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Report

on the Geology of the

UNITED VERDE EXTENSION MINE

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REPORT ON THE UNITED VERDE EXTENSION MINE

By F. L. Ransome

PURPOSE AND SCOPE OF THE EXAMINATION

At the request of Mr. J. S. Douglas, President of the United Verde Extension Mining Company, I arrived in Jerome early in July, 1927 and, with the exception of about 28 days occupied by two trips to Oregon, was continuously at work, until the middle of December, engaged in a study of the United Verde Extension Mine and the immediately surrounding district. The particular purposes of the examination were: (1) to ascertain whether there is any probability of a downward continuation of the main ore body within the boundaries of the Company's property; (2) to appraise the possibility or probability of the existence of other ore bodies of comparable size within the Company's ground; and, finally, (3) to suggest directions for future major development. No detailed instructions were drawn up for this work and no time limit was placed upon it.

It appaared to be the opinion of Mr. Douglas, with which I concurred, that the members of the resident mine staff were fully capable of finding all of the ore within the known ore-bearing territory of the mine, their intimate knowledge of the workings and of the behavior of the known ore-bodies being such as no new-comer, occupied for only a few months with the broader geological features, could hope to attain. Nevertheless, it was reasonable to expect that there would result fron my work at least some suggestions concerning what may be termed minor or secondary

exploration and these I shall make in the appropriate place. Inasmuch as I hope later to publish a paper on the geological features of the Jerome district, I shall confine myself in the present report to a brief outline of those conditions that have a direct bearing upon the practical questions with which the report is primarily concerned.

In the present study of the mine, none of the previous geological work was accepted without verification. I examined all accessible parts of the underground working, in the hope that in the generally more or less schistose rocks, some structure might be recognized, which would prove to have a significant relation to ore deposition. This hope was only partly fulfilled. I found that, in general, the earlier mapping has been faithfully and accurately carried out. Where there is disagreement with it, this is usually a question of interpretation rather than of record. In my opinion, however, the 100-foot-scale geologic level maps, in general use in the Company's office, embody far too extensive imaginative projection into areas where there are no underground workings. Such maps, displaying much that is conjectural without distinction from what is fairly well established, may be useful for special purposes but are likely to be misleading as general working guides.

In the course of the mine examination a collection was made of over 400 specimens, chiefly rocks. The specimens have been labelled, cataloged and indexed and should be useful in future geological and developmental work, especially as some of them come from places that will soon be no longer accessible.

No geological level-maps have been prepared to accompany

this report as such work would require considerable time and can, in the light of my report and collection, be done by members of the regular staff, if desired. If the Company wishes, however, I will willingly undertake to prepare revised geologic maps or to render such aid as may be necessary for their preparation.

Throughout my stay at Jerome I enjoyed the most cordial cooperation on the part of all connected with the United Verde Extension mine and acknowledge with particular appreciation the helpfulness of Mr. Olaf Hondrum, chief engineer, and the members of his staff.

GENERAL GEOLOGY OF THE DISTRICT

The most comprehensive and detailed account of the geology of the Jerome district is that by Reber [1], which has been supplemented by later papers by Fearing [2], and Lindgren[3].

It suffices here to state that the fundamental rocks of the district constitute a complex of schists and intrusive rocks of pre-Cambrian age which had their present characteristics imposed upon them by the folding and metamorphism of that early era. They constitute the roots of pre-Cambrian mountains, which, however, had been worn down by erosion to a nearly level surface at the beginning of the Cambrian. The principal ore deposits were formed before the completion of this period of erosion.

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[1] Reber, L. E., Geology and ore deposits of Jerome district: American Inst. of Min. and Met. Engineers, Trans. vol. 66, pp. 3-26, 1922.

[2] Fearing, J. L. Jr., Geology of the Jerome district, Arizona; Economic Geology, vol. 21, pp. 757-773, 1926.

[3] Lindgren, W. Ore deposits of the Jerome and Bradshaw Mountains quadrangles, Arizona; U.S. Geol. Survey, Bull. 782, pp. 54-97, 1926.

In Cambrian time, the region sank below the sea and was covered successively by the dark red basal sandstone of the region, which is here supposed to be the equivalent of the Cambrian Tapeats sandstone of the Grand Canyon, altho some geologists consider that it may be of Devonian age.[1] The basal sandstone, of variable thickness but attaining a maximum of about 100 feet, is overlain successively by from 600 to 1000 feet of Devonian and lower Carboniferous limestone and by red sandstones and shales, up to 500 feet thick, of Permian age - the Supai formation.

After a long period of erosion, the region was covered in late Tertiary time by basaltic flows, which accumulated to a thickness of over 700 feet. The eruption of the basalt was followed by normal faulting and by the erosion that has shaped the topography of today.

The primary or hypogene mineralization, which produced the ore bodies of the United Verde and United Verde Extension mines in their original form, and practically all of the downward or supergene enrichment, which resulted in the remarkable main ore body of the United Verde Extension mine, took place before the deposition of the basal sandstone. The ores of these mines are consequently pre-Cambrian or pre-Devonian, according to the opinion held as to the age of the sandstone.

Inasmuch as the stratigraphy of the Paleozoic formations has no bearing on the problems dealt with in this report, no particular study was made of these rocks.

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[1] See Fearing, J. L. Geology of the Jerome district, Arizona; Ec. Geol., vol. 21, pp. 758-759, 1926.

The general surface distribution of the more important rock units or groups in the part of the Jerome district adjacent to the principal mines, is shown in Plate I.

PRE-CAMBRIAN FORMATIONS

With few exceptions the pre-Cambrian rocks are more or less schistose and have been considerably metamorphosed by the close folding and compression and by the igneous intrusions of pre-Cambrian time. Some of them are completely recrystallized into fine-grained schists that contain no vestige of their original texture or mineral composition. Consequently it is not surprising that various geologists, attempting to subdivide them, have differed in opinion as to their original character and appropriate nomenclature. As a whole they belong to the group of rather diverse metamorphic rocks that on general maps of the region have been designated Yavapai schist. They are so represented, for example, on the geological maps of the Jerome and Bradshaw Mountain quadrangles, which accompany Lindgren's[1] recent report on those areas.

Locally, attempts have been made to divide the pre-Cambrian rocks at Jerome into a number of units.

Reber, in the paper previously referred to, divides the principal pre-Cambrian rocks as follows, the younger rocks being at the top:

(4) United Verde diorite. (Intrusive)

(3) Quartz porphyry. (Later known as Cleopatra porphyry. Intrusive)

(2) Bedded sediments.

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[1] Lindgren, W., Ore deposits of the Jerome and Bradshaw Mountain quadrangles, Ariz., U.S. Geol. Survey, Bull. 782, 1926.

(1) Greenstone complex. (Includes what was later called "Deception porphyry" by Finlay.)

Reber considered the "greenstone complex" as consisting chiefly of metamorphosed volcanic flows and pyroclastic rocks with minor bodies of intrusive rock. His "bedded sediments" are described as consisting of a great variety of materials, among which he mentions quartzites, slates, conglomerates and one bed of "limestone or marble" up to 20 feet thick. The "quartz porphyry" he regarded as intrusive and probably an offshoot from the Bradshaw granite, which is extensively exposed south of the Jerome district. The "United Verde diorite" is characterized as an "augite diorite with diabasic phases."

Fearing, in the paper previously cited, maintains that the "Deception quartz porphyry" should not be included in the "greenstone complex" but, like the "Cleopatra quartz porphyry" is an intrusive sheet or sill, the "Deception quartz porphyry" being the older of the two. He divides the remainder of the "greenstone complex" as follows:

Basic tuff - - - - - - - - - - - - - - - -	Not fully exposed.
Diabase flow or sill, often of dioritic texture - - - - - - - - -	- 1200 feet.
Andesitic or diacitic tuff - - - - - - -	0 - 200 feet.
Rhyolite tuff - - - - - - - - - - - - -	- 600 feet.
Bedded shale or ash - - - - - - - - - -	0 - 70 feet.
Basic tuff - - - - - - - - - - - - - - -	Not fully exposed.

I regret to state that, in my opinion, this section is wholly unreliable. It appears to have been based on measurements across the prevailing schistosity in a cross-cut in the United Verde mine, but this cross-cut affords no satisfactory basis for

the nomenclature or thicknesses given by Mr. Fearing. His statement that these divisions have been mapped in the workings of the United Verde Extension mine is not supported by any maps known to me. They certainly do not all appear in the figure to which he refers on page 763 of his paper, which is a map of the 1400 level of that mine, altho in that illustration he represents as "rhyolitic tuff" rock which on the maps prepared by him for the company he shows as "acid volcanics".

Enough has been presented to indicate that there is considerable diversity, if not confusion, in the nomenclature applied to the pre-Cambrian rocks (See figure 1.)

My own observations lead to the conclusion that there are five, possibly six, major groups of rocks involved in the pre-Cambrian complex as exposed in the central part of the Jerome district. These, beginning with what is probably the oldest are as follows:

(1) WALNUT SPRINGS GREENSTONE. The rocks of what it is here proposed to name the Walnut Spring Greenstone are typically exposed at and near the swimming pool near Walnut Spring. They comprise two principal varieties, both greenish gray on fresh exposures. One variety is fine-grained, more or less schistose rock, which is characterized by wavy, discontinuous banding. The other variety is coarser-grained, less noticeably banded and shows grains or phenocrysts of quartz. The two varieties are intimately associated, and the coarser variety near the contact with the finer-grained variety, contains fragments of the latter. Other varieties of the Walnut Spring greenstone, especially when weathered, have some resemblance to altered tuffs.

Under the microscope, the fine-grained variety is recry-

Nomenclature of rocks in the Verde District, Ariz.

Present report.	Reber, 1920.	Fearing, 1926.	Current usage, United Verde Mine.	Current usage, U. V. X. Mine.
Walnut Spring greenstone. (Banded rhyolite flows).	Bedded sediments.	Greenstone, including some sedimentary material.	Bedded sediments.	Greenstone; Quartz porphyry in part.
Gold Hill rhyolite. (Felsitic rhyolite flow or flows. Few or no quartz phenocrysts.).	Greenstone.	Greenstone.	Greenstone.	Greenstone; Acid volcanics. "Bedded sediments" where greatly sheared.
Deception rhyolite. (Flow or flows. Quartz phenocrysts small and sparse).	Greenstone.	Deception quartz porphyry (Intrusive.)	Fragmental greenstone.	Deception porphyry.
Cleopatra rhyolite. (Probably mainly a flow or flows. Quartz phenocrysts abundant)	Quartz porphyry. (Intrusive).	Cleopatra quartz porphyry.	Quartz porphyry.	Quartz porphyry. Cleopatra porphyry.
Verde diorite. (Intrusive)	United Verde diorite. (Intrusive).	United Verde diorite. (Intrusive).	United Verde diorite.	Diorite.
Diabase.	Greenstone.	Diabasic greenstone. (Flow or sill).		Greenstone.

stallized to a finely crystalline aggregate of quartz, sericite and some epidote and chlorite. It is more siliceous than might be supposed from the general appearance of the rock and contains (Spec. U. V. X. 8) 72.4 per cent of Si O_2 and 1.8 per cent of Ca O.[1] The coarser variety (Spec. U. V. X. 143) contains quartz phenocrysts as large as those commonly present in the Cleopatra rhyolite. The texture of the rock, as seen under the microscope, suggests the possibility that it may be a tuff but field relations indicate that it probably is a devitrified glassy rhyolite with abundant included fragments - a flow breccia.

This rock contains 73.2 per cent of Si O_2 and 2.6 per cent of Ca O.

On the supposition that the banding of these rocks is indicative of sedimentary bedding, they were termed "bedded sediments" by Reber and are so mapped in the United Verde mine. In the United Verde Extension mine, the finer-grained variety has generally been mapped as "greenstone" and the coarser-grained variety, at least in part, has been mapped as "quartz porphyry". I regard them as metamorphosed rhyolite flows, the banding being interpreted as flow-lines in an originally glassy lava. The inclusions of the finer grained variety in the coarser variety are not readily explainable if these rocks are sedimentary but can be accounted for, if the rocks are rhyolite, as fragments of previously solidified lava caught up in parts of the flow that congealed later or in a subsequent flow.

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[1] These and other chemical determinations cited in this report were made by Mr. S. H. English, chemist at the United Verde Extension smelter, at Clemenceau.

The name greenstone is commonly applied to altered volcanic rocks of more basic composition than the rocks here described but the name is appropriate so far as color is concerned and has become a familiar term in the district. These considerations appear to justify its retention.

(2) GOLD HILL RHYOLITE. The formation termed in this report the Gold Hill rhyolite is exposed in Deception Gulch from near the Gold Hill tunnel, whence it derives its name, for a distance of about 1000 feet eastward. The rock of this area generally weathers brown and is brownish gray on fresh fracture. As a rule, it is not noticeably schistose, but locally some schistosity is developed and in such places the rock may be greenish gray. Contorted flow lamination is conspicuous in some exposures in Deception Gulch. Quartz phenocrysts are rare or absent but the microscope shows abundant quartz in the groundmass of the rock. Small phenocrysts of orthoclase or sanidine are fairly abundant, usually associated with phenocrysts of a sodic plagioclase. The rock is a more or less altered glassy rhyolite, probably erupted as a flow or flows. In places it shows distinct flow brecciation.

The Gold Hill rhyolite does not appear to have been distinguished previously as a separate formation and is known at the surface only at the type locality in Deception Gulch. It is in every respect, however, identical with the rock that, in the United Verde Extension mine has usually been mapped as "acid volcanics", when any separation of the "greenstones" has been attempted. Chemical determinations on a specimen (U. V. X. 168) from the United Verde Extension mine gave 71.4 per cent of SiO_2

and 0.9 per cent of Ca O.

(3) DECEPTION RHYOLITE. The rock described in this report as Deception rhyolite is typically exposed in the rugged gorge through which Deception or Walnut Creek flows east of the Verde Central mine. It is separated from the Gold Hill rhyolite by a belt of Cleopatra rhyolite (next to be described) which in Deception Gulch is about 2500 feet wide from east to west.

The Deception rhyolite is generally a rather roughly schistose rock which is greenish gray on fresh fracture and weathers brown. As a rule it contains small, rather sparsely distributed and somewhat angular phenocrysts of quartz. Near the contact with the Cleopatra rhyolite, as may be seen on the pipe-line on Cleopatra Hill, it has a distinctly brecciated character which is strongly suggestive of flow brecciation. There is no evidence that the Deception rhyolite is intrusive but much to suggest that it is an originally glassy rhyolite flow which has been rendered schistose and has undergone considerable metamorphism. In microscopic character and in many exposures underground it closely resembles the Gold Hill rhyolite and may be a more metamorphosed variety of that rock. Chemical determinations made on a specimen of Deception rhyolite (N.V.X. 72) gave 75.6 per cent of Si O_2 and 0.3 per cent of Ca O. On another specimen (U.V.X. 49) the results were Si O_2 74.0 per cent, Ca O 0.3 per cent.

The Deception rhyolite was included in the "greenstones" by Reber, altho he remarks that its character is open to question. Finlay named it "Deception porphyry" and Fearing, in the paper previously referred to, designates it as "Deception porphyry"

and "Deception quartz porphyry". He regards it as an intrusive sill. Mr. Hansen, chief geologist of the United Verde mine, maps it as "fragmental greenstone", his view apparently being that the small quartz phenocrysts are fragmental grains and not true phenocrysts.

(4) CLEOPATRA RHYOLITE. The Cleopatra rhyolite is typically exposed on Cleopatra Hill and in Deception Gulch, in the general vicinity of the Verde Central mine. It is the "quartz porphyry", "Cleopatra quartz porphyry", or "Cleopatra porphyry" of the various reports on the Jerome district and of the geologic maps of the mining companies.

This rock shows considerable variation from place to place but its distinguishing characteristic is its abundance of easily visible quartz phenocrysts. In places, as on the east slope of Cleopatra Hill, the rock is schistose. In other places it is massive, the conspicuous quartz phenocrysts lying in a very fine-grained brown matrix that has every appearance of having once been largely volcanic glass altho this glass has devitrified or become a very fine-grained aggregate of quartz and feldspar. In a number of places, particularly in Deception Gulch, along the western margin of the mass, between the Verde Central Mine and Walnut Spring, the rock is unquestionably a flow-breccia, in which fragments of previously solidified porphyritic rhyolite have caught up and carried along in still-liquid portions of the mass. Even where Cleopatra rhyolite shows no distinct brecciation, it exhibits streaky variations in texture that are strongly suggestive of movement in a viscous lava flow. In short, the Cleopatra rhyolite, as exposed on the surface, has

the characteristics of a thick viscous flow certainly not those of a deep-seated intrusive mass.

In the mines, the apparent occurrence of some of the Cleopatra as lenses or isolated masses in the other pre-Cambrian rocks suggests that the rhyolite is intrusive. No convincing evidence of intrusion was found, however, and it is certain that some of the isolated bodies shown on some mine maps as "quartz porphyry" are not the Cleopatra rhyolite. It is entirely possible, moreover, that the main body of Cleopatra rhyolite may have been erupted as a flow while, at the same time, portions of the rhyolitic magma may have been intruded into the older rocks as dikes.

The eruption of the Cleopatra rhyolite probably occured long before the deposition of the ore bodies and consequently is not responsible for the copper mineralization in the Jerome district.

(5) VERDE DIORITE. It is generally accepted in the district that the Verde diorite is an intrusive mass altho this conclusion rests chiefly upon the character of the rock and its general relations to the other rocks rather than upon direct evidence of intrusion. The rock is a massive medium-grained angite diorite, which as a rule is considerably altered. Generally, as the rock is found in the mines, the augite has been altered to amphibole or to epidote, chlorite and carbonates, the feldspars are decomposed and considerable secondary quartz is present. As a rule the diorite is not schistose altho schistosity may be locally developed at its margins. Chemical determinations made on a specimen of fairly fresh diorite from the United Verde open pit (specimen U. V. X. 1) gave 49.8 per cent of SiO_2 and

8.6 per cent of Ca O.

(6) DIABASE. The rock here designated diabase has not been recognized at the surface and in the United Verde Extension mine is not present in the vicinity of any known ore body. Large masses of it have been penetrated, however, in the long exploratory drifts to the east and north of the Audrey shaft, in Jerome Verde ground, on the 1400 and 1700 levels. On the mine maps it has generally been shown as "greenstone" altho on his published map of the 1400 level (Economic Geology, vol. 21, P. 763, 1926) Fearing terms it "diabasic greenstone flow." The diabase is a generally massive rock of rather fine texture and greenish color. In thin section, under the microscope, it shows the characteristic ophitic texture of diabase with abundant augite. The plagioclase feldspars are decomposed and the rock contains much secondary epidote and chlorite. Chemical tests (U.V.X. 233) showed 46.2 per cent of Si O_2 and 5.6 per cent of Ca O. Without insistence upon any high accuracy for these determinations, it is clear that the rock is much more basic than the rhyolitic "greenstones" of the mine and is fairly close to the Verde diorite in composition. I could find no evidence for regarding it as a flow and am inclined to believe that it is intrusive and rather closely related to the Verde diorite.

It appears from the foregoing that the principal pre-Cambrian rocks of the central part of the Jerome district comprise 4 rhyolitic formations, namely, the Walnut Spring greenstone, the Gold Hill rhyolite, the Deception rhyolite, and the Cleopatra rhyolite, all of which are believed to have been erupted at the surface as flows, and two basic igneous rocks, namely the Verde diorite and the diabase, of which the diorite is intrusive and

the diabase may be intrusive. So far as my observations go, there are no sedimentary rocks in the pre-Cambrian of the central part of the Jerome district. Certainly conglomerates, sandstones, shales and limestones are absent and it is at least doubtful whether any bedded tuffs are present.

Occasionally, in the following pages it will be convenient to refer collectively to the Walnut Spring greenstone, the Gold Hill rhyolite and the Deception rhyolite. Generally when the terms "greenstone" and "rhyolitic greenstone" are used they are to be understood as referring to any or all of the three rocks mentioned, without any attempt to distinguish between them.

By way of summary it may be stated, that in pre-Cambrian time the Jerome area was covered by a series of rhyolitic lava flows, erupted over a surface of older rocks which are not anywhere exposed in the district. Possibly some of the earlier flows were intruded by dikes, or even by larger bodies, of the magma that solidified as the Cleopatra rhyolite but that rhyolite as a whole is believed to have congealed on or very close to the surface as it existed at that time.

PRE-CAMBRIAN STRUCTURE

All of the pre-Cambrian rocks, except the Verde diorite and some of the diabase appear to have been closely folded in pre-Cambrian time. This folding was accompanied or followed by intense compression along nearly east-west lines so that the rocks were rendered schistose. It is, in general, this schistose structure, striking nearly north and standing nearly vertical, that is the most conspicuous structural feature of the rocks. Whatever original layering may have been present in the succession

of rhyolitic flows has been obliterated or greatly obscured.

It is possible on the various levels of the United Verde Extension mine to map separately the Walnut Spring greenstone, the Gold Hill rhyolite, the Deception rhyolite, and the Cleopatra porphyry. When, however, an attempt is made to utilize these level-maps for the construction of geological cross-sections thru the mine, the distribution of these rocks is so different on successive levels as to exclude any simple structural explanation. The observed relations suggest that the rocks were intricately folded and perhaps faulted before they became schistose but it is very doubtful whether it would be practicable to show this structure in sections other than in a much generalized and largely imaginary fashion. It is to be remembered that all of these rocks are rhyolite, that they never had the regular stratification of sedimentary beds, that there are no persistent, readily recognizable "key" layers that would give a clue to the structure, and finally that the differences in character brought about in any one rock by the imposed schistosity are, as a rule, far more conspicuous than the original differences between the individual members of the rhyolitic series. Prolonged study might overcome the difficulties referred to, but it does not appear that the occurrence of ore is dependent upon these earlier and obscure structures in the "greenstones" and consequently there is no economic justification for persistency in an attempt to decipher them.

From the economic point of view the significant lithologic units are: (1) the rhyolitic "greenstones" as a whole (including the Walnut Spring greenstone, Gold Hill rhyolite, and Deception rhyolite), (2) the Cleopatra rhyolite, and (3) the

Verde diorite. It is the relative distribution of these three units, in conjunction with certain zones of shearing, that has determined the place of ore deposition.

LOCAL MODIFICATIONS OF THE PRE-CAMBRIAN ROCKS

Black schist - A large part of the ore of the United Verde mine occurs in a dark, schistose rock commonly referred to as "black schist". It is very fine-grained and much of it resembles a slate rather than an ordinary crystalline schist.

Reber described this rock, in his paper previously referred to, and apparently regarded it as a member of his "bedded sediments", altho he also states that it is probably a product of alteration by magmatic solutions that may have been closely related to ore deposition. Fearing[1] refers to the black schist as being almost entirely composed of ferruginous chlorite and states that the "Cleopatra porphyry", the "Deception porphyry", the "rhyolite tuff" and the "bedded sedimentaries" have all been "observed grading into black schist". Lindgren[2] ascribes the ferriferous chlorite of the black schist to the action of ascending solutions connected with ore deposition but suggests that the black schist may have been originally a slate of sedimentary derivation.

My own observations have convinced me that most of the black schist is intensely sheared and metamorphosed Cleopatra rhyolite. Some of it still retains residual phenocrysts of quartz and in a number of places all gradations can be found

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[1] Loc. cit., p. 762

[2] Loc. Cit., pp. 72 and 74

between Cleopatra rhyolite and black schist. The dark color is due to the development of the ferruginous chlorite referred to by the writers mentioned, this development being a phase of the same process of mineralization to which the formation of the hypogene ore was due. Possibly the other rhyolitic formations may, in places, have been altered to black schist. Such change would not be improbably, altho I have not seen any evidence of it.

Contact schist - In the United Verde Extension mine there is exposed on all of the main levels a belt of very fissile schistose rock which extends generally in a north-northwest direction from the main ore body and intervenes between the Verde diorite on the west and the Gold Hill rhyolite ("acid volcanic greenstone") on the east. This is the "bedded sediments" of the company's geological maps and the "schist related to ore deposition" of Mr. Lindgren's map.

This rock has generally been regarded as a distinct member of the pre-Cambrian group but, in my opinion is a local modification of the Gold Hill rhyolite and possibly, to a minor extent, of other members of the rhyolitic "greenstones". As a rule, it grades into the Gold Hill rhyolite with no definite contact, the fissile, crumpled "bedded sediments" gradually being succeeded by the more moderately schistose "greenstone". In a few places in the mine the Gold Hill rhyolite shows local schistose portions that undoubtedly would have been mapped as "bedded sediments" did they occur in the position where the main belt of this fissile is normally found. It is fairly certain that the "bedded sediments" of the United Verde Extension mine is merely a very strongly sheared portion of the Gold Hill rhyolite and, because of that shearing, the rock has been a path for ore-

depositing solutions. The rock has not only been squeezed to a finely laminated schist, in which all original texture has been obliterated, but on account of its thinly laminated character has been a zone of weakness along which later movement has taken place, as shown by the prevalent crumpling and distortion of the laminations.

As previously mentioned, the contact schist ("bedded sediments") generally follows the contact with the relatively massive diorite. It is believed to owe its structure to that fact, the Gold Hill rhyolite having yielded most readily to pressure where it was squeezed against the resistant diorite mass. Whether the Verde diorite exerted this pressure at the time of intrusion or was merely a passive mass against which the older rhyolitic rock was molded by regional pressure, I am unable to say. The fact that, at a few places, the contact schist does not appear to occur exactly at the contact with the diorite does not, I believe, invalidate this general explanation of its origin. It records zones of maximum yielding to stress with the accompaniment of rock flowage thru the development of an exceptional degree of schistosity.

GENERAL CONDITIONS THAT DETERMINED HYPOGENE ("PRIMARY") ORE DEPOSITION.

Examination of the general geologic map of the central part of the Jerome district shows that the ore body of the United Verde mine occurs where Verde diorite, Cleopatra rhyolite, and one or more of the rhyolitic greenstones come together. In a general way the United Verde ore body is limited on the northwest and west by the Verde diorite, on the south by the

Cleopatra rhyolite, and on the northeast by "greenstone". Examination of the map further shows that there is only one place in the district where the three rocks mentioned have this relative position. It is a highly suggestive fact that the only other large ore body found in the district, that of the United Verde Extension mine, has roughly the same general relation to the Verde diorite, the Cleopatra rhyolite and the "greenstone". As is well known, the two ore bodies lie on opposite sides of the great Verde fault, the United Verde ore-body in the footwall, to the west and the United Verde Extension ore body in the hanging wall, to the east.

Both ore bodies occur chiefly in Cleopatra rhyolite or in black schist, which is for the most part a local modification of the Cleopatra rhyolite. Of all the rocks in the district, the Cleopatra rhyolite appears to have been most susceptible to extensive replacement by ore, particularly where it has been sheared or fractured and where it is adjacent to the Verde diorite. That the diorite was an essential factor in the mineralization is certain. To the presence of the diorite mass were probably due the shearing and fissuring which gave passage to the ore-bearing solutions; the body of diorite, as a whole impervious and massive, forced the solutions to travel along its margin; finally, it is probable, altho not demonstrable, that the deeper portions of the dioritic magma, before its consolidation, supplied the iron, copper and zinc of the present ore bodies.

In the United Verde Extension ground the zone of contact schist represents the most important and continuous belt of shearing along the margin of the Verde diorite. It furnished a passage for the ore-bearing solutions and itself contains

important ore bodies. The main ore body, however, was formed where this zone of shearing entered the Cleopatra rhyolite.

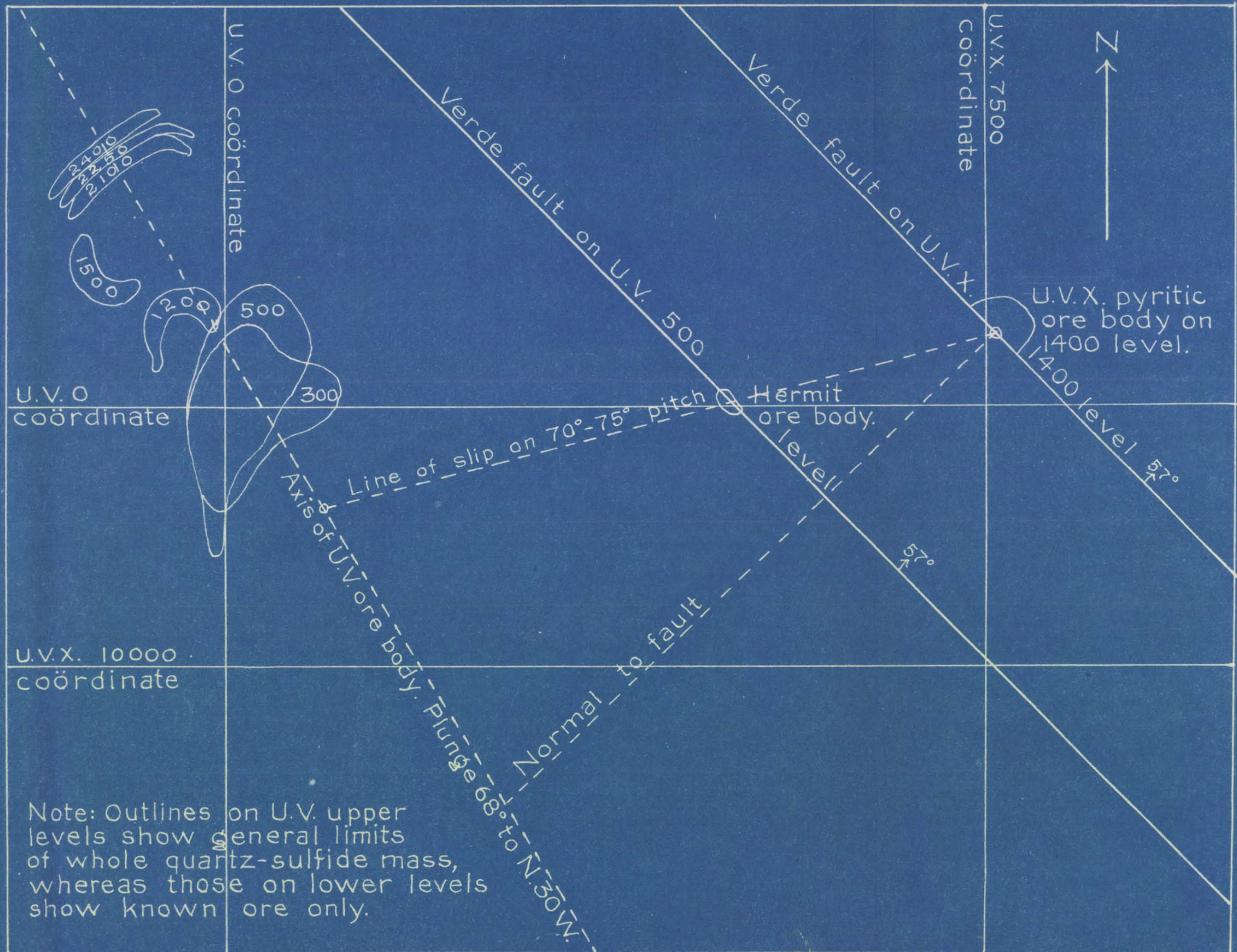
It happens, as is plainly shown on the mine maps, that this ore body lies, in a general way, at the intersection, and mainly within the angle, of the Verde and Florencia faults. These faults, however, appear to be wholly later than the original or hypogene mineralization altho they may have controlled to some extent the supergene enrichment that transformed the United Verde Extension ore body from what was probably a low-grade pyritic mass into the present large, compact and high-grade deposit of chalcocite.

RELATIONS OF THE UNITED VERDE AND UNITED VERDE EXTENSION ORE BODIES TO THE VERDE FAULT.

The course of the Verde fault (or, as it is sometimes called, the Jerome fault) is generally nearly northwest and southeast. The United Verde and United Verde Extension ore-bodies lie approximately on an east-west line, on opposite sides of the fault. The United Verde ore body, exposed at the surface, lies about 2000 feet west of the fault, in the footwall, the fault dipping to the northeast at about 57 degrees. The United Verde Extension ore body, as projected vertically to the surface, lies about 1500 feet east of the fault. (See figure 2)

The original exploration of the United Verde Extension ground appears to have been suggested by the conjecture that there might be, in the hanging wall of the fault, a segment sliced off from what was originally the upper part of the United Verde ore body. Later, however, geologists found that if the

Figure 2.



Horizontal projection on United Verde Extension 1400 level.
500 FEET TO 1 INCH

down-thrown block, containing the United Verde Extension ore-body, were slipped back until the base of the Paleozoic beds in the down-thrown block was restored to the same level as the base of the same beds in the footwall block, this movement, equivalent to a dip-slip of about 1900 feet or a throw of 1560 feet,[1] was not sufficient to place the United Verde Extension ore-body above the United Verde ore-body. Inasmuch as the faulting has been supposed to have occurred wholly in late Tertiary or Quaternary time, obviously the throw could have been no greater than the 1560 feet required to restore the base of the Paleozoic sedimentary beds to their original continuity of level. Therefore, it was argued, the two ore-bodies can never have been continuous and it followed that, somewhere in the footwall must be the downward continuation of the United Verde Extension ore-body, below the fault.

Drill-holes, cross-cuts and drifts in the footwall in the general latitude of the two ore bodies, failed to find the ore body sought. The idea was then advanced that the Verde fault might have a large horizontal component of movement. Mr. Searls, for example, thought that the hanging-wall block might have moved some 1500 feet southeast of its original position. Work done in accordance with this hypothesis also failed to find any ore in the footwall country. In this connection it may be pointed out that attempts to determine the horizontal component of the fault movement by matching particular rock masses on opposite sides of the fault can scarcely be successful. In the first place, the distribution of the various rocks in foot and hanging wall is not accurately known and, in the

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[1] This is my estimate. Lindgren makes the throw 1620 feet and it has generally been considered to be about 1600 feet. F.L.R.

second place, the rock masses are of irregular form and their outlines, say on the 1500 level in the footwall, are likely to be considerably different from those 1560 feet higher, on the same side of the fault, with which the outlines on the 1500 level, in the hanging wall, must be compared to ascertain horizontal displacement.

Before further consideration of the possible relation of ore bodies on opposite sides of the fault, two questions should be answered. The first is - What is the relation of the main ore body of the United Verde Extension mine to the low-grade pyritic ore body of the lower levels? The second question is - Does the Verde fault cut off the United Verde Extension ore body as a whole?

With respect to the first question, it may be pointed out that on the 1500 level, the uppermost level on which the pyritic ore body has been approximately outlined, it is separated from the main ore body by about 120 feet. This intervening ground, however, has not been explored and the two ore bodies may actually join. This ground, moreover, is greatly disturbed and faulted and the apparent separation of the two ore bodies may be due to faulting. In any case, even if no considerable body of sulfides connects the main ore body with the pyritic ore body, it is reasonable to regard them as portions of one general zone of mineralization. I consider it highly probable, moreover, that the pyritic ore body represents the original character of the main ore body, before enrichment took place. Originally therefore, the path of the hypogene mineralizing solutions was upward thru the ground now occupied by the pyritic mass, into the ground now

occupied by the main ore body. Both masses are parts of one great ore zone which as a whole pitches to the north or north-north-west, as shown in the projection of the ore bodies on the plane of the fault, which accompanies the report of Mr. Lindgren.

With respect to the second question, I believe that the United Verde ore zone, as a whole, is cut off by the Verde fault. Parts of the main ore body and of the pyritic ore body rest directly upon the gouge of the main fault and are obviously cut off. Other portions appear to die out before reaching the main fault and there is even a suggestion that the ore on the lower levels may be dipping to the northeast and continuing downward in approximate parallelism with the fault. This appearance is probably deceptive. It is evident on all the levels of the mine that the hanging-wall country for 100 to 150 feet northeast of the main gouge of the Verde fault is a zone of intense shearing and faulting, in which the relative displacement has been generally down, to the northeast. It is due to the complicated movements in this shear zone that portions of the main ore body disappear before they reach the main Verde gouge. They are cut off by minor faults within the shear zone. Furthermore, as the general pitch of the ore bodies as a whole is more northerly than the strike of the Verde fault, the south end of the ore body, which was also the enriched portion, was the first part to be cut off by the fault and does not appear on the 1700 level. The low-grade pyritic mass is at least about 230 feet long and 160 feet wide on the 1700 level and the body is known on the 1800 and 1900 levels but has not been developed fully on the latter two levels. If the northern limit of the mass, its dip

and its pitch, were all known, some prediction might be made as to the probable extent of the pyritic body below the 1900 level and as to the position and attitude of the section along which it must be finally cut off by the Verde fault. These data, however, are not available. That the whole of the United Verde Extension ore zone is cut off by the Verde fault at generally increasing depths northward appears to be fairly certain.

If the United Verde Extension ore bodies are parts of one general zone of mineralization which rests as a whole on the footwall of the Verde fault, where is the continuation of this zone in the footwall country?

Mr. Lindgren, in his report to the company, expresses the opinion that the movement on the Verde fault is not far from a slip straight down the dip and that consequently the horizontal component is small. I fully agree with this. All exposures of the fault that I have seen show grooves and striations that pitch approximately 75 degrees to the south. He also consideres that the body of crushed, enriched ore mined in the United Verde mine on the 500 level, under the Hermit claim, is a fragment from the pyritic ore body of the United Verde Extension mine that has been left behind in the fault zone. This is highly probable. If so, it establishes the general direction of movement on the fault and shows the path that the United Verde Extension ore bodies must have followed in their descent from relatively higher levels at the time of faulting. That path points to a position south of the United Verde ore body but high above the present surface. In his published report[1] Lindgren says:

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[1] U. S. Geolog. Survey, Bull. 782, p. 87.

The suggestion has often been advanced that the large ore body may be the downfaulted upper part of the United Verde; but, as pointed out by Rickard and Finlay, this is improbable, because its trend and plunge are different and its projection upward, after allowing for the 1700 foot slip along the main fault, would bring it above the town of Jerome, or a long distance south or southeast of the United Verde body.

Quite true; but the United Verde ore body itself plunges 68 degrees to the north northwest and, if projected upward, to an intersection with the fault, would also be considerably south of its position at the present surface. We must consider, not the present top of the United Verde ore body, but the former top, now eroded away, where it was cut off by the fault.

It is highly significant that the general geological environment of the United Verde ore body is the same as that of the United Verde Extension ore body and that this association of rocks occurs nowhere else in the district. When this particular grouping of "greenstone", Cleopatra rhyolite and Verde diorite is found on opposite sides of a great fault it is difficult to avoid the conclusion that the duplication of conditions is due to the separation by faulting of what was once continuous.

The United Verde Extension ore body was plainly cut off from its former downward continuation. Extensive exploration of the footwall, extended far northwest and southeast of the region of its probable occurrence, has failed to discover any other root than the United Verde ore body. Furthermore, very extensive exploration in all directions from the United Verde Extension ore body has not brought to light any down-faulted top of the United Verde ore body, unless it be the Extension ore body itself.

The main ore body of the United Verde Extension mine, having undergone extensive supergene enrichment to a mass now

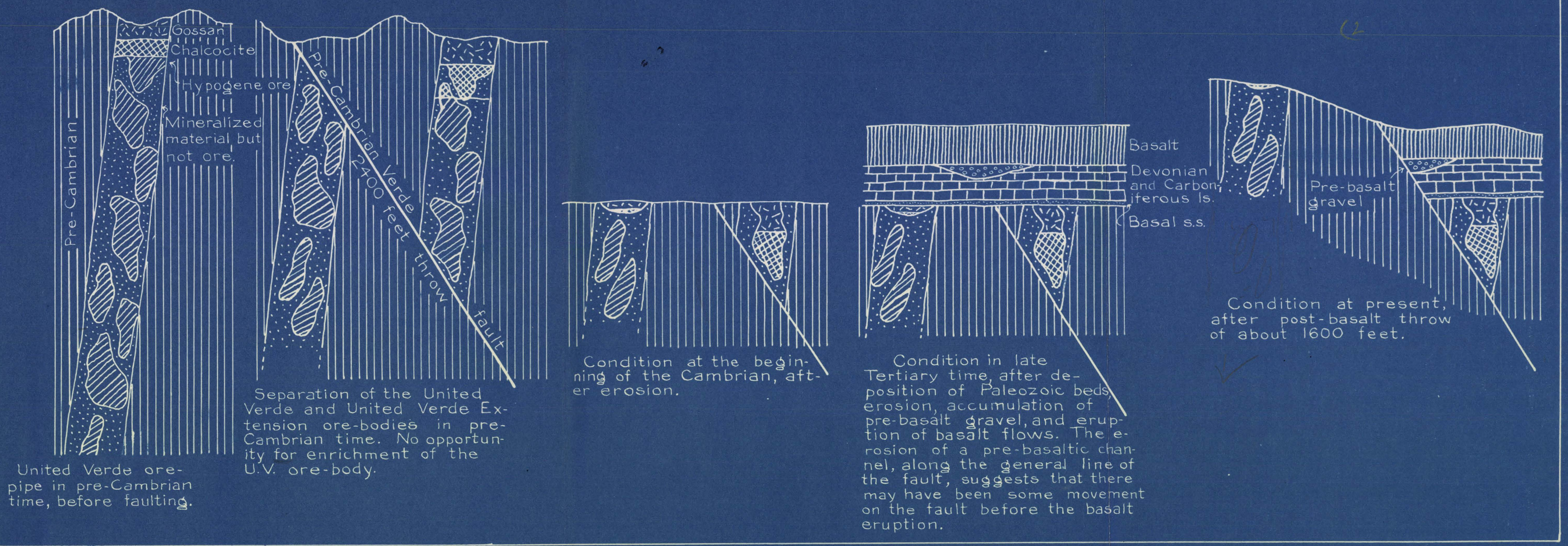
largely chalcocite, is of course very different from the hypogene, enriched ore of the United Verde; but the low grade pyritic ore body, with considerable sphalerite, is identical in character with much low-grade material to be found in the United Verde mine. It is to be remembered that the great sulfide mass of the United Verde is only in relatively small part ore. Moreover, it is reported that some of the upper levels of the United Verde mine contained little but such lean sulfides. Consequently, the fact that the pyritic ore body on the lower levels of the United Verde Extension mine is not as rich in copper as the ore of the United Verde is no proof that both bodies could not have originally been parts of the same continuous sulfide mass.

In order to test the suggestion that the United Verde Extension ore body has been faulted off from the top of the United Verde ore body, and to check rough calculations previously made, a simple model of paper and cardboard was constructed to the scale of 500 feet to the inch. The base of the model was taken as the 1700 level of the United Verde Extension, elevation 3409 feet. It was assumed that the Verde fault is a plane and that its trace on that level is a straight line coursing north 45 degrees west. It was assumed that the pyritic ore body on the 1700 level is about one half of the area before faulting and consequently that a point at coordinates 11400 N. and 7550 E. could be taken as the center point of this particular horizontal section of the original pyritic ore body. The fault was assumed to have a uniform dip of 57 degrees. The plunge of the United Verde ore body (the vertical angle between a horizontal plane and the longest axis of the ore body) was taken as 68 degrees. The direction of plunge was estimated at north

30 degrees west. Of course these various assumptions are not strictly accurate and take no account of possible variations in the dip and strike of the fault or in the angle and direction of plunge of the United Verde ore body. Furthermore, the position of the inclined axis of so irregular a body as the United Verde sulfide mass is not a matter susceptible of precise determination. On the whole, however, the assumptions made appeared to be as close approximations to fact as could be represented in a simple model.

It was found, under these conditions, that the Verde fault cut the inclined axis of the United Verde ore body at a point a bout 4000 feet above the 1700 United Verde Extension level, or at an elevation of 7409 feet. Projected downward, this point would fall about 600 feet southeast of United Verde zero coordinate point. This would require a throw on the Verde fault of about 4000 feet. A line drawn from this point of intersection of the Verde fault with the axis of the United Verde ore body to the assumed central point of the pyrtic ore body on the 1700 United Verde Extension level, obviously defines the direction of slip, in the plane of the fault. (See figure 2) It was found to have a pitch between 70 and 75 degrees, to the southeast, which accords closely with actual observations on the fault striations. Furthermore, this line passes directly thru the plotted position of the Hermit ore body of the United Verde mine, thus not only confirming the suggestion made by Mr. Lindgren, that this body is "drag" from the United Verde Extension pyritic ore body, but also showing that it may be regarded as ore faulted down from a part of the United Verde ore body that has long since been removed by erosion.

Figure 3.



United Verde ore-pipe in pre-Cambrian time, before faulting.

Separation of the United Verde and United Verde Extension ore-bodies in pre-Cambrian time. No opportunity for enrichment of the U.V. ore-body.

Condition at the beginning of the Cambrian, after erosion.

Condition in late Tertiary time, after deposition of Paleozoic beds, erosion, accumulation of pre-basalt gravel, and eruption of basalt flows. The erosion of a pre-basaltic channel, along the general line of the fault, suggests that there may have been some movement on the fault before the basalt eruption.

Condition at present, after post-basalt throw of about 1600 feet.

Diagrammatic representation of probable stages in the faulting of the United Verde and U.V. Extension ore-bodies.

Scale about 1 inch=1000 feet.

In addition to the direct evidence presented for the original continuity of the United Verde and United Verde Extension ore bodies, there is another consideration that has weight as one link in a chain of cumulative evidence. On opposite sides of the strongest fault in the Jerome district occur the only two large ore bodies known in the district. They were originally of similar character and have a similar relation to adjacent rocks. The one in the hanging wall is plainly cut off by the fault and is in such a position that it may have been faulted off from the ore body in the footwall. It would certainly be a remarkable coincidence if the only two great ore bodies in the district had such a suggestive relationship and were nevertheless entirely independent of each other.

Up to this point, all of the evidence considered indicates that the United Verde ore body and the United Verde Extension ore body were once continuous. There is one feature, however, that may, by some, be regarded as antagonistic to this view. This is the necessity of accepting the view that the movement on the fault took place at two widely separated periods. It has been shown that a reversal of throw on the fault, of about 1600 feet, would restore the base of the Paleozoic sandstone in the down-dropt block to the position of its original continuity with the same sandstone, above the United Verde pit. Consequently, the post-Paleozoic (presumably late Tertiary or Quaternary) faulting is limited to a throw of 1600 feet. On the other hand the throw necessary to replace the United Verde Extension ore body on top of the United Verde ore body, is at least 4000 feet. The only escape from this dilemma is to concede that the fault began in pre-Cambrian time, with a total throw of 2400 feet.

It was apparently immobile thruout Paleozoic and Mesozoic time but was revived in Late Tertiary or Quaternary time, after the basaltic eruptions, and acquired a further throw of 1600 feet.

That such behavior is possible is shown by the Bright-Angel fault in the Grand Canyon, which was described by me in 1908.[1] This fault, in pre-Cambrian time, had a throw of at least 300 feet, the block on the west being dropt relatively to that on the east. After the deposition of the whole Paleozoic series there was a smaller movement on the fault, this time in the reverse direction. Other faults are also known in the Grand Canyon region which show a similar renewal of movement after long periods of quiescence.

The supposition that there were two distinct periods of movement on the Verde fault, separated by a period of inactivity finds some additional support from the occurrence at two places, one on the 500 level of the United Verde, the other on the 1900 level of the United Verde Extension, of calcitic vein material that appears to have replaced crushed diorite. This vein material may represent the original pre-Cambrian gouge, of which only fragments have survived the crushing and grinding of the later period of movement.

On the whole, altho there is admittedly an element of improbability in the explanation of two-period faulting, this element is believed to be outweighed by the evidence previously adduced in support of a throw of 4000 feet.

It is concluded that the United Verde and United Verde Extension ore bodies were originally one and that they have been separated by a throw of about 4000 feet on the Verde fault.

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[1] Science, vol. 27, pp. 667-669, 1908.

PRACTICAL CONSEQUENCES OF THE CONCLUSION THAT THE TWO ORE BODIES WERE ORIGINALLY ONE.

The most direct and obvious conclusion to be derived from the foregoing discussion is that the United Verde Extension mine, so far as concerns known ore bodies, has a definite bottom on the Verde fault. Furthermore, the conclusion that the district contained originally only one large ore body, which occurred where the rocks have a certain unique relative distribution, diminishes the probability that other large bodies will be found in depth, within the United Verde Extension ground. The company's territory northeast of the Verde fault is covered by Paleozoic beds, overlain in part by basalt. The character and distribution of the pre-Cambrian rocks in this area are imperfectly known. Nevertheless it is traversed by the Josephine tunnel and by a number of long drifts and cross-cuts, none of which has shown any important mineralization. While no one can be certain that long-range underground prospecting from the United Verde Extension mine may not open up an ore body, I can see no probability of such an event. By "long-range prospecting" is meant such work as the 1904 and 1320 S. drifts, not to mention many drifts previously run to the north, east and south, particularly on the 1200 and 1400 levels. Apparently the best chance of adding to the known ore reserves lies in continued exploration of the Cleopatra rhyolite ground south of the Florencia fault with a view to picking up offshoot or fringing bodies from the main ore body; in searching for residual masses of chalcocite in the great gossau areas of the upper levels; in more thoro exploration of the margin of the main diorite mass; and possibly

by following down the pyritic ore body below the 1900 level in the hope of finding some chalcopyrite ore above the Verde fault. I should expect to find this pyritic plunging steeply to the north-northeast. Whether it will be advisable to follow it down to the fault by an inclined winze from the 1900 level or by sinking the Edith shaft another 100 feet and cross-cutting, is a question to be determined by the engineering staff.

MISCELLANEOUS SUGGESTIONS FOR PROSPECTING

The contact schist ("bedded sediments") has been found to contain important vein-like ore bodies on levels above the 1400 level. The recognition of this schist as a local modification of the "greenstones" around the margin of the diorite, rather than as an original distinct formation, having no genetic connection with the diorite, leads to the suggestion that the principal zone of this rock, instead of continuing northwestward as indicated on the company's geological maps, may curve around the northern end of the diorite mass (for example, in the regions 11900 N. and 7000 to 7300 E. on the 950 and 1100 levels; 1200 N. and 7100 - 7200, on the 1200 level; 11,900 N. and 7100 E. on the 1300 level; and 1200 N. and 7200 to 7400 E. on the 1400 level,) and contain one or more ore bodies. In general it will probably be advisable to leave no large portion of the margin of the principal diorite mass, including,the rock adjacent to the contact, unexplored. The greater number of the important ore bodies found in the United Verde Extension mine, as well as in the United Verde, have had a marginal position with reference to the diorite or have occurred in shear zones within it. There are certainly very few that are not at some point in contact with

or very near that rock.

The ore bodies that occur within the diorite mass, such as 1407 and 1307 A. are generally in such crushed and disturbed ground that it is difficult or impossible to determine whether they are replaced sheared diorite or replacements of masses of other schistose rock included in the diorite. These ore bodies have generally a southwesterly dip and appear to be cut off below by northeasterly-dipping gouges. Thus they wedge out below. How much of their apparent southwesterly dip is due to shearing along northeasterly-dipping fault planes and how much may be an original inclination, I was unable to determine. Owing to the generally crushed and broken character of the ground in which they lie and the absence of any datum bed or layer by which displacement might be measured, I was also unable to gain any clear idea of the details of the structure in the vicinity of these ore bodies. Presumably, where ore bodies such as 1307 are cut off below by a northeasterly-dipping fault, there should be, in the footwall, another segment of what was originally the same ore body. Probably 1307-A, on the 1300 level, is such a segment, which was once continuous with 1307 ore body. The ore body stopped at 1307-A may itself be a down-dropped mass, once part of an ore body of which another segment may be found west of it, between 1307-A and the main Verde fault. As a general guide to prospecting for faulted segments of ore bodies in the zone of disturbance along the northeast side of the main Verde fault, I can only offer the suggestion that the direction of slip on the subsidiary faults, like that on the main fault, was probably steeply down the dip, with a pitch of 75 degrees or more, to the southeast. I agree with Mr. Lindgren that more

development might be carried out in the couhtry between the known ore bodies and the main Verde fault. The extension of cross-cut 1204, which was in progress when my examination was concluded in December, 1927, and was showing abundant native copper, is in line with this suggestion.

On the 1300 level, it would be advisable to explore the country west of 1307-A stope, to the fault.

On the 1400 level, 1425 cross-cut, which I was unable to examine, is reported to have cut some pyritic material west of the 1407 ore body. This suggests that enrichment, in this particular part of the mine, did not extend to the 1400 level and consequently that there is not much chance of finding any but low-grade pyritic material, such as is known to be present on the 1500 level, in this part of the mine.

Development during recent years has led to the discovery of a number of bodies of residual chalcocite ore in the extensive mass of gossan above the 1300 level. This suggests that the gossan mass should be rather thoroly explored. At present there appear to be no particular clues to the position of the residual ore bodies but such clues may become apparent when the ground is better known.

Some specific recommendations for development, level by level, are submitted for consideration, as follows:

<u>800 level</u>. Drive north from 807 or south from 806, with a view to exploring the diorite contact in 7100-7300 E. and 11,700 11,800 N.

Drive northeast from 824 N. into 7000-7100 E. and 11,400-11,500 N.

Explore gossan in 7500-7600 E. and 11,000 to 11,100 N.

Explore country southeast of 827, into 10,800-10,900 N. and 8,100-8,200 E.

950 level. Explore north contact of diorite, near 11,900 N. and 7100 E.

Explore south contact of diorite and gossan area between 902 W. and 906.

The possible occurrence of ore in 10,900-11,000 N. and 7,800-8000 E. is worthy of consideration.

1100 level. It would probably be well to explore the north contact of the diorite, between the Edith shaft and the Main Top ore body, altho this might await the result of similar work on levels above or below.

There is a large block of unexplored ground on this level south of the long west cross-cut that begins at 7600 E. 11,600 N. There may be ore in this area but, if so, it will probably be indicated by the developments from 1204, on the level below.

1200 level. Explore north of 1202 W., between 7100 and 7200 E., for example, by a cross-cut north on 7175 E.

There is apparently some chance for ore between 11,200-11,400 N. and 7,500 - 7,600 E.

1300 level. The ore zone followed in 1354 N. appears to swing westward at 1160 - 1200 N. following the north contact of the diorite, towards the Main Top. It should be followed in this direction. Drift 1354 N. north of 1200 N. appears to be entirely north of the mineralized zone, which I suspect runs nearly east and west here.

Some attempt should probably be made to ascertain whether there may not be ore along the line joining the 1307 A body and

the Main Top body.

1340 N. drift appears to end in diorite. It should, I believe, be continued for 25 or 50 feet, to the northeast.

1400 level. Drift in 7300 - 7400 E. and 11,900 - 12,000 N. should be continued northwest to the contact of the diorite with the contact schist ("bedded sediments").

Some additional prospecting (possibly carried out since my visit) appears to be justified in 10900 - 11000 N. and 8000 - 8100 E. to look for a downward extension of ore known on the 1300 level, south of the Florencia fault.

1500 level. A cross-cut is suggested into 7600-7700 E. and 11,400 - 11,500 N.

1505 N. should be continued. It appears that not enough has been done to prove that the ore mined in 1505 S. or the mineralized zones northeast of it, cut in 1504 cross-cut, may not open up into ore bodies in the unknown territory northwest of 1504.

1600 level. Drift 1602 S. between 11,100 and 11,200 N. passes thru a mineralized zone. This zone might be explored to the northwest and southeast. There is a chance for some ore in both directions. A drift should probably be run for about 100 feet south, from the bend in 1602 S., at 8100 E. coordinate. I believe that some work had been started here before I left. This ground, however, does not hold out much promise in view of the work beneath it, on the 1700 level.

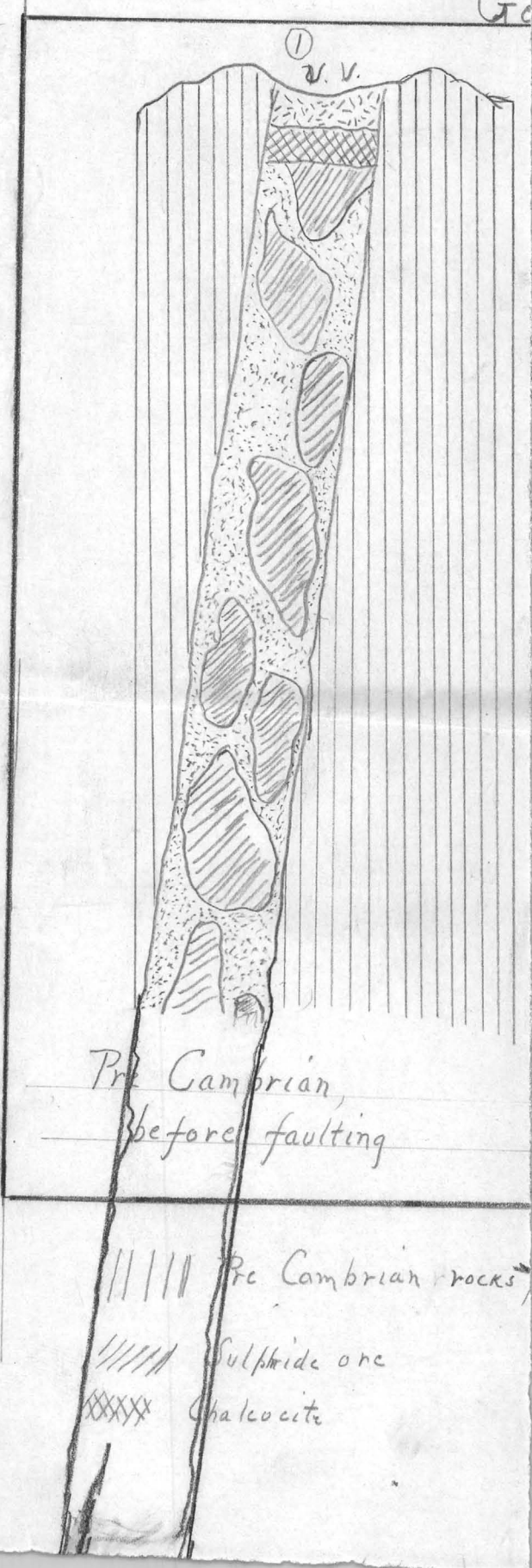
1700 level. This level offers little encouragement. It is apparently below the influence of enrichment and the pyritic ore body has been sufficiently explored to show its very low-grade character. Before the level is abandoned, however,

I suggest some exploration to the vicinity of 7500 E. 11,700 N.

1800 level. If there is any ore on this level, it is probably in 7400 - 7600 E. and 11,700 - 11,800 N.

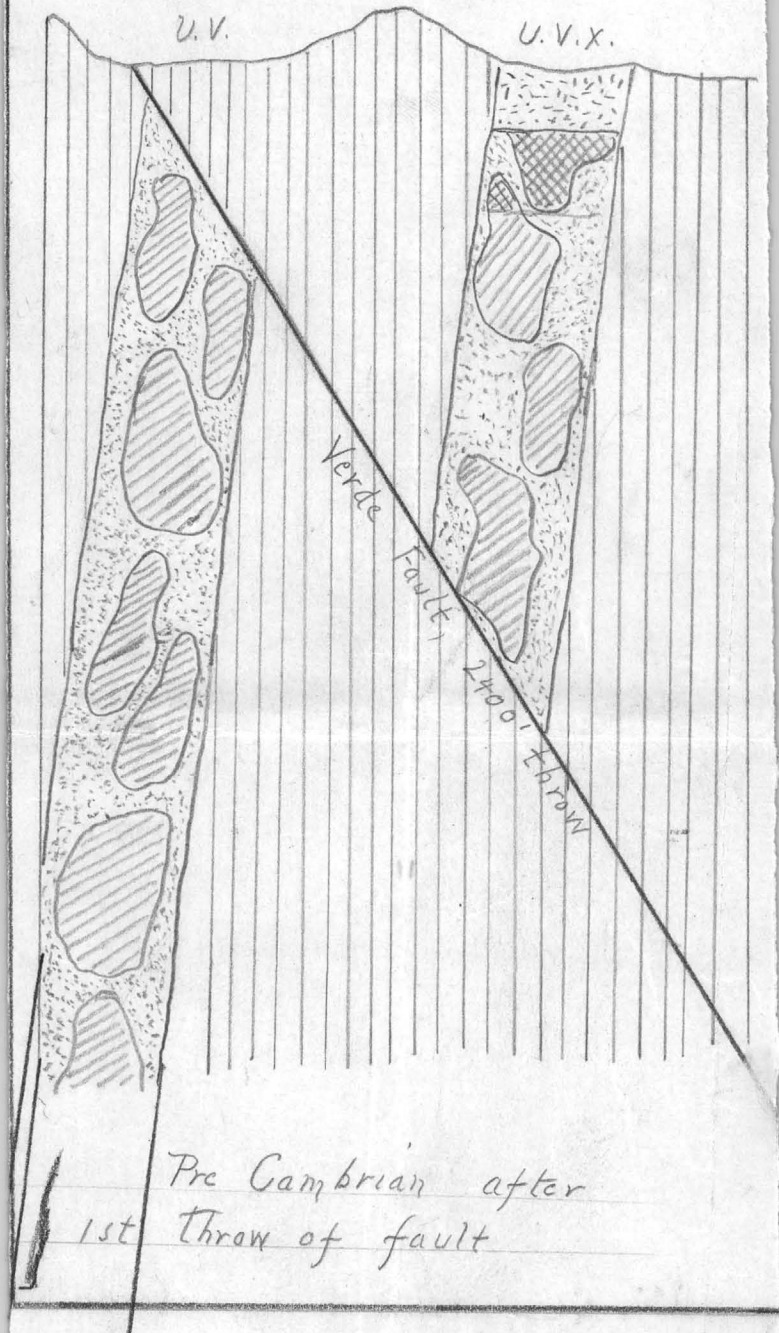
1900 level. The two sulfide bodies on the 1900 level are so small, so low in grade and so close to the Verde fault, that it is doubtful whether it is worth while to sink on them or to run a deeper level to them from the Edith shaft. My own inclination would be to abandon them, particularly when it is considered that any deeper work on them would pass into the greatly disturbed ground between the main Verde fault and its hanging wall branch.

Elsewhere, also, the 1900 level, in my opinion, offers no inducement to further exploration.


1
V. V.
Pre Cambrian
before faulting
Pre Cambrian rocks
Sulphide ore
Chalcocite

ological History of U.V. -

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Pre Cambrian after 1st throw of fault

Gossan

Mineralized but not

U.V.X. Ore Bodies

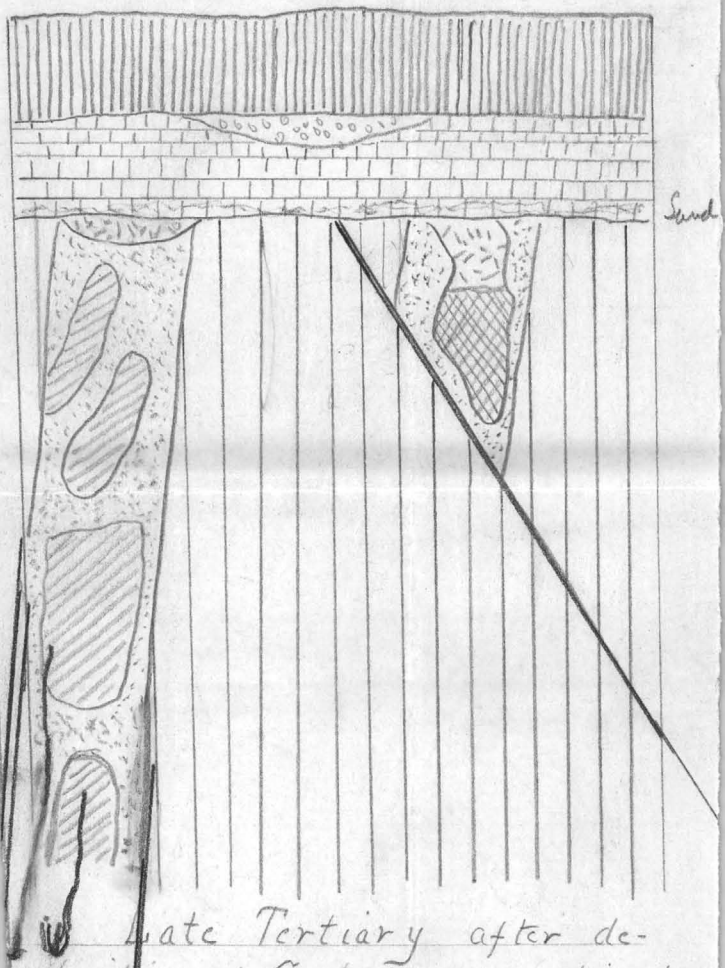
(3)



ore

(after Ransome)

(4)



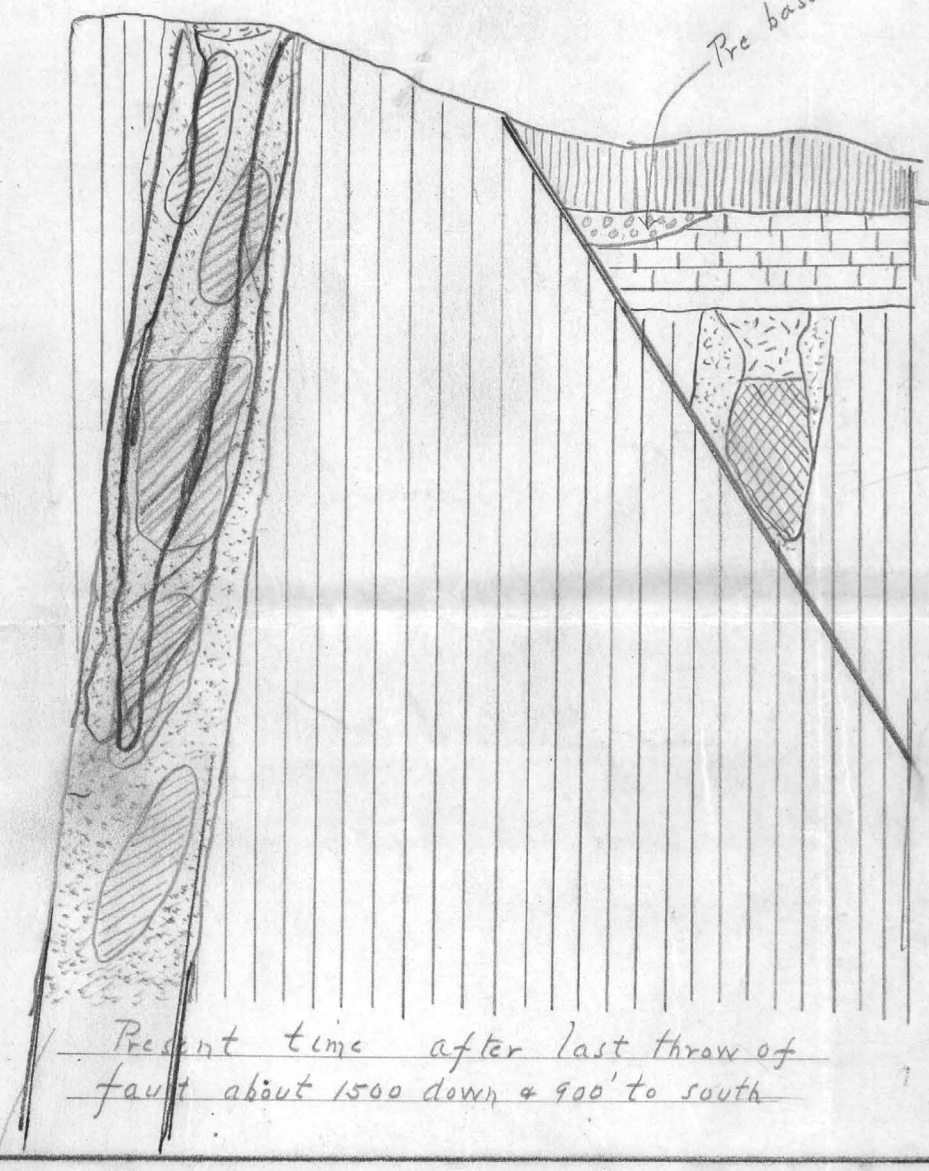
Late Tertiary after deposition of Carboniferous sediments and flows of Tertiary lava.

Basalt lava

Conglomerate

Limestone & Sandstone

(5)



Present time after last throw of fault about 1500 down & 900' to south

Scale 1" = 1000'