we both have done many times in the past. Let me know where and how much to send so that you can cut loose and come stright up here.

With old time sincere regards,

Ernie W. Watson

1318 So. Ivar Avenue
Rosemead, Calif.
August 23, 1948.

(handwritten)

Dr. E. W. Watson
Hill Top, Arizona
Via Portal.

Dear Mr. Watson:

I am writing this at the Wicks office, who has just told me about your plans and program regarding the production of a rougher jig concentrate at Hill Top and milling the jig concentrate at Lordsburg, N.M.

I have just returned from a three weeks engagement installing flotation process equipment at the Butterfly Mine on Irskine Creek, Kern, Co. Calif.

Mr. Frank Wicks mentioned that you may desire my services in operating the selective flotation mill at Lordsburg. If so, please let me know at your earliest convenience so that I will not be held up by taking on more ore testing work. My present investigations should be completed within the next two days.

Please reply by air mail.

With kindest regards.

Sincerely yours,

J. T. Terry

JOSEPH T. TERRY
1318 So. Ivar Avenue
Rosemead, California.

November 8, 1948.

Dr. Ernie Watson
Hill Top Mine
Via Portal, Arizona.

My dear Friend:

Mr. Wicks and I still talk about our enjoyable trip to Hill Top, and sojourn under your hospitable roof.

I made a trial flotation test on the jig sample with apparent good results but desire to check it before making a definite statement.

With this idea in mind, I would appreciate receiving about ten pounds of a composite basket and hutch concentrate.

I have faith that your ability and tenacity will overcome all the adverse odds and that success will crown your efforts.

With very kindest regards,

Sincerely yours,

JOSEPH T. TERRY.

JOSEPH T. TERRY
1318 So. Ivar Avenue
Rosemead, California.

December 16, 1948.

Test No. 2 Piedmont Mines Inc. Jig Concentrates.

Product	Weight in Grams	% Wt.	Assays. % Lead	%Zinc.	%Wt. X Assay / 100	
Lead Concentrate	170.5	34.10	63.1	7.0	21.51	2.38
Iron Concentrate	60.3	12.06	31.1	8.5	3.75	1.02
Middling	52.2	10.44	15.3	9.5	1.59	0.99
Tailing	267.0	53.40	2.5	4.9	1.33	2.61
Heads	500.0	100.0	28.2	6.7	28.18	7.00

Distribution of lead and zinc in products in percentage.

	Lead	Zinc
Lead Concentrate	73.33	34.00
Iron Concentrate	13.30	14.57
Middling	5.64	1.41
Tailing	7.83	50.02
	100.00	100.00

The material tested by Flotation, is a jig concentrate in which the lead and zinc contents are largely in an oxidized state. Oxidized zinc does not respond to selective flotation and its recovery in marketable form by leading or other methods will necessitate considerable experimentation

The jig concentrate was ground in a laboratory ball mill to a wet pulp, 100 percent minus 80 mesh.

By combining the lead concentrate, and the iron concentrate, plus a calculated recovery of 73.33 percent of the lead and zinc in the middling gives a calculated total recovery of 90.76 percent of the total lead assaying 54.73 percent lead and 7.38 per cent zinc.

Respectfully submitted,

JOSEPH T. TERRY

ASSAY CERTIFICATE

Ed Eisenhauer, Jr.
320-322 So. San Pedro
Los Angeles 13, Calif.
Phone VA 9328

Los Angeles, Calif. Dec. 16, 48

I hereby certify that the samples described below, received from

J. T. Terry, assay as follows:

Owner's mark and sample	Percentage of Copper	Lead	Zinc.
Heads		28.2	6.7
Midds		15.3	9.5
Lead Concent.		63.1	7.0
Tailings		2.5	4.9
Pyritic Iron		31.1	8.5

Charge: $12.00

Ed Eisenhauer, Jr. (signed)
Assayer

JOSEPH T. TERRY
1318 So. Ivar Avenue
Rosemead, California.

January 21, 1949.

Mr. Erne Watson
Manager
Piedmont Mines Incorporated
Hilltop, Arizona, via Portal.

Dear Mr. Watson:

I am sending you for inspection, samples of sulphidized lead carbonate, iron pyrite and tailing from your jig concentrate by my selective flotation process. My process is applicable to mixed sulphides and carbonate ores.

Because of the fact that the valuable minerals in Hilltop ore are finely disseminated through the gahgue matrix, it is my opinion that your present equipment of a crusher, rolls and jig are not adequate to effect a satisfactory recovery.

One cannot go wrong by duplicating the design and specifications of successfully operating mills, built for example by the Denver Equipment Co. or Western Knapp Co.

Under my method of treatment three separate banks of flotation cells are required with conditioning tanks between, for lead, zinc and pyrite, respectively.

If you will let me know what tonnage mill you contemplate building, I shall take it upon myself to send you plans, specifications and data.

I am still hoping that the day is not far off when Mrs. Terry and I can join you at Hilltop. Incidentally, Mrs. T. is an excellent cook.

We are having a drizzling rain at this writing.

Hoping that this finds you well and comfortable,

Sincerely yours,

JOSEPH T. TERRY

C
O
P
Y

JOSEPH T. TERRY
Metallurgist - Ore Treatment
Mining - Milling - Leasing.

March 17, 1949.

1318 So. Ivar Ave.
Rosemead, Calif.
Tel: Atlantic 65932

Dr. Erne Watson
Hilltop, Arizona,
via Portal.

Dear Mr. Watson:

Herewith is the tabulated result of the flotation and gravity concentration test on your jig tailings based on the re-flotation of the tailings from the previous test reported. I owe Mr. Eisenhauer $1.75 for the last assays.

I was in Frank Wicks office yesterday, and he mentioned that there is still a chance that you may want me on your staff at the mine. Nothing would please me more than to work for and with you.

Trusting all is well with you physically, spiritually and financially,

Sincerely yours,

Joseph T. Terry

3/12/49

Gravity and flotation concentration test on
Hilltop jig concentrates.

	Weight in Grams	Wt. in %	Ounces per ton Gold	Silver	Percent lead.
Concentrate	197.5	39.50	tr	6.60	60.3
Middling	143.0	28.60	tr	2.02	14.9
Pyrite	7.7	1.54	tr	4.00	00.00
Tailing	151.8	30.36	tr	0.17	0.98
Heads by Assay	500.0	100.00	tr	3.33	28.44

Percent weight X assays equals Heads by calculation

	Silver	Lead
Concentrate	2.607	23.818
Middling	0.577	4.261
Pyrite	.061	0.000
Tailing	.051	0.297
Heads by calculation	3.296	28.376

Distribution in per cent of total values

	Silver	Lead
Concentrate	79.09	83.93
Middling	17.50	15.01
Pyrite	1.85	00.00
Tailing	1.56	1.06
	100.00	100.00

Calculated recovery,
79.09 X 17.50 plus 79.09 equals 92.93 per cent of total silver.

83.93 X 15.01 plus 83.93 equals 96.52 per cent of total lead.

Ratio of concentration.

Concentrate minus tailing

---------- based on silver 2.30 tons into 1
" " lead 2.16 " " 1

Heads minus tailing

This test was made on tailings from a previous test representing 33.59 per cent by weight of pulp and assaying 6.7 per cent lead, by state sulphidizing and flotation. producing a tailing assaying gold trace. Silver 0.17 ounces % lead .098 Previous calcuations were rectified to conform to the final tailing.

The flow sheet recommended is grinding the jig concentrate in a rod mill. Classify on a 35 mesh screen and return the oversize to the mill. Tan

Table the 35 mesh pulp and take off a lead concentrate. Cut out a sand middling on the table and return it to the mill. Run the slimes table tailing to a conditioning tank and then by step sulphidizing recover a flotation concentrate.

It is my opinion that this can best be done at the property.

On oxidized lead ores, classification on stainless steel screens, and concentrators is superior to free settling classifyers such as the Dorr, thereby avoiding over grind of the lead minerals.

JOSEPH T. TERRY
3/17/49

F.

LEGEND FOR HILLTOP MINE

Mine Workings

	Shaft
	Winze
	Raise
	Chute
	Workings back of, or below section or plan
	Workings in front of, or above section or plan
	Adit
	Prospect

Rocks

Ls	Limestone (undifferentiated)
Qt	Quartzite
Sh	Shale
Pp	Porphyry (undifferentiated)

Minerals

Ca	Calena
Sp	Sphalerite
Py	Pyrite
Chal	Chalcopyrite
G	Garnet
E	Epidote
Ch	Chlorite
Crs	Carbonates (not lead ore)
Min	Mineralization

Alteration Symbols

Mbl	Marble
Sls	Secondary silicates

Alteration Symbols (Cont.)

Hn	Porcellanite (Hornfels)
Mt	Metamorphosed
Ox	Oxidized
Sl	Slightly altered
Cs	Cassan
Md	Moderately altered
ST	Strongly altered
FeO	Oxidized iron minerals
CuO	Oxidized copper minerals
	Low grade ore mineralization
	Sulphide ore
	Oxidized ore

Structural Symbols

Gg	Gouge
Br	Breccia
Flt	Fault
30 Gg 2'	Fault showing dip and with 2' of gouge
60	Dip and strike of beds
	Broken ground not breccia, i.e., fragments not rotated
70	Jointing "shear" or fracturing with dip
30	Direction and dip of striations on faults
	Known contact
	Inferred contact
70	Angle away from plane of section

N.B. When above symbols are orange read pre-ore: when red, undifferentiated; when green, post-ore.

Some abbreviations are formed by dropping consonants of the words