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Item 1

GUIDES TO ORE
ELY DISTRICT

BLANCHARD Nov. 1928.

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Blanchard's First Report
Not Issued

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PURPOSE OF THE REPORT

The purpose of this preliminary report on the beds of the Ely formation is to furnish, during the geological investigation of the district, a general guide to positions of particular limestone horizons within the formation.

The report is based on a three weeks study, and the information presented is necessarily incomplete. At a later date a full report will be submitted.

Only beds in the lower half of the formation are considered. The reason is that to date these beds alone have been proved to carry vigorous mineralization. They consist of massive and cherty limestones, as contrasted with the more sandy beds which comprise the upper half of the formation, and which have not been thus far found particularly hospitable to ore.

At least three other formations - the Chainman shale, the Joana limestone, and the Pilot shale - all of which lie stratigraphically below the Ely formation, are known to be ore-bearing. Their immediate promise for important ore in the Kimberly area seems less than that of the Ely formation, and they have been examined only incidentally. The later, full report on the ore-bearing beds of the district will define more closely their possibilities, as well as furnish further detail regarding the beds of the Ely formation.

THICKNESS OF THE ELY FORMATION.

The measured thickness of the lower half of the Ely formation is 3212 feet. This comprises only the massive and cherty limestones shown in the geologic column.

The upper half of the formation, consisting largely of limy sandstones, and called by us the Rib Hill sandstone to distinguish it from the underlying massive and cherty limestones, has not been measured to date. Its thickness probably will be found to equal, and possibly exceed, that of the underlying massive and cherty limestones.

The rocks comprising an approximate 200 foot thickness immediately below the 3212 feet shown in the column are exposed only intermittently through alluvium. They are known to consist of shales and limestones that grade upward into the base of the Ely formation as shown in the column, and grade downward into the more homogeneous Chainman shales; but their character is not well determined, and they consequently are not shown in the column. Whether they properly belong to the Ely or to the Chainman formation has not been to date determined. They probably belong to the Chainman.

C H A R A C T E R O F T H E B E D S

The lower half of the Ely formation, shown in the geologic column, consists of massive and cherty limestone horizons. Although thin layers, 4 feet to 25 feet thick, of massive limestone occur locally within the thicker cherty horizons; and although prominent cherty layers occur within the thicker massive limestone series; the column nevertheless divides itself naturally into alternating predominantly massive and predominantly cherty series of beds.

The massive series generally weather out boldly as cliffs or reefs; the cherty series are mostly thinner bedded, and generally weather to slope surfaces except where the dip is flat. Exceptions, noted in the geologic column, exist in both cases.

The base of the formation consists of 150 feet + of semi-massive beds in which the chert content is low or absent. The top of the formation consists of a measured thickness of 569 feet of massive beds, almost free from chert, capped by a prominent 58 foot cherty horizon that separates the lower half of the Ely formation from the Rib Hill sandstone.

Between these two extremes of massive limestone, nearly free from chert, occurs a 2435 foot thickness in which the beds are more or less continuously chert-bearing, although, as stated, certain horizons are predominantly cherty while others are predominantly massive. The broader distinctions between the various horizons are shown in the generalized column opposite this page. The detailed distinctions are shown in the larger scale, detailed geologic column.

The beds near the base of the column, both massive and cherty, are thinner, more shaly, finer grained, and mostly darker in color than are those above, the Marble Beds constituting a local exception. In color they are commonly dark gray-blue to bluish-black.

The beds above, beginning with the Lower Mud Cherts, are commonly lighter in color, ranging from bluish-gray to the drab color characteristic of dried mud. Although no fixed rule applies, the massive limestones of the middle and upper portions of the column are in general darker in color than are the thinner bedded, cherty ones.

These distinctions apply in a broad way for the portion of the Ely formation shown in the geologic column, but must not be too rigidly applied. Local exceptions are common. They are noted in the detailed geologic column.

The lower half of the Ely formation is not likely to be confused at the surface with the Rib Hill sandstone, since the latter usually weathers either to a dull yellow, gritty sandstone or to a sandy, grayish blue limestone.

VALIDITY OF THE COLUMN

Beginning with the Upper Mud Chert series, most of the column was measured on a dip slope. This makes it difficult to ascertain closely the true thicknesses of the beds, even on a surveyed profile, and it is not improbable that thicknesses for the middle and upper portions, as shown in the column, exceed slightly the actual thicknesses. Two checks at the surface in different areas show a variation of not more than 8% for the entire upper half of the column, and various checks for 500 feet ± sections of the column show almost no variations. The thicknesses of the different series, as shown in the column, therefore are accepted as approximately correct, but a variation of 5% should be allowed, with the probability that actual thicknesses are slightly less than shown.

The lower 600 feet of the column was measured at Big Bend, Keystone, Watson Spring, and Saxton Hill. It showed no notable variations in thickness at any of these places, and is accepted as correct.

Some doubt exists as to the true thickness of the Coarse Banded Chert series near the middle of the column. At no place in the district has there been found an unbroken column through the lower half of the Ely formation. The nearest approach is at Big Bend and on the ridges to the west, but a great deal of faulting occurs here near the middle of the column, particularly at the base of the Coarse Banded Chert series. Much duplication of the beds occurs, and complete assurance is lacking that the true succession and the true thicknesses of the beds for this series have been determined. The weight of evidence, however, suggests that at most there is missing not more than 100 feet in the column as presented, with the probability that none is missing. No other place in the district has yet been found where a detailed check on this portion of the column could be made.

Since much of the column is exposed only on dip slopes, and since the thinner bedded, more cherty horizons weather mostly to float, there is no assurance that the thicker cherty horizons as shown in the column may not contain thin layers of massive limestone. It is distinctly probable that they do, since that is the usual condition where such horizons are exposed on other than dip slopes. But it does not seem likely that massive beds, individually more than 5 feet to 10 feet in thickness, have been missed, because the massive beds, even on dip slopes, usually weather out as prominent reefs.

MARKER BEDS

Individual beds, so distinctive in physical characteristics that they may be rigidly depended upon as definite markers in the formation, are rare. Near the base of the column, certain 6 inch to 12 inch beds show pronounced concentrations of crinoids and minute shell fossils, and serve as markers. But, in general, crinoids and shell fossils, such as spirifers and brachiopods, are too irregularly and generally distributed through the beds to identify particular horizons.

In the Marble Beds, concentrations of thick, gray chert in certain thin layers are distinctive, though not invariably present.

Other horizons, such as the Basal Cherts, the Thin Wavy Cherts, the Mineral Chief Massives, and the Contact Cherts at the top of the column, - are not likely to be confused with other horizons.

But in most of the column continuous exposures of at least several hundred feet of the beds are needed before an opinion is possible as to what horizons are present, and in some cases even such length of exposure would not serve definitely to place the horizons.

Because of this fact, it is advisable, wherever possible, first to determine the horizons and the faults showing at the surface, and to project them underground, before attempting to determine the position of the beds from the limited exposures there.

RELATION OF BEDS TO ORE

All the beds in the lower half of the Ely formation except the 150 foot + semi-massive series at the base have been found altered to jasperoid, and have shown evidences of mineralization, in some portion or other of the district. The more cherty horizons have been especially susceptible to alteration, possibly because their more brittle character induced greater fracturing during the period of intrusion, and permitted freer ingress of the solutions.

The thickness of limestone which may be regarded as a potential ore carrier in the lower half of the Ely formation is therefore approximately 3,000 feet.

From the limited study to date, it seems evident that within this 3,000 feet, certain horizons will prove especially favorable. The Matilda ore, for example, lies consistently near the base of a particular cherty horizon, 650 feet to 750 feet below the Rib Hill sandstone. Until more work has been done in checking up the various horizons both at the surface and underground, no opinion is in order as to how many proved ore horizons exist, nor to what extent they may be more favorable than intervening horizons.

17 Rib Hill Sandstones:

This series of limy yellow sandstones and sandy grayish blue limestones has not been worked out in detail because mineralization within these beds has not been thus far found to show outstanding promise. A rough estimate places the thickness of the Rib Hill sandstone series at not less than that of the massive and cherty limestones series beneath. At a later date a more careful estimate of the thickness of this sandstone series will be made.

16 Contact Cherts:

Lying between the upper Massive Limestones and the Rib Hill sandstones is a 58 foot thickness of cherty beds. Chert bands are irregularly continuous throughout the horizon, varying in thickness from 1/2 inch to 1-1/4 inches. In some areas the chert, as in the Matilda-Veteran country, is contained within the grayish-blue limestone; at other places, as at the top of Rib Hill, it is contained within the grayish-yellow sandstones. Usually the chert content of this horizon is 20% - 35% of the total volume, though locally it is as low as 10%. Nowhere has it been found missing entirely.

This abundance of chert through a 58 foot thickness of beds, between the yellow Rib Hill sandstone and the bluish-gray massive limestone, makes the contact chert horizon one of the most dependable horizon markers. It has been used as the key bed in working out the numerout NE - SW faults in the area northwest of the Alpha shaft.

15 Upper Massive Limestones:

A thick series of massive limestones, bluish gray in color, weathering usually in 1 foot to three foot beds. This series constitutes a buffer between the Rib Hill sandstones and the principal cherty horizons of the Ely formation. The lower portion carries irregular chert nodules, sparsely disseminated, but nowhere prominent. At approximately 260 feet above the base, or 300 feet below the top, occurs a 20 foot to 30 foot thickness in which chert nodules, 3 inches to 12 inches in diameter, are irregularly concentrated. The upper 300 feet are nearly free of chert in any form.

This limestone series lies with more or less consistency between the cherty jasperoids of the Veteran and Alpha areas and the Rib Hill sandstones to the south, but the jasperoid extends out into these massive limestones also. In such places the jasperoid characteristically assumes large nodular or bulb-like shapes, in sharp contrast to its more broken and thoroughly brecciated character in the underlying cherty horizons. Because of its great thickness without prominent chert horizons, it constitutes an excellent marker. Measured thickness southwest of Big Bend is 569 feet.

At the top of Rib Hill approximately 400 feet ± thickness of this limestone dips northerly toward the Nevada Consolidated pit in a large reversed block of faulted limestone and Rib Hill sandstone that constitutes the top of Rib Hill. The limestone here exposed is the upper 400 feet ± of the series.

14 Matilda Cherts:

Like the Upper Mud Chert series, the Matilda Chert series is poorly exposed. The composition of its beds is judged largely by the float which lies mostly in place in a low slope, and by the evidence from the beds at and near the Matilda workings. The beds of this series weather almost identically with those of the Upper Mud Cherts until the top of the Matilda series is approached, but the chert bands in the Matilda are slightly thicker, the chert is often a reddish gray rather than a consistent black color, and the chert bands commonly are several inches apart in the limestone beds, rather than closely spaced as is common in the Mud Chert series. One striking feature is the presence, about 3/4 the way up from the base in the Matilda, of a 38 foot bed of coarse chert nodules. The other distinguishing feature is the greater abundance of massive limestone beds in the Matilda, especially toward the top, and the fact that in most cases these beds weather out boldly as reefs. Measured thickness is 470 feet.

13 Upper Mud Cherts:

This series is exposed only on a dip slope, with exposures poor. Judged from the few exposures and the large amount of float which seems to lie mostly in place, the general character is similar to the Lower Mud Chert series, except (1) there is less coarse chert, and what there is, lies in the lower half, rather than constituting the central portion; (2) the massive beds that carry no chert lies largely in the central portion instead of near the base and top, and these beds weather out usually in 3/4 foot to 2 foot beds, rather than as thin mud slabs. Measured thickness on dip slope, 452.5 feet.

12 Mineral Chief Massives:

A prominent cliff-forming series of massive blue limestone beds, weathering out as 3/4 foot to 2 foot beds, almost entirely free from chert. Sharply in contrast with the generally thin banded mud chert series above. Not readily distinguished from the upper portion of the Coarse Banded Chert series below except on weathered slopes, where the latter do not form the prominent cliffs characteristic of the Mineral Chief Massives.

These beds, together with the top of the Coarse Banded Chert series, form the backbone of the ridge on the Mineral Chief claim northwest of the Boston & Ely shaft. They likewise are the massive limestones that extend through the western portion of the Matilda Extension claim down through the gulch into the northwest portion of the Jack Pot Claim. Measured thickness, 65 feet.

11 Coarse Banded Cherts:

A series of semi-massive to nearly massive limestones, characterized by 2" - 3" nearly continuous chert bands running through the limestone beds, with the bands 3" to 3' apart. Usually the bands are 8" - 20" apart. Locally the bands may be concentrated in 5' - 15' horizons, alternating with nearly massive horizons of equal thickness. A 10' horizon of thinner, more closely spaced chert bands is present below the center. Toward the upper portion the

beds become more massive, with the chert bands less continuous and with the chert larger and more nodular. These upper beds resemble rather closely the overlying massive beds, but weather more readily to slope surfaces. Measured thickness, 122'.

The beds shown in the column as constituting the Coarse Banded Chert series have not been found lying conformably upon beds recognized with certainty as the Skylark Cherts. They were picked up at the top of a complexly faulted area whose base comprises the top members of the Skylark series. Some question therefore exists as to whether the full thickness of the series is represented in the 122' column. A possibility exists that approximately 110' of beds, more or less similar to those comprising the bottom 36' of the series, may have been omitted, though this is not likely.

10 Skylark Hill Cherts:

The Skylark Hill cherts weather out in thin drab mud slabs with black chert bands very similar to the Lower Mud Chert Series. They may be distinguished from the latter, when in place, by (1) the more frequent alternations of massive beds with the cherty horizons, (2) the generally thinner horizons of both massive and cherty types, and (3) by the generally parallel arrangement of thin chert bands, giving these bands a stratified appearance. At the top and base of the series the parallelism of the bands is less marked. In the more central cherty horizons the parallelism is so pronounced that those beds are not likely to be confused with any others in the Ely formation. Measured thickness, 265.5'.

9 Big Bend Massives and Wavy Chert Series:

Prominent cliff-forming massive gray-blue limestones which weather out into 1' - 2' beds. The upper and lower 40' sections are almost free of chert. The remaining central portion of the series contains much chert, and this differs from any other known chert occurrence in that the chert bands are very thin, 1/4" - 1" thick, and are characteristically wavy and continuous. A measured 77' thickness of the wavy thin cherts occurs near the center.

The massive character of these beds, with the wavy thin cherts in the central portion, is in such marked contrast to the underlying mud cherts and the overlying Skylark Hill chert series, that it should prove a prominent marker underground.

Measured thickness of the entire series at Big Bend is 213.5'.

Note: The wavy thin cherts are exposed at the top of Saxton Peak for a thickness of 15', but erosion has removed the rest. Presumably a flat fault has cut out the lower 255' of the Lower Mud Chert Series, and the upper 25' - 35' of the Upper Lane City Cliffs, where the discordance in strike and dip of the beds occurs approximately two-thirds the way up the northwest slope of Saxton Hill, since this portion of the Big Bend limestones is missing on Saxton Hill.

8 Lower Mud Cherts:

A thick series of variable composition, but for the most part weathering into thin, shaly slabs, 1/4" to 3/4" in thickness, that resemble slabs of drab - gray mud. Embedded in these slabs are nodules and irregular bands of black chert, 3/4" to 2" thick. Weathered slopes resemble somewhat the debris from the underlying Basal Chert Series, but chert is less uniform in width, and slabs are drab in color rather than dark blue.

The upper and lower parts of the horizon carry the thinner-bedded portions, with the chert bands most consistently present. The central portion is more massive, bluish-drab in color, with the chert nodules more irregular and larger in size. In this portion the chert often consists of bands 2" - 4" thick, 1' to 3' apart, but the typical mud cherts, slabby on weathered slopes, are never absent wholly, and serve to identify the horizon.

At approximately 50' both above the base and below the top occur beds of massive, grayish limestone free of chert. They may be distinguished from the overlying massive beds of the Big Bend Massive and Wavy Chert Series in that they weather into the 1/4" - 3/4" mud slabs, instead of weathering out into the thick massive gray-blue beds of that series. These beds together with the Big Bend Massive and Wavy Chert Series constitute the top of Big Bend Ridge.

Measured thickness at Big Bend is 397.5'.

7 Upper Lane City Cliffs:

No essential difference between these and the lower cliffs, except that the upper ones for the most parts are even less cherty than the lower. Thickness at Watson Spring is 85'; at Big Bend 76'; at Saxton Hill only 50' were measured, but faulting probably has deleted part of the horizon.

6 Upper Lane City Cherts:

Prominent occurrence of thin, irregular bands of chert, mostly black, varying from 1/4" - 1" in width, usually 1/2" - 1" apart, constituting ordinarily 20% - 35% of the rock volume. Locally the central beds are more massive, containing less chert, but the upper and lower portions stand out prominently against the overlying and underlying massive, less cherty cliffs. Chert usually weathers out with a yellowish color. Horizon varies from 22' at Saxton Hill to 38' at Big Bend. At latter place the central beds are less cherty than the top and bottom ones. A prominent marker where exposed to weathering.

5 Lower Lane City Cliffs:

Consist of fine to medium crystalline, gray-drab to gray-blue beds, massive, weathering out 3/4' - 3' beds. Largely made up of massive 3' - 4' dark fine grained beds alternating with 1' - 2' medium grained gray to grayish white mottled beds. At 25' up from the base is black, dense bed with conchoidal fracture. Occassionally shaly partings exist between beds, but for the most part the entire series is compact and massive. Usually forms prominent cliffs. Central portion carries chert which varies from 3" - 6" link-sausage nodular bands to thin, 3/4" wavy bands, but in general this series is deficient in chert. At Watson Spring and

Lane City, chert is almost absent. On Saxton Hill and at Big Bend it is more prominent, especially in central and lower portions. Thickness of horizon at Saxton Hill and Big Bend is 118'.

4 Semi-Massive Dark Shaly Series:

Fine grained to medium grained crystalline, dark bluish gray to nearly black, semi-massive shaly beds that weather out in 3" - 24" beds, and usually form slope surfaces. They have a splintery fracture, and where fine grained and black, closely resemble basalt. On weathered slopes one of their best means of identification is the presence of small corals and chert colonies that resemble mouse-turds in size and aggregates. In some parts of the district, as at Keystone and Big Bend, the upper and lower portions of the series show distinct black bands of cherts, similar to those in the Basal Cherts below, but less rigidly parallel. The central portion, however, has been found to carry chiefly the mouse-turd variety, and in any event the splintery fracture and dark shaly crystalline texture in semi-massive beds, serves to identify the beds belonging to this horizon. At Watson Spring the horizon is almost wholly free of any but the mouse turd cherts. Elsewhere more abundant and larger chert nodules and bands occur at top and bottom. Measured thickness varies from 75' - 84'. At Big Bend the thickness is 77'.

3 Marble Beds:

Above the Basal Cherts lies a series of medium grained, crystalline, lighter gray beds, with chert sparser and more irregular in occurrence, and with most of the chert nodular. At 10' - 12' above the top of the Basal Cherts occurs a 2' - 4' bed of concentrated 8"-20" gray chert nodules that locally, as at Keystone, resembles a quartzite bed. 10' - 15' above this lies another bed with similar chert concentrations that usually weather out brown. Locally these two beds are less cherty, but in most places they carry relatively more chert than enclosing beds, and therefore constitute reliable markers. The beds of this series alter to marble more readily than the darker, shaly overlying and underlying beds, and usually weather out as prominent cliffs.

Measured thickness at Big Bend, 65'.

2 Basal Cherts:

The Basal Cherts constitute the first prominent markers at the base of the Ely formation. They consist of thin bedded, fine grained, dark shaly beds with parallel black chert bands 1/2" - 1-1/2" thick, usually 1/2" - 2" apart. In the upper and lower portions the chert bands constitute as much as 35% of the volume. The central portion comprises a 10' - 18' thickness of more massive, lighter colored beds with irregular chert nodules. It weathers to grayish-brown, in contrast with the darker beds above and below. The series measures 75' in thickness.

1 Lower Thin Bedded, Massive Limestones:

The base of the Ely geologic column consists of 150' + of thin bedded, semi-massive limestones, with individual beds usually 3" - 10" thick. These limestones are mostly fine grained and shaly, but toward the bottom become medium grained and crystalline. Chert is irregularly present, and shows a general but irregular decrease toward the base.

Although thin, black parallel chert bands are locally present, the chert is mostly nodular and unevenly distributed through the beds. Several 6" - 12" shaly beds, noted in the column, show pronounced concentrations of crinoids and minute shell fossils.

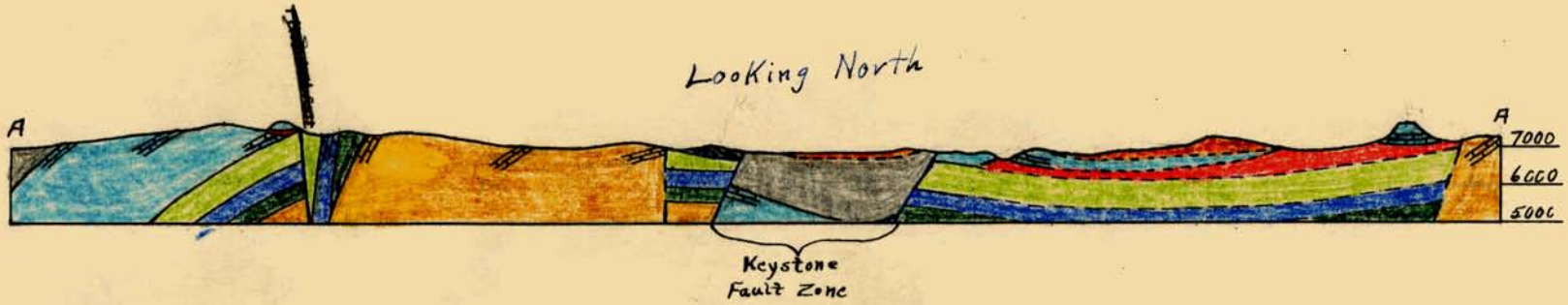
The series is underlain by a 20' - 30' bed of dense, grayish white shale. Below that bed occur 200' ± of alternating shales and limestones before the more homogeneous shale beds of the Chainman formation are reached. In the altered areas this 200' ± of beds alters mostly to a baked, dense shaly product in contrast to the more limy overlying beds of the Ely formation that alter to marble, garnet, and jasperoid. For conveneience in mapping, the base of the Ely formation is therefore placed at the top of the 200'± mixed series, or at the top of the highest known thick shale bed.

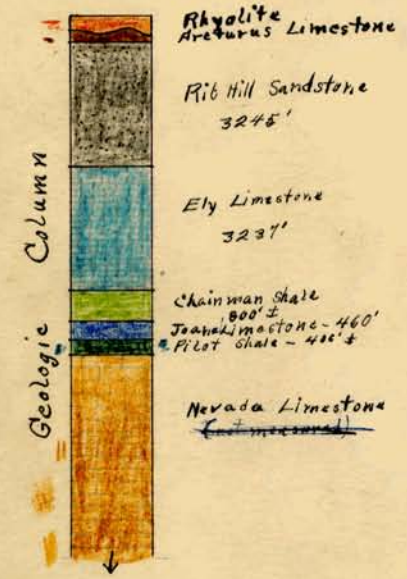
The 150' ± thickness of thin bedded, semi-massive limestones, designated as the base of the Ely formation, usually weathers to slope surfaces. As a result, few exposures in contact with the Chainman shale have been accurately measured, and the true thickness of this particular series of beds has not been determined. The thickness probably exceeds 150', but probably does not exceed 200'.

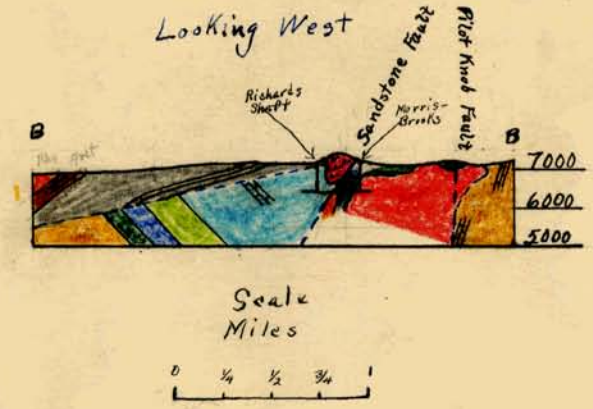
Plate 2

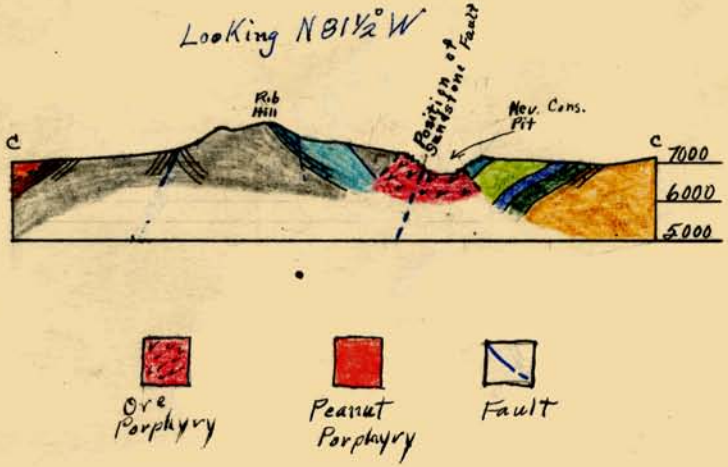
General Geologic Sections through the Ely District showing Major Structural Features

Minor Faults omitted.









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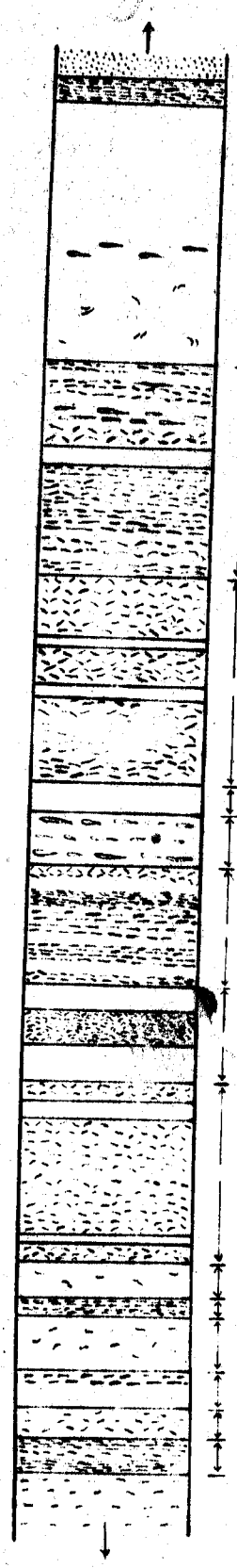


Rib Hill Sandstone
Contact Cherts

Upper Massive Limestones

Matilda Cherts

Upper Mud Cherts

Mineral Chief Massives
Coarse Banded Cherts

Skylark Hill Cherts

Big Bend Massives and Wavy Chert Series

Lower Mud Cherts

Upper Lane City Cliffs
Upper Lane City Cherts
Lower Lane City Cliffs

Semi-Massive, Dark Shaly Series
Marble Beds
Basal Cherts

Lower Thin Bedded Massive Limestones

GENERALIZED COLUMN

through

LOWER HALF

of the

ELY FORMATION

Scale 1" = 400'

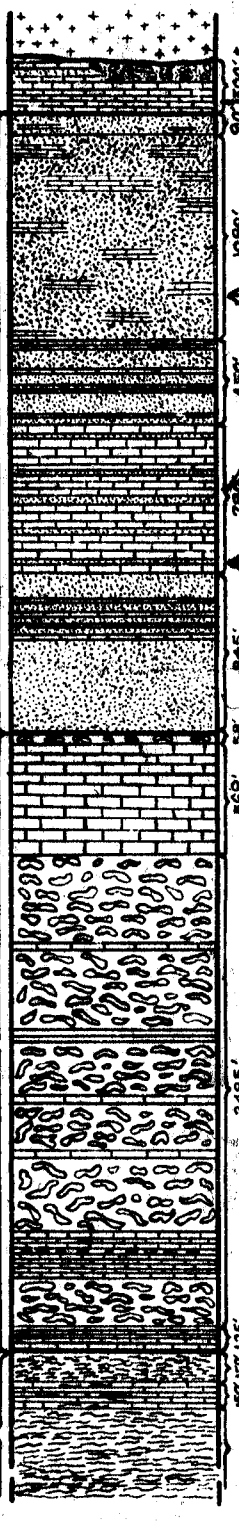
To accompany report
by R. B., July, 1928.

Plate I

GENERALIZED COLUMN THROUGH THE ELY FORMATION

showing

MAJOR SUBDIVISIONS OF THE ELY LIMESTONE AND RIB HILL SANDSTONE.



Large crinoids & brachs.

Rhyolite and tuff.

Thin bedded dense gray limestone; locally small nodular chert that weathers pink. Sandy layers sparse.

Brilliant brick red and yellow sandstone.

Small fossils

Mottled gray, yellow, and brick red sandstone with irregular and discontinuous gray limestone beds.

Twisted & Coiled forms

Yellow and Indian red sandstone with thin intercalated gray-blue limestone beds.

½" Brach.

Massive gray-blue limestone with intercalated sandstone beds.

Corals

Yellow and Indian red sandstone with sparse, thin gray limestone beds.

Contact cherts.

Upper massive blue limestone.

Scale 1" = 1000'.

500 0 250 500 750 1000

Cherty limestones with intercalated massive blue limestone beds.

Lower thin-bedded limestone.

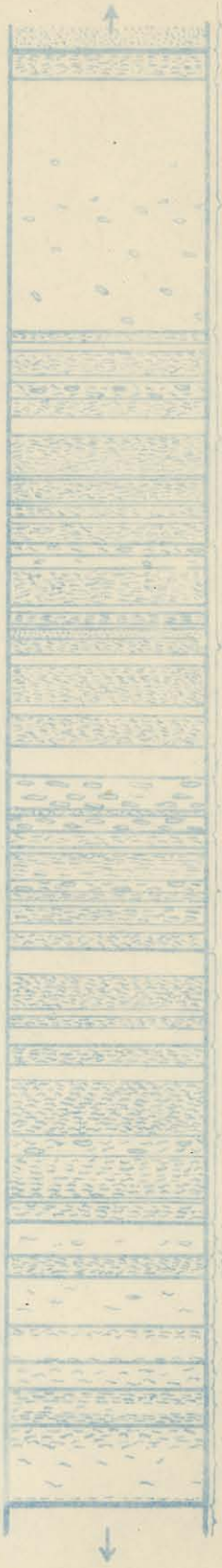
Shale.

Thin-bedded limestone and shale.

Shale.

Consolidated Coppermines Corporation.
Geological Dept. November 1928.
Drawn by: E.H.P. Checked: No. Z-6

Plate II.



Rib Hill Sandstone
Contact Cherts

Upper Massive Limestone

GENERALIZED COLUMN

through

the

ELY LIMESTONE

Scale 1"=400'

Matilda Cherts

Upper Mud Cherts

Mineral Chief Massives
Coarse Banded Cherts

Skylark Cherts

Big Bend Massives &
Wavy Chert Series

Lower Mud Cherts

Upper Lane City Cliffs
Upper Lane City Cherts
Lower Lane City Cliffs.
Semi-Massive, Dark
Shaly Series.
Marble Beds.
Basal Cherts

Lower Thin Bedded Limestone.

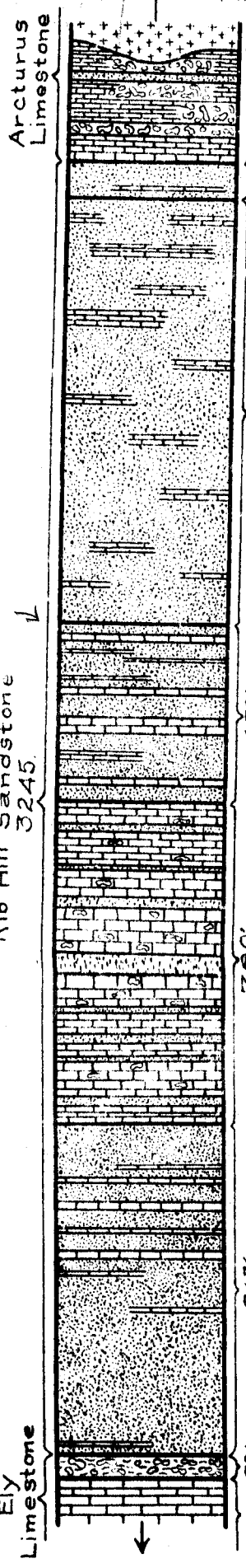
Chainman Shale

To accompany report by
R.B., November, 1928.

Consolidated Coppermines Corporation
Geological Dept. November 1928.
Drawn by: E.H.R. Checked: No. Z 4

Plate III.

GENERALIZED COLUMN THROUGH RIB HILL SANDSTONE AND EXPOSED ARCTURUS LIMESTONE.



Rhyolite & Tuff.

300'+ Thin bedded, dense, light gray to dark gray limestone with local concentrations of small chert nodules which weather pink. Sandstone layers thin and sparse.

90' UPPER BRICK RED SANDSTONE MARKER BED.
Mottled brilliant brick red and golden yellow sandstone.

1080' MOTTLED BRICK RED SANDSTONE SERIES.
Mottled brick red and yellow-gray sandstone with generally discontinuous gray limestone layers. Limestone colored locally, golden yellow. Coloring less brilliant and sustained than in 90' marker bed above.

Base of Arcturus as mapped by Spencer for west half of district. Not consistently adhered to by him.

450' UPPER YELLOW SANDSTONE.
Yellow-gray sandstone with irregular Indian red coloring. Locally intercalated beds of gray, sandy limestone

720' RIB HILL LIMESTONE.
Massive gray-blue limestone with intercalated beds of yellow sandstone. Limestone mostly sandy. Chert nodules irregular and sparse

Scale 1"=400'.

100 50 0 100 200 300 400 500

843' LOWER YELLOW SANDSTONE
Yellow-gray sandstone with irregular Indian red coloring. Thin intercalated gray, sandy limestone beds, especially in upper half.

Consolidated Coppermines Corporation
Geological Dept. November 1928.
Drawn by: E.H.R. Checked: No. Z5

58' CONTACT CHERTS

UPPER MASSIVE LIMESTONE

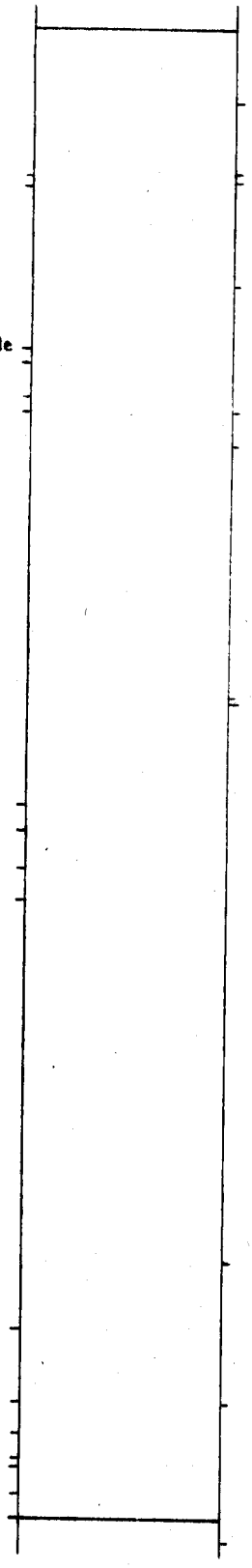
(For further detail regarding Column see Appendix A.)

Plate IV

GEOLOGIC COLUMN through the ELY LIMESTONE showing HORIZONS FAVORABLE to KNOWN COPPER and LEAD ORE.

Lead ☐ Copper ☐

0 40 200 400
Scale in Feet



Munroe above flat fault
Sevastopol

Lower Workings; Matilda Lode

Munroe below flat fault
Upper Workings; Matilda Lode

Eldorado, center of claim.

Eldorado, N.E. corner of claim (approximate).

Miscellaneous Lane City prospects, Eliah Issues Union. (See text).

Richards Sulphide

Richards Oxide

Alpha 650-1400 Levels

Veteran; exact position not determined.

Alpha below 1400 ?

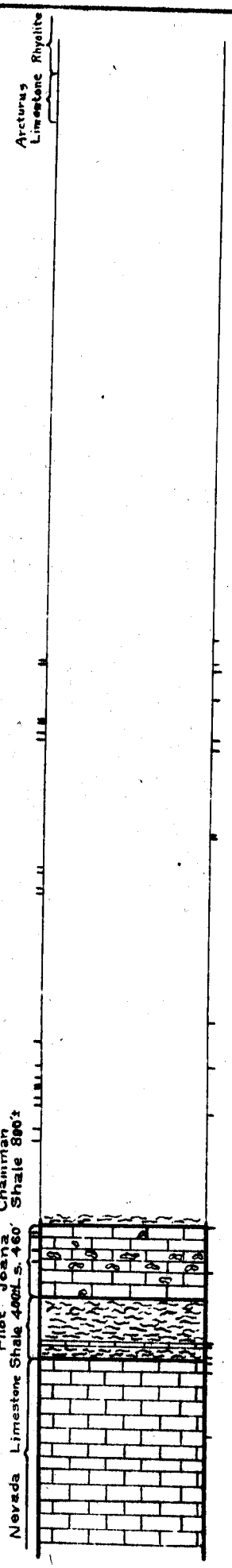
Ruth

Ely Witch

Consolidated Coppermines Corporation, Kimberly, Nevada
Geological Department November 1928
Drawn by: E.H.R. Checked R.E. No. Z 11

Plate V

GEOLOGIC COLUMN from ARCTURUS to NEVADA LIMESTONE showing HORIZONS FAVORABLE to KNOWN COPPER, LEAD, and GOLD ORE.



Copper

Lead

Gold

Scale in Feet.

Sevastopol; Munroe above flat fault.

Lower workings, Matilda Leads.
Upper workings, Matilda Leads.

Munroe below flat fault.

Eldorado*

Miscellaneous, Lane City*
Elijah
Isaacs
Union*

Saxton*

Chainman - Revenue*

* See text.

Richards Sulphide

Richards Oxide
Alpha 650-1400 Levels

Veteran*

Alpha below 1400 ?

Ruth

Ely Witch

Old Glory
Pilot Knob*

Taylor

Probable position
Mitchell copper.*

Consolidated Coppermines Corp., Kimberly, Nevada.
Geological Department November 1928.
Drawn by:- E.H.R. Checked: R.B. No. Z 10.

AULTMAN MINE

Was furnishing the greater portion of this valuable metal. The ore of this mine was of such character that it could not be reduced rapidly, it being decomposed quartz, a large portion of which was clay, which baffled the most experienced smelters of the camp. It was at last concluded to abandon this mine so far as smelting ore was concerned; they however worked the property in pursuit of lead, which was not found in paying quantities, but they did develop a large vein of ore carrying gold. The mine was left in this condition until 1887, when Messrs. Underhill, McOmie and others secured a lease upon the mine and worked the property for a number of years. They constructed a mill of ten stamps capacity and reduced the ore by crushing and passing the same over copper-silvered plates. The process was incomplete and the loss too great to make it profitable. Under this lease they developed large quantities of ore that can be made profitable by working on a large scale and with a complete milling plant. It would be difficult to estimate the amount of ore developed in the Aultman, it not being sufficiently blocked out, but there are large quantities of the average value of $8 per ton in gold. This is the property of Governor McKinley, Geo. D. Saxton and Marshall Barbour of Canton, Ohio, who own a number of patented mines in the district, of which further mention will be made in this article. The Aultman is situated on the south side of the canyon on what is known as Aultman Hill. Just below and adjoining the Aultman on the north is the

JOANA MINE

Whose rich ore attracted so much attention about three years ago. It is separated from the Aultman by a small porphyry dyke. The late A. R. Watson was the original locator, and through his energy the mine was opened and developed. While Mr. Watson operated the mine about fifteen hundred feet of tunnels, drifts and openings were made. The ledge was stripped and exposed on the west end of the mine for a distance of three hundred feet which showed the ledge to be very large. One of the principal openings, the one leading to what is known as the cave, is reached through a tunnel sixty feet in length, at which point a cave was encountered and the ore vein was also reached. From this point an incline forty-five feet in depth was sunk. At the bottom of the incline a drift was driven one hundred and twenty-five feet to the east, and also another thirty-five feet to the north. Several cross-cuts were made at different places, all of which are in ore of good grade. To the west of the work in the cave are other extensive works, in which a large amount of drifting and sinking has been done and a quantity of good ore was exposed. A great many tons of ore were milled from this portion of the mine with fair results. From a statement of facts regarding the Joana mine, prepared by the Hon. Thos. Wren of Eureka, Nevada, the following quotation is made: "The ore was reduced at a small ten stamp water mill at the town of Ely, about three miles from the mine. The mill is poorly constructed and the only appliances for saving gold were copper plates.

Less than one-half the gold was saved by this mode of working, as was shown by constant assays of the tailings. Approximately seven dollars a ton was saved by this process, as shown by the returns by Watson under oath to the assessor of White Pine county, for the purpose of taxation. This would give, adding the gold lost in the tailings, an average of fourteen dollars a ton in the ore worked. The amount taken out in the aggregate was something over fifteen thousand dollars. The exact figures are on record in the office of the assessor of White Pine county." Some distance further to the west there is a tunnel one hundred and fifty feet in length that cross-cuts the ledge. The whole length of the tunnel is in ledge matter. Some time ago this tunnel was sampled in sections by an experienced sampler, the average of the different samples taken giving $4.15 in gold. There have been various estimates of the amount of ore in sight. It would be difficult indeed for all estimates to be made with any degree of accuracy. Some, however, have shown more than fifteen thousand tons of the average value of $12.50 per ton. The gold is free but the clay and oxide of iron require more than the ordinary plate process for saving the gold.

The Joana mine has been unfortunate, it has suffered as many mines have before it. When the first great strike was made, and it was known that it was a mine of unusual merit, litigation began which ran through the courts for a term of several years at great expense and annoyance to the owner. The property was tied up and could not be untied until the judgment of the court was had. During this litigation a number of mining men visited the Joana at various times and made examinations of the property. It is generally believed that the property met their expectations and was satisfactory; but the law suits stood in the way until all were tired out. Had it not been for this unfortunate affair it would no doubt, be one of the large producers of the day, and the district of Robinson would be in quite a different condition.

The Joana mine is now the property of Messrs. Hilp, Wren, Cheney, Sadler and Jackson. These gentlemen own a number of mines in the district.

JOANA NO. 2

The property of Messrs. Ostergard, House, Lawson, Hilp and others adjoins the Joana on the west. There has been considerable work done, but not sufficient to develop the va[illegible]s of the claim. In the deepest working they have some good ore, the same as the Joana in character. Out of a number of tons milled from this property $4 per ton in gold was saved.

CHAINMAN GROUP

The property of Messrs. Lyons, McGill, McOmie and Underhill, is situated on Aultman hill, adjoining the Aultman mine on the west and the Joana No. 2 on the south. The group is composed of

five mines, which are the Chainman, Chainman Gore, Turkey V Southern Cross -- all adjacent to other. The development work upon the group is mostly done upon the Chainman and Chainman Gore mines. The entrance to the mine is through a large tunnel, which taps the ledge at a point 500 feet from the mouth of the tunnel, and 125 feet from the surface. At the point of intersection made by the tunnel and ledge a lateral drift has been run to the west a distance of 300 feet; also, a lateral drift has been run to the east 75 feet to a winze which extends down to a second or lower level of the mine, a distance of 100 feet below the tunnel or first level Thus it will be seen the total depth at this point is 227 feet. Going back to a point where the lateral drift west leaves the tunnel a distance of sixty feet to west in the drift a crosscut has been made to the south, and an opening to the north at the same point, which shows the ledge at this point to be thirty feet wide. Forty feet further to the west, in the lateral drift, there is a stope to the south where some ore has been extracted and reduced at the Chainman mill, which averaged $11 per ton. There is an opening to the surface a distance of something more than 100 feet through the roof of the stope, which is in ore all the way. On the opposite side of the drift there is a crosscut to the north. The distance taken from the back of the stope and to the end of the crosscut shows the ledge to be 42 feet wide. The ore stope extends along the lateral drift to the west, a distance of fifty feet to another crosscut to the north, and shows the ledge to be twenty-four feet wide. The crosscut is not entirely across the ledge. An average gives $6.50 gold per ton. Fifty feet further west in the lateral drift another crosscut is made to the north twenty-eight feet; also to the south a distance of eighty feet. The crosscut to the south has not extended entirely across the ledge. The average value of the north crosscut is $16 per ton in gold. The average in the south crosscut is $6 per ton in gold. The ledge at this point is shown to be 108 feet wide. Twenty feet further west in the lateral drift is an incline shaft which is the working shaft of the mine, which extends to the surface where there is a Common Sense whim erected; that ~~the~~ incline also extends down to the second level. The later drift has been driven several feet further west. All of these workings are in ore.

Beginning at the intersection of the incline with the second level, a drift has been run west a distance of 65 feet all in ore. Another has been run south for some distance in ore, and another east at a distance of 120 feet the ledge is crosscut 45 feet to the south in $10 gold ore. This crosscut did not reach the wall. One hundred and thirty-five feet further east, on the east drift the ledge is again crosscut to the south a distance of 35 feet in $8 gold ore. Thirty-five feet further east the ledge is again crosscut to the south a distance of 40 feet in $8 gold ore. At a distance of 20 feet further east in the east drift, the winze to the upper level is reached, which is referred to above. At the

bottom of this winze a drift leads to the north 28 feet, cutting through a small point of lime and opens again into a large chamber from which a large quantity of ore has been stoped. This stope extends 200 to the northwest and 20 feet southeast, and to the level above. The ore taken from this portion of the mine was high grade. Samples can be had running into the thousands, but the average would probably reach $35 to $40 per ton. There have been several thousand tons of this ore worked at the Chainman mill. There still remains several thousand tons of same quality in the mine. There is no indication of the south wall of the mine having been reached; it is also questionable whether the northwest has been reached. It is the common opinion that the south or hanging wall is shale, and that the north or foot wall is porphyry. Through the mine in many places bunches of lime are found; but thus far they have been but bunches, ore being found on each side of the lime. The ore in the Chainman group is similar to that in the Aultman and Joana mines, possibly not so free as that in the last named mine. The reduction of this ore has all been with the ordinary stamp mill, using copper plates for saving the gold. The last work showed a saving of about 60 per cent of the gold, while at the beginning but 40 per cent was saved. A considerable portion of the gold that is not free is found in a white carbonate of lead, and another portion is found in a heavy black iron, either of which can be readily saved by concentration. The cyanide process has been used upon the tailings at the Chainman mill. The tailings carrying some free gold. and gold alloyed with the carbonate of lead, makes the process fall short of being a success.

The Chainman ledge passes through the entire length of the Ch inman mine to the west end of the location and continue on its westward course through the Turkey and V mines. These mines are but little prospected, and nothing is known of their value except that they are on the extension of the Chainman and Aultman lode. The same can be said of the Southern Cross mine. There is some more work done upon the Southern Cross. Samples taken from one of the shafts assayed $27 per ton. Between the Southern Cross and the Chainman mines lies the

THE GOLDEN REVENUE

The property of Messrs. Simpon, Campton, Harris and others. There is a shaft and other workings upon the mine that expose a large vein of ore that assays $5 to the ton in gold. The deepest workings are about 175 feet, where the ore is found at the bottom; but very little prospecting has been done. West of the Golden Revenue and South of the Chainman lies the

ELY MINE

The property of General Thomas and F. M. Clark. The workings consist of a tunnel 40 feet long, at the end of which a shaft is sunk inthe ledge, which is about six feet wide and assays $5 per ton in gold. The ledge can be traced the entire length of the mine. South of the Ely and to the western end lies

THE MOHAWK

The property of General Thomas and F. M. Clerk. The workings consist of a tunnel 40 feet long, at the end of which a shaft 30 feet deep and an open cut upon the mine in which ore has been developed that assays $10 per ton in gold. West of the Chainman group lies the

ROB ROY MINE

The property of Captain Carpenter, Hilp and others. The claim has been developed by a series of tunnels in which some very good ore has been found. Owing to the presence of water near the surface the ore is not free, but is in a sulphurate form. The owners have expended at least five thousand dollars on the property. Adjoining the Rob Roy on the west is

THE LOS ANGELES

The property of Wm. Watson, Leach Bros. and others. There is a shaft and tunnel upon the mine on which the owners have done considerable work and exposed some ore. A general sample taken assayed $75 per ton in gold. A lot of second-class ore worked at the Chainman mill yielded $4 in gold. South of the Rob Roy mine lies

CHIEF OF THE HILL

Owned by Samuel Parkinson and others. The owners have done some work on the mine and developed some ore.

Adjoining the Los Angeles mine on the West is the Saxton, the property of Governor McKinley and others. At this point the ledge is very strong. Croppings are found high above the surface in many places over the mines. The prospect is covered by U. S. patent and has remained idle for many years. A sample taken from one of the old shafts upon the ledge assayed $18 in gold. The ore is free and of the same character found in the above described mines. This is considered to be one of the best locations in the district. West of the Saxton is

THE AURORA GROUP

Owned by Messrs. Graham, Williamson and Rockhill. The group is composed of four mines, the Katy G., Emma G, Oregon and Mount Morgan. The working consists of a tunnel 112 feet long and a shaft 35 feet deep and a tunnel 75 feet long. At the shaft there is a body of very good ore assaying $7 per ton in free gold. The ledge is seven feet wide, and in some places very strong. The croppings assay $10 in gold. Like the Saxton this property has great merit, the ledge being very strong and well defined. It is understood in this vicinity that this property is under bond to New York parties.

The Rosebud mine is to the west of the Aurora group and is the property of Mr. Rockhill. There is a shaft upon this mine 40 feet deep and a tunnel 100 feet long which expose ore worth $5 per ton in gold.

Continuing to the southward on the main mineral belt, but a great many locations are passed over, all of which have some work done upon them and show more or less gold. They are but slightly prospected, and nothing can be said as to their value, except that they all show the same ledge matter and are of the character that is found in the previously described mines. The ledge is very prominent and can be readily traced the entire distance to the

GOLD HILL

Group, located upon a hill by that name, about two and one-half mines distant from the Aurora group, and is the property of Messrs. Williamson and Rutledge. The locations of this group are the Gold Hill, Gold Hill No. 2 and May. There is a shaft forty feet deep on this group of mines that shows ore its entire depth. The ledge at this point is six feet wide, assaying $10 in gold. There is an immense outcrop of the ledge all over the hill from which good results are obtained with a pan. The ore is harder, the quartz not so much decomposed, and does not contain so much iron and lead as some of the other mines.

South of and adjacent to the Gold Hill group is the Hell in the Hill mine, owned by Thos. Rockhill and Newton Boyd. There is an incline upon this mine 62 feet deep which shows the ledge to be about six feet wide at a depth of 35 feet. At this point the incline has left the ore, the ledge continues to the bottom of the shaft but is not the same grade. Fifty tons of ore taken from this shaft assayed $27 in gold to the ton. The ore is the same in character as the Gold Hill, does not show as much gold in panning, but is remarkably regular in assaying. The ledge is very prominent and crops out at several points on the mine.

There are a number of other locations upon Gold Hill. The principal ones are the City of New York, owned by Messrs. Ostigard, Moore and Weber. They have a shaft 70 feet deep, a drift has been run 30 feet from the bottom of the shaft which is all in ore assaying $7 per ton in gold.

The Hickory, lying north of the Hell in the Hill, belonging to Capt. Harmon and Capt. Carpenter, has a shaft 35 feet deep in ore.

North of the Gold Hill mine some distance is the Midnight and Phoinix locations, owned by D. C. McDonald, Jas. P. McOmie, J. B. Simpson and others. There is a shaft on this mine 90 feet deep which taps a strong ledge six feet wide of ore assaying $18 in gold. A small streak of ore in the ledge assays $450 in gold and 67 per cent. lead.

East of the Midnight a short distance is the October location, the property of Messrs. Simpson and Rynearson. The mine was worked in the early days of Robinson at which time a deep shaft was sunk and some ore was extracted which was principally silver carrying but little gold.

Journeying to the north-west the ledge makes a turn more to the south. There are locations most of the way upon which some prospecting has been done which all show gold. At a distance of about two miles the Magna Charter is reached, the property of Thos. Rockhill and others. The ore is of an entire different character, resembling the ore of the north ledge, carrying silver, lead and gold. The ore runs about 30 per cent. lead, 3 ounces silver and $2 in gold. The ledge is three feet wide at a depth of 40 feet. Two miles west of the Magna Charter the

WEST CAMP

mines are reached. These mines were worked in the early seventies. The ore found here is different in character from the mines already described, some of them carrying copper in large quantities. The principal mines of this vicinity are the Boulder and Boss, the property of John Daly, upon which there has been considerable work done. On the former there is a shaft and open cut. Ores taken from these workings and shipped for reduction assayed $50 in silver and 47 per cent. lead. The latter claim (Boss) has a deep shaft out of which some high grade silver-lead ore has been extracted.

The Ragsdale and Rockhill mine in the vicinity shows a vein two feet wide at a depth of 87 feet, which assays 50 per cent. lead, 18 ounces silver and $50 gold.

Messrs Hilp, Wren and others own several mines in this locality, the principal ones being the Pilot Knob, carrying gold; the Emma, carrying gold, silver and lead; the Mannouth, Monitor, Star and Star of the West, all carrying copper and ores worked for that metal. The ore was reduced at a local copper smelting furnace and gave good results.

West camp is at the extreme north-west end of the mineral belt and upon the summit of the range.

Returning to the Aultman mine the

GOLDEN FLEECE

Lies just to the east and adjoining the Aultman. It is the property of Thos. Rockhill and the Ragsdale estate. The work consists of two tunnels and a shaft. The ore assays 30 ounces silver and $10 gold.

South of the Golden Fleece and east of the Southern Cross, is the Golden West, but little prospected and is owned by Williamson and Simpson.

North of the Golden Fleece is the Golden Wedge, owned by Messrs. Thompson & Weber, which is also but little prospected. There is some ore upon it that shows gold.

North of the Golden Wedge is the Thoroughbred, belonging to Wm. Watson and others. It has a shaft fifty feet deep which exposes good ore.

Adjoining the Joana on the north and east is the

FLORIDA

Group, the property of D. C. McDonald and John F. Cupid. The group includes the Florida, Dauntless and Quadrant, which extends across Robinson canyon to the north. Upon the Florida in the middle of the Robinson canyon, the owners have sunk a shaft 87 feet deep, they drifted north 25 feet and sunk again at the end of the drift 55 feet, making a total depth of 142 feet. The bottom of the shaft is at the footwall of the ledge. They then crosscut 30 feet reaching the hanging wall, showing the ledge in the bottom to be 30 feet wide. There is also an open fissure that exposes the ledge latterly for one hundred and fifty feet. The ore in these workings assay from $4 to $13 per ton in gold. Two hundred feet to the north of the shaft just described there is another shaft in the croppings of the ledge 25 feet deep in which there is eight feet of ore that assays $5 per ton in gold. The ledge is traced through the full length of the Florida and across the Dauntless. Upon the Dauntless there are three tunnels, one of which is 115 feet cutting the ledge; one is 68 feet long cutting the ledge, and one 30 feet which has not yet reached the ledge. The ore assays $8.75 per ton and carries some copper.

Upon the east extension of the Golden Fleece is the Lone Star, the property of Messrs. Hayes & Berry, on which there is a shaft 15 feet deep in ore.

Journeying along the ledge to the east a number of locations are passed which are but little prospected. At a distance of one and one-half miles the General Logan mine is located, the property of Messrs. House, Morris, Hilp and others. There is a tunnel 75 feet long and a shaft 30 feet deep on the claim which exposes ore assaying $7 per ton.

South of the General Logan is the May Day, the property of Messrs. House, Morris and others. There is a tunnel on this mine 120 feet long and an incline in the tunnel 20 feet deep in ore that assays $6 per ton in gold and sixty ounces in silver. Some high grade ore is also found in the May Day. These mines are upon the extreme southeast end of the mineral belt and are about one mile west of the town of Ely.

One mile up Robinson canyon from the town of Ely, and upon the north side of the canyon is Maggie hill, from which point the description of the north ledge will be taken up. The principal

mines on this hill are the Mohee group and the Maggie group. The Mohee group is the property of D. C. McDonald and J. F. Cupid The workings consist of a shaft 35 feet deep, an incline 20 feet deep and a shaft 20 feet deep. The ore assays $4 in gold per ton, come of which carries 40 per cent. copper.

Down the hill and to the south of the Mohee is the Maggie group, owned by Messrs. Lyons & McOmie. The work consists of several small shafts or openings. The ledge in places is about ten feet wide. Some of the ore pans as high as $12 per ton in gold, most of it being free.

East of Maggie Hill are a number of locations that cover the ledge almost to the town of Ely. Some of them prospect well.

West from the Maggie Hill are a number of locations. Some of them are the Florida Tunnel, Yankee Blade and Buckeye Fraction, owned by Fred Clark and others.

About one half mile from Maggie Hill is the Robust mine, owned by Messrs. Riepe & Thomas. This mine is about 3,000 feet south-east from the Joana. There is a shaft 60 feet deep and a drift 22 feet. Both shaft and drift are all in ore. The ledge is six feet wide and assays $12 per ton in gold. About 150 tons of this ore is extracted and upon the dumps at the mine. Some estimates show a thousand tons in sight.

Passing along the ledge to the west numerous locations are seen. The Blackstone, Ohio and Union, carrying gold, silver and lead, are the property of Governor McKinley and others. All have work upon them and expose considerable ore.

North of the last named mines are the Rip Van Winkle and Edna, owned by Messrs. Simpson, Lyons and McOmie. These mines have shafts and open cuts upon them, the greatest depth attained being 25 feet. The Rip Van Winkle ore carries gold and silver about equal. The Edno ore assays from $5 to $80 in free gold.

South of the Union and Ohio is the Cloud and the Gold Bug. The latter is owned by Messrs. Weber and Ostergard, in which quite a body of $10 ore is found.

West of the Ohio is the Great Western the property of Messrs. Hilp, Wren and others. The works aggregate 400 feet and some good ore i s exposed.

West of the Great Western lies the Commodore, Issacs, Hicks, Eliza, Bullion and Springville, the property of Governor McKinley and others. These mines were all worked in early days and produced most of the bullion at that time. The ore was silver, gold, and lead.

Crossing Robinson canyon again to the south are a number of mines located upon a high mountain lying between Robinson canyon

and a large canyon coming into Robinson canyon from the south, known as the canyon leading to White River. Here are found the Hidden Treasure, belonging to McDonald and Cupid; the Ontario, Point, Sheba and Shife belonging to Messrs. Hilp, Wren and others, and some locations belonging to John Farrel. There has been a large amount of work done upon this mountain and several shipments of ore have been extracted. The ore is silver, gold and lead.

West from this mountain about two miles distant is the property of Messrs. Jackson and Kind of Eureka, known as Key Stone from which a large quantity of ore has been extracted and reduced. A number of shipments were sent to the Eureka furnaces for treatment which yielded about two hundred dollars per ton in silver. There was also a lot of this ore reduced at the Monitor mill, Steptoe creek, and another lot was reduced at the Chainman mill. Afterward the parties owning the property erected a mill at the mine and reduced some of the ore. The process they employed was the lixivation process to which the ore readily yielded. The mine is still in good condition to produce. Owing to the present low price of silver the owners deem it best to await a change.

In addition to the lode claims there are within the limits of the District

PLACER MINES

About one-fourth of a mile from the town of Ely in the mouth of Robinson canyon. The Robinson Canyon Consolidated Mining Company has located about 10,000 feet of ground extending up the canyon to a point above the Joana mine, which is located as placer ground. The property is worked through shafts -- six in number. The bed rock is found at an average depth of seventy feet. On the bed rock from two to eight feet of gravel is found which carries gold. It is coarse and easily saved in an ordinary sluice box, which method is used by the Company in the spring of the year, when there is surface water running down the canyon. Several runs have been made in this way. The Company is now arranging to put in dry separators, when they expect the property will be made pay.

The Maud S. placer claim adjoins the property last described, and extends up the canyon and includes twenty acres within its boundaries. It is owned by J. B. Williamson and in all respects is like the property of the Robinson Canyon Consolidated Placer Mining Company.

It will be seen from the above description that the mineral belt extends from the May Day mine on the south-east to the mines at West Camp on the north-west end, covering a distance of about eight miles in length. The width of the belt varies some. At

places it is fully a mile wide, and at no place is it less than half a mile. Mineral can be found on all portions of the belt. There are many locations in the district that have not been mentioned in this article. However a sufficient number has been, to give the reader a general idea of its magnitude.

Nature has done her part for the success of the camp. The ore is very soft, most of it can be mined without blasting, thereby saving a great expense. There are numerous springs in the district that can be used at the mines, and at the town of Ely there is a large stream of pure water that is not effected by frost or by hot and dry seasons. The hills are covered with an abundance of timber, suitable for mining and fuel. Good wagon roads are built to all portions of the district, and all the mines are easy of access. All that is required for a live and booming camp is money, and he who invests will reap the reward.

GUIDES TO ORE

in the

ELY DISTRICT

Roland Blanchard

November, 1928

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PRELIMINARY STATEMENT ON THE USE OF ORE GUIDES

Ore guides that are infallible cannot be established in a district until the last of its ore has been found. But in districts where development and extraction have been carried on over a period of years and where portions of the ground have been more or less cut up, as at Ely, there may be established certain ore controls that are proved nearly invariable for the ground dissected, that leave little to the imagination for that particular ground, and that constitute the firmest basis for guiding exploration into adjacent poorly explored or wholly unexplored areas.

To be practicable, ore guides must conform to the following requirements:

1. They must be based upon some simple relation to the ore, such as the association of orebodies with a certain porphyry dike, fracture zone, or limestone bed. It may be stated as a general working principle, subject to very few modifications, that the more involved the reasoning back of an exploration program, the less likely is that program to yield ore.

2. They must be so clearly described and so easy to grasp that the mine foreman or shift boss will have no difficulty in comprehending and applying them. In a large mine it is physically impossible for the geologist to keep in detailed touch with each new development each day. Unless the major ore controls are so simple that those actively engaged in the exploration are able to recognize them readily and grasp their significance, a good chance therefore exists that factors important in the localization of ore will be overlooked.

3. The guides must be larger and easier to find than the ore; otherwise it may cost more to find the guide than to find the ore itself. The envelopes or "shells" of sericitized porphyry that surround the disseminated porphyry copper orebodies in certain districts are excellent guides in such districts because they usually are two or three times as large as the ore, and the more important ore occurs entirely within them. The veins of native sulphur associated with the Britannia copper orebodies, on the other hand, are poor guides because the

volume of the ore exceeds the volume of sulphur probably a hundred times, the sulphur veins do not always exist where the ore exists, and the veins, even when present, frequently are not found until the ore itself has been disclosed.

4. The major guides should be clearly distinguished as long range and short range guides, so the operating management may be in position to appraise the risk, and apportion expenditures accordingly. At Bisbee, for example, manganese at the surface in association with fissure silicifications is regarded as an almost infallible guide to copper ore in the limestone beneath. A large surface area with prominent manganese showings corresponds usually to a large ore area, while a surface area with small and spotty manganese showings corresponds usually to small and spotty ore. The manganese showings occur as much as 1800 feet above the ore, and almost invariably play out in depth before the ore is reached. Since they serve only as general guides to the ore areas, they are termed long range guides. On the other hand, the larger occurrences of primary hematite are rarely more than 300 feet from important ore, and nearly always touch that ore at some point. Since these hematite bodies lead directly to or within a few hundred feet, they are termed short range guides.

5. The guides should be demonstrated <u>facts</u> of ore occurreme that will stand without the crutch of theory to support them. Many ore occurrences may be better understood in the light of geological theory. But when an exploration program becomes based to an important degree upon theoretical considerations, it is usually foredoomed to failure. One proved fact of ore association, such as the fact that the ore actually does occur repreatedly in a certain limestone horizon, is worth a dozen theories of where the ore ought to occur.

Although numerous ore guides exist in every mining district, the dominant guies in most districts may be reduced to three or four major ore controls so simple that even the miners have no difficulty in recognizing them. In favored districts even a single major guide may dominate. Thus, at Christmas and San Pedro, the important orebodies touch somewhere along the "marble line," or along the imaginary line between the garnet zone and the marbleized and unaltered limestone lying beyond. Prospecting the marble line there would disclose probably 90% of all commerical ore produced by the mines to date. At Pilares the more important orebodies lie within 75 feet of the outer edge, or periphery, of the 1200' x 1800' fractured

oval (dimensions of oval from memory); and prospecting this outer zone would likewise account for probably 85% of the mine's production. At the O. K. mine near Milford, Utah, the orebodies in the monzonite are associated with small quartz veins that make out from a central plug or cylinder of quartz; and the ore decreases rapidly with distance from that central plug. These examples illustrate the simplicity to which prospecting may be reduced in especially favored districts.

In some districts the problem is not so simple. In the garnet areas at Morenci, prospecting the marble line would have yielded only a small percentage of the total garnet ore; some of the richest oreshoots were embedded deep within the garnet zone itself. The explanation is that at Christmas and San Pedro mineralization took place under comparatively quiet conditions, and the sulphide orebodies were deposited without disturbance in the reducing zone at the outer edge of the oxidizing zone; or in other words, at the outer edge of the garnet-epidote zone, along the marble line. At Morenci turbulent conditions prevailed throughout a large part of the period of ore deposition. And although some of the sulphide ore began depositing along the marble line, disturbances occurred which crushed and broke open the garnet areas; and the ore still in solution penetrated and was precipitated more or less at random within the garnet zone itself.

It will usually be found that each mining district has its own ore habits which must be in large part mastered before exploration programs may be intelligently and economically laid out. Such mastery may require several years of detailed work, though during that period progress will be made which will continually reduce the exploration hazards. From work already done, it is evident that finding ore in

the Ely district outside the large porphyry mass at Nevada Consolidated pit will be no such simple matter as finding it by following the periphery of the oval at Pilares. It will not even be as easy as finding ore at Bisbee, since more blind structures exist at Ely. The most carefully thought out program may be vitiated by a flat fault which was not visible at the surface or in accessible underground workings; or an orebody may have been cut out by an intrusion of the post-ore rhyolite, which, with true irony, failed to destroy the evidence of vigorous mineralization above the ore. Since none of us is Omniscient, mistakes will be made in laying out the prospecting, sometimes through oversight on our part, sometimes through the vataries of mineralization which were not subject to analysis prior to discovery of the ore. A certain allowance must be made for this, particularly when prospecting the limestone areas, where ore is characteristically erratic in behavior and occurrence. But that does not mean that we should go to the other extreme, and fail to avail ourselves of the most carefully reasoned program that is possible at the time. We must remember that we are not competing with a technique that is 100% perfect. The science of finding ore is probably not more thant 35% efficient at the present time. And if we improve that technique 10%, or even 5%, we are accomplishing a great deal.

-o-

The material which constitutes the basis of this report represents the results of six months detailed field work in the Ely district by E. N. Pennebaker and four months by the writer. The work by Pennebaker consisted largely of mapping, differentiating, and classifying the jasperoid and porphyry occurrences while directing

active exploration. The work by the writer consisted largely in constructing a geologic column through the Ely formation, in mapping the major faults and sedimentary horizons, and in determining which horizons are orebearing. To some extent, the two lines of work overlapped.

The major surface structures, and many of the minor ones, have been worked out for the principal zone of copper mineralization, which extends from the Matilda workings at the west to the Ely Witch property at the east, - an area 5 miles long and roughly 2 miles wide. And most, though not all, of the mineralization outcrops have been classified and mapped for the Kimberly area lying along this zone west of Nevada Consolidated pit.

The next step consists in carrying downward to the ore the surface structures and mineralization outcrops so as to translate those structures and outcrops specifically into terms of ore beneath. Inaccessibility of many of the underground workings up to the present, has prevented doing this comprehensively to date.

One difficulty that will be encountered in carrying out this work is the fact that much flat faulting occurs in the mineralized areas within a few hundred feet of the surface. That will make it impossible, in some cases, to correlate the surface structures directly with those existing at the horizon of the ore. And the outcrops at the surface, in many instances, probably will be found to lead downward to the ore by devious, rather than direct routes. Definite progress in correlating the surface ore guies with the ore therefore may be expected to be slow.

Another difficulty is the fact that much of the exploration

consists of churn drilling. In the porphyry areas the churn drill records probably furnish most of the information needed. In the limestone areas they do not tell, in most instances, whether the surface structures to be explored actually were encountered in depth; and if ore or encouraging mineralization was found, whether it occurred in the cherty limestones, the sandy limestones, the sandstones or the shales; or whether it occurred in the same fault block in which the hole was begun, or in some other block. In most instances, they likewise do not furnish information as to what local conditions may have precipitated ore at those particular places. The churn drill date therefore will prove of restricted value in ascertaining the causes of ore localization beyond showing the shape and position beneath the surface of the porphyry and rhyolite. From the standpoint of geological correlation, it is unfortunate that the churn drill exploration so heavily overbalances the underground exploration, particularly the accessible underground workings; for in a district as complexly faulted as the Ely district, a greater amount than usual of ordinary underground development work in the limestone must be done, and must be accessible for examination, before the ore possibilities of that ground may be intelligently appraised.

-o-

The present paper seeks to focus attention upon (1) agencies within the district that have a proved direct bearing upon the finding of ore; (2) agencies within the district not yet fully proved, but which seem likely to have such bearing; and (3) agencies which have proved effective as ore guides in other limestone copper districts

under conditions closely resembling those prevailing at Ely. Distinction is made between ascertained facts, reasonable probabilities, and the more remote conjectures, and throughout the report the attempt is made to define the degree of doubt involved in using guides that are not yet securely established in the district, and upon which least dependence may be placed in projecting exploration into new areas.

The important point to be kept in mind is that although certain protions of the ground in the Ely district have been rather thoroughly cut up, and their ore habits ascertained, there reamin other large, well mineralized portions that have been but little explored, even by drilling. It seems likely that most of the guides found dependable in proved ore areas will apply in the untested ground; but in limestone districts, where ore is characteristically erratic in occurrence, constant watch and diligent search must be maintained both for local exceptions and for new, broad ore controls.

Much of the material in this report relating to the Ely district has been contributed by Pennebaker and his assistant, Rott; but neither is necessarily held responsible for the views expressed. Much of the detail relating to ore occurrence in Nevada Consolidated ground has been obtained from H. T. Marshall. But no feature of ore occurrence in Nevada Consolidated ground is discussed which has not been personally examined and digested by the writer.

"Roland Blanchard"

November, 1928.

G U I D E S T O O R E

GENERAL GUIDES

The Major Copper Bearing Area

The principal known copper bearing portion of the Ely district conprises an E - W rectangular area roughly 5 miles long by 2 miles wide. It extends from the Matilda property on the west to the Ely Witch property on the east; and from the Taylor mine on the north to a point near the top of Rib Hill on the south.

Not all of this area is copper-yielding, nor is all of it equally promising for copper. But the area consistitutes a compact unit whose surface carries the more prominent copper stains and other surface evidences of copper mineralization contained within the district. And although other portions of the district have yielded small, spotty, and isolated copper occurrences, commercial copper, so far as now known or indicated, is sharply confined to the rectangular area named.

The Master Fault Zones

1. <u>Sandstone Fault Zone</u>:

Running centrally in a general E - W direction through this rectangular area is a strong zone of dislocation, with the surface showing predominantly limestone and shale to the north, and predominantly sandstone to the south. In shape the zone resembles somewhat a carpenter's drawknife, with the handles pointing to the south; and the zone does not extend the full length of the rectangular area.

But it occupies the main central portion, and constitutes the locus of major fracturing, occurring within that area.

Because the zone separates in a general way at the surface the limestone and shale from the sandstone area, it is called the Sandstone Fault Zone.

Vertical displacement along the zone varies from 4500 feet at the Alpha and Morris-Brooks mines, to more than 6000 feet at Nevada Consolidated pit and at the Ruth mine, - with downthrow on the south, or sandstone side. Locally "apparent" downthrow occurs to the north, as in the vicinity of the Butcher Boy and Copper Queen claims, and likewise near the Cliff claim. But present evidence suggests that this condition is due to thrust faulting which has thrown comparatively thin slices of sediments out of their normal position.

To date it has not been determined whether this zone of dislocation carries a single continuous break for its entire length, or is made up of a series of closely connected breaks. But for distances of 1000 to 3000 feet both into the hanging and footwall, strong fracturing occurs both parallel and at right angels to the main central line of dislocation. And this belt of fracturing constitutes by far the strongest and most persistent zone of E - W fracturing within the district.

All major copper orebodies of the district are closely associated with the Sandstone fault zone, particularly with the straighter portion that corresponds to the blade of the drawknife. The major orebodies that do not touch the central line of dislocation directly lie within 2500 feet of it, and lie within fractured areas that do connect directly with that central line. And it is evident from a study of surface evidences of mineralization, and of other ore local-

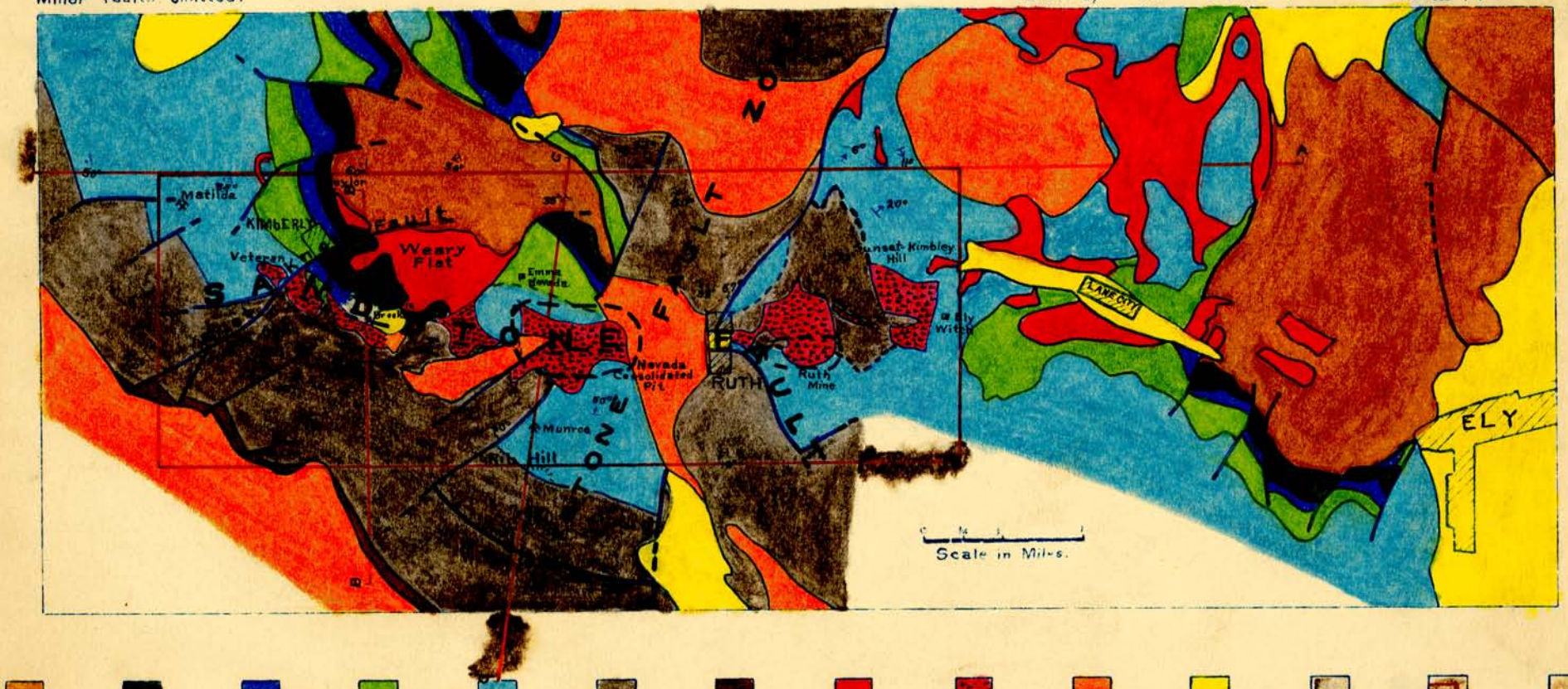
GENERAL MAP of the ELY DISTRICT

Showing

MAJOR STRUCTURAL FEATURES.

Adapted in part from Spencer's Map.
Not accurate as to detail.
Minor faults omitted.

Consolidated Coppermines Corporation, Kimberly, Nevada.
Geological Department. November 1928.
Drawn by: [illegible] Checked: R B. No. Z 7.



Nevada and Pogonip Limestone | Pilot Shale | Joana Limestone | Chainman Shale | Ely Limestone | Rib Hill Sandstone | Arcturus Limestone | Peanut Porphyry | Ore Porphyry | Rhyolite | Alluvium | Fault | Principal Copper Bearing Area | Line of Section

izing agencies in the district, that although some portions of the Sandstone fault zone are entirely barren of copper, the ground lying within that zone, and within one-half mile of the central line of dislocation, is by far the most promising ground for copper in the district.

2. Keystone Fault Zone.

Running in a general north to northeasterly direction through the district, nearly at right angles to the Sandstone fault zone, is a second zone of dislocation, known as the Keystone fault zone.

This zone intersects the Sandstone zone slightly east of the latter's center, and differs from it in that, instead of showing a major downthrow on one side, the Keystone zone as a whole, for an average of more than a mile, is dropped down variably from 4700 to 5600 feet below the surrounding country. It may be visualized as a broad cleft or canyon running through the district in a N - S direction, approximately a mile deep filled for the most part with a dropped- down block of sediments.

The Keystone zone, south of its intersection with the Sandstone, is less clearly defined than to the north, because it here contains a large block of sediments, 1½ miles long and averaging more than a mile wide, that has been overturned, and now lies upside down with respect to the general structure of the district. But the overturning of this block directly in the path of the Keystone zone, together with its marked distortion and fracturing, emphasizes the strength and persistence of the Keystone fault movement.

Unlike the Sandstone fault zone, the Keystone does not thus

far show distinct evidences of being a major ore locus, though a suggestion of it is held forth by the mineralization in the Munroe country south of the Sandstone fault zone, in the overturned block of sediments referred to. The significant feature, from the ore standpoint, is that the intersection of the Sandstone and Keystone fault zones coincides with the major copper deposition of the district; namely, the deposit at Nevada Consolidated pit.[x] From this more or less central point of major fracturing and mineralization for the district, important copper mineralization, constituting nearly a third of the total ore found in the district to date, makes out along the Sandstone zone for a length of two miles to the east and two miles to the west, though the volume of copper mineralization in the two directions is not necessarily equal, nor evenly distributed.

[x] The term "Nevada Consolidated pit orebody", as used in this report, includes the ore in the vicinity of the pit belonging to both Nevada Consolidated Copper Company and Consolidated Coppermines Corporation.

The west extension, lying along the Sandstone fault zone between Nevada Consolidated pit and the Alpha mine, has been much less prospected than the remainder of this mineralized zone. It carries the largest untested or imperfectly tested blocks of favorable mineralized surface showings remaining in the district. And although chances for further ore occur at various places along nearly the full length of the Sandstone fault zone, the west extension lying between the Keystone fault zone and the western limits of the Alpha mine is the most inviting ground to prospect for further important copper orebodies.

The Ore Porphyry

The monzonite porphyry of the district comprises two types: (1) an unevenly grained rock with numerous coarse feldspar and horne-

blende phenocrysts ranging from ¼ to 1 inch in length; (2) a medium grained rock, more evenly granular, with but few phenocrysts, and these usually less than ¼ inch long.

In the former the phenocrysts are predominantly cream to pink feldspar crystals, scattered irregularly through a darker matrix, with the feldspar phenocrysts often constituting 10% or more of the total rock volume. In appearance the texture suggests ordinary "peanut brittle" candy, and name "peanut porphyry" is used locally in the district to designate this type of monzonite.

Although copper mineralization is at various places associated with the peanut porphyry, the copper occurrences are small, and none has been found thus far which constitutes commercial ore for other than small leasing operations.

In contrast with the peanut porphyry, the more evenly granular type has yielded all the commercial disseminated copper ore of the district, and with it are closely associated likewise the larger known limestone copper orebodies.

Because the more evenly textured porphyry has either yielded or is closely associated with all known major copper occurrences of the district, it is locally called the "ore porphyry."

It seems probable that the peanut porphyry and the ore porphyry belong to a single intrusive mass, although the conclusive evidence of one grading consistently into the other, has not yet been found. The evidence of their being phases of a single intrusive is (1) in their unaltered form they are chemically and mineralogically almost identical; (2) enough scattered large feldspar phenocrysts occur locally in the ore porphyry to suggest an origin in

common with the peanut porphyry, though probably the ore porphyry represents a later phase; (3) copper mineralization is associated with both types, though the volume of known copper associated with the peanut porphyry is small.

The plan maps of the district shows that intrusion of the peanut porphyry was not guided by the fracturing of either the Sandstone or the Keystone fault zones; but that intrusion of the ore porphyry was closely guided by the Sandstone zone and that its locus occurs at the intersection of that zone with the Keystone, at Nevada Consolidated pit.

This suggests that the dislocation and fracturing which resulted in formation of the two master fault zones of the district either was absent or was not far advanced at the time of intrusion of the peanut porphyry; that intrusion of the penut porphyry may have brough about an important part of that fracturing and faulting; and that, in any event, much of the fracturing and the principal movement along the fault zones was completed before intrusion of the ore porphyry took place. In other words, that all three phenomena are related in point of time, and belong to one general period of intrusion and deformation.

Although the ore porphyry is clearly localized along the Sandstone fault zone - chiefly along the "blade" of the drawknife structure - it breaks away from that zone toward the east end, near the Ruth mine, and make off toward but does not reach another faulted area near Lane City. Along this divergence east of the Ruth mine, in the Sunset-Kimbley Hill area, occurs an outcrop of the ore porphyry, roughly ½ mile in diameter, which carries approximately 1,000,000 tons of very low grade and doubtfully commercial dis-

seminated copper ore. This body lies a mile from the central line of dislocation of the Sandstone fault zone.

Save for this one case of doubtful ore, the porphyry of the district which carries known commercial oreshoots, touches, without exception, at some point or other along the central line of dislocation of the Sandstone fault zone, either at the surface or underground; and the farthest limit of definitely commercial porphyry copper ore from that central line is not more than a half mile.

It remains to be proved by future exploration of the ore porphyry masses underground whether this close spatial relation of commercial disseminated porphyry copper ore to the Sandstone fault zone will continue invariable. Present known facts suggest that it probably will. But irrespective of that consideration, exploration already accomplished is sufficient to establish the ore porphyry as the carrier of the important disseminated copper ore of the district, and to leave only remote hope that the peanut porphyry will yield more than small, scattered copper bodies.

Recapitulation

The major area of copper ore deposition in the Ely district comprises an E - W rectangular block roughly 5 miles long by 2 miles wide. Running almost centrally through this block in an E - W direction is a broad zone of dislocation and fracturing from one-half to a mile wide, known as the Sandstone fault zone, in which the south side has been dropped from 4500 to more than 6000 feet with respect to the north side. Most of the ore porphyry of the district has been intruded along that fault zone, and most of the known important copper orebodies both within the porphyry and

the limestone, occur along it. The central locus of copper mineralization for the district occurs at the place where the Sandstone zone, slightly east of its center, is cut by another strong zone of faulting and fracturing (known as the Keystone fault zone), that trends in a general N-S direction through the district, nearly at right angles to the Sandstone zone. Ground lying west of this central locus, between Nevada Consolidated pit and the western limits of the Alpha mine, offers the greatest present promise for finding further important ore both in the porphyry and in the limestone.

GUIDES WITHIN THE PORPHYRY

A. Structural Features

1. Truncated Apexes

Large intrusive bodies rarely settle and cool with a smooth upper surface. Usually there are projections or surges of the intrusive upward along lines of weakness in the overlying sediments or other intruded rock. Where these surges break through and follow fissures or bedding planes for considerable distances, dikes and sills result. Where the intrusive merely surges upward along a line of weakness without breaking through, irregular, cone-like or ridge-like masses of the intrusive, ranging in height from a few hundred to nearly a thousand feet, are formed on the top or along the edges of the underlying intrusive mass. These cone- or ridge-like projections along the upper surface of intrusive stocks are usually called apexes. (Some writers, as W. H. Emmons, refer to them as domes, roofs, or cupolas of the larger underlying intrusive mass.)

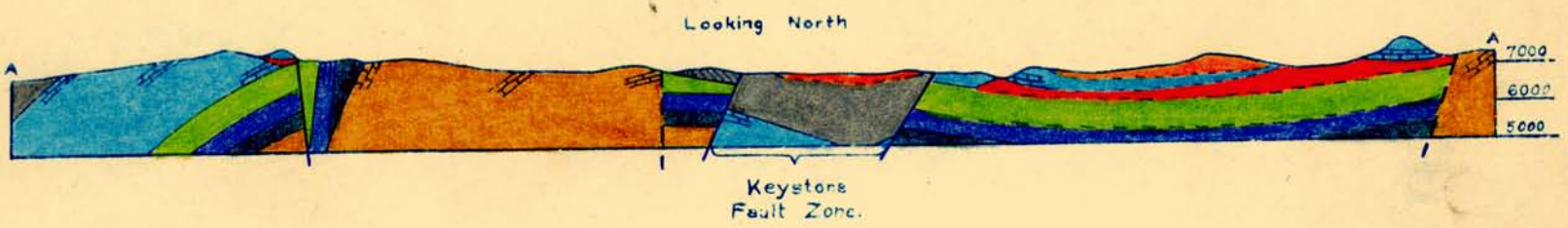
When erosion has planed down the country to the level where the upper central portions of these apexes are exposed at the surface, such outcrops of the porphyry or other intrusive are called "truncated apexes".

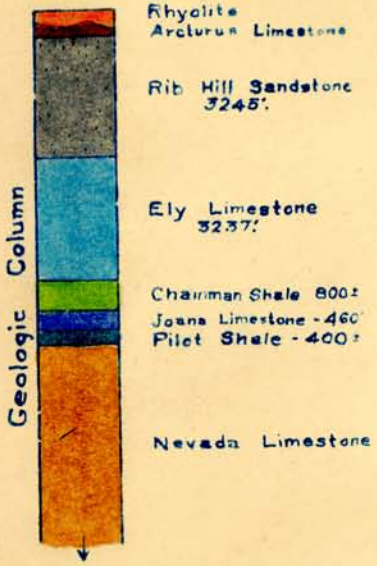
In most porphyry copper districts truncated apexes have been found especially hospitable to disseminated copper ore. Not only is there often a marked concentration of primary sulphides in such structures, but the porphyry of the apexes likewise generally is finely crackled or fractured, permitting thorough leaching of the low grade primary ore near the surface and concentration of it as secondary copper ore several hundred feet below. Utah Copper, the Cactus mine, Sacramento Hill, Chino,

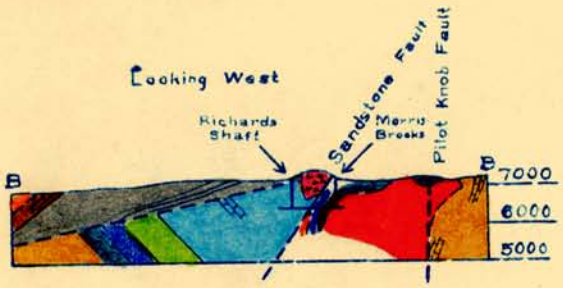
GENERAL GEOLOGIC SECTIONS through the ELY DISTRICT

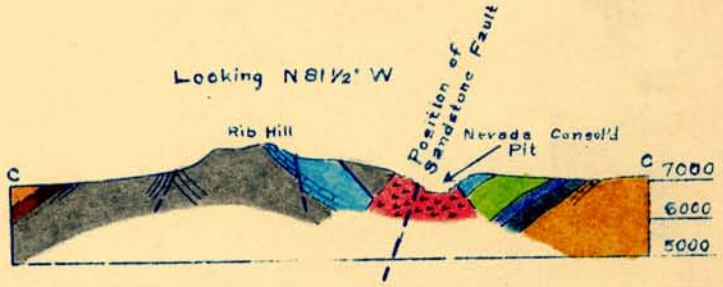
Showing

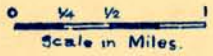
MAJOR STRUCTURAL FEATURES.











Minor Faults omitted.

Consolidated Coppermines Corporation, Kimberly, Nevada.
Geological Department. November 1928.
Drawn by: E.H.F. Checked: R.B. No. Z 8

Plate II

Miami and Inspiration are examples of enriched disseminated copper deposits in such truncated apexes; though in some cases, as at Utah Copper and Miami, a part of the copper mineralization occurs in the fractured quartzite or schist which adjoins the porphyry.

In the Ely district the main intrusive porphyry stock never has been definitely located. With its position in doubt, it becomes difficult to determine which of the smaller porphyry outcrops constitute apexes. Another difficulty is that several of the moderately small porphyry outcrops such as the Morris-Brooks, Old Glory, and Veteran bodies - which from their surface exposures might be expected to represent apexes - are in reality flat, sill-like porphyry bodies underlain by limestone and shale.

The best guess at this time is that the peanut porphyry mass in Weary Flat constitutes at least the western portion of the main porphyry stock of the district. And of the various smaller bodies of ore porphyry, the masses at Nevada Consolidated pit and at the Ruth mine come the nearest to resembling the truncated apexes of other districts, since both bodies are known to spread conelike in opposite directions beneath the surface, and have not to date been found underlain by sediments except in what probably are local bulges of porphyry out into the sediments. These two probable apexes carry the largest porphyry orebodies of the district.

No known truncated apexes at the surface remain unprospected, and this ore guide therefore would have application chiefly in prospecting beneath the surface possible extensions of known porphyry masses.

Such an extension of the Nevada Consolidated porphyry

body into the Munroe country seems at this time a fair probability, but not enough exploration has been done to determine its shape, or to reveal whether or not it possesses ore possibilities.

Another place where apex structures may exist is the ground along the Sandstone fault zone between Nevada Consolidated pit and the Morris-Brooks mine. A portion of this ground has been drilled at irregular intervals, and partial records of the results are available. But the churn drill information has not yet been analyzed or plotted upon sections so as to reveal the shape of the porphyry bodies beneath the surface sediments. Until that is done, no opinion is in order as to possible favorable apex structures in that area.

2. Ore Porphyry Kidneys:

As already stated, several of the moderately small ore porphyry occurences in the district, as at the Morris-Brooks, Old Glory, and Veteran mines, are comparatively flat, sill-like bodies underlain by limestone and shale. In shape they resemble a flat-lying clam or kidney. They vary in size from small bodies to masses roughly 2500 x 600 x 600 feet in maximum dimensions.

Like the probable apexes at Nevada Consolidated pit and the Ruth mine, the three major ore porphyry kidneys (Morris-Brooks, Old Glory, and Veteran) have each yielded commercial disseminated copper orebodies, and have had associated with them commercial copper ore in the immediately adjacent limestone. The proportion of porphyry and limestone ore vary with the respective areas, from minor porphyry and predominant limestone ore at the Old Glory to minor limestone and predominant porphyry ore at the

Morris-Brooks and Veteran. But in all cases commercial ore was present in both the ore porphyry kidney and the adjacent limestone.

The record of these ore porphyry kidneys as localizers of ore therefore is 100%.#

The only areas now known and regarded favorable for occurence of further ore porphyry kidneys are the Munroe country and the ground lying between Nevada Consolidated pit and the Morris-Brooks; - areas which likewise are favorable for possible apex structures.

#The probable kidney of peanut porphyry lying between Weary Flat and the Taylor mine has not been productive, and only small, spotty copper ore occurs in the shale and limestone at its outer edge at the Taylor mine. This is consistent with the general lack of ore in the peanut porphyry, regardless of structure.

3. Horizontal "Bulges":

Where the thicker portions of the ore porphyry kidneys make a horizontal swell or "Bulge" out into the enclosing sediments at the Veteral and Old Glory mines, a greater concentration of primary copper sulphides occurs than elsewhere. This is true also at the Ruth mine, where the porphyry of the supposed apex bulges from the main porphyry mass southward toward Ruth Gulch, and carries the major part of the Ruth porphyry ore within that bulge.

Structurally these horizontal bulges do not differ greatly from the apexes, except that they usually are smaller, and lie in a horizontal, rather than a vertical, plane. Their record for ore, both in the ore porphyry at Ely and in the ore-bearing intrusives of other disseminated copper districts, is such as to justify their thorough exploration wherever found in well mineralized areas.

4. Jasperoid Roof Pendants:

At several places within the porphyry occur isolated remnants of limestone, sandstone, and shale, ranging from 50 to several hundred feet in diameter, and in some cases projecting several hundred feet down into the porphyry. They resemble somewhat the short, stubby stalcatites that frequently project downward from the roofs of limestone caves. They represent the irregular, downward projections of formerly overlying sediments that have been eroded. "Roof Pendants" is the name commonly applied to these remnants.

At the Veteran mine the caved area shows jasperoid masses marooned at the surface in the kidney of ore porphyry; and Spencer noter that similar jasperoid occurs locally, but in no sense continuously, above the porphyry ore at several hundred feet greater depth. There seems little reason to doubt that the jasperoid from the surface downward to the ore is continuous as roof pendants. Irrespective of whether or not one regards them as a cause of ore deposition, the jasperoid roof pendants and the porphyry ore are clearly associated at the Veteran.

Within the porphyry mass of Old Glory Hill a greater concentration of copper mineralization occurs in several instances near the jasperoid roof pendants than elsewhere in the nearby porphyry. The same condition holds for the roof pendant in the porphyry at the Beehive shaft. Ore in commercial amounts has not been found concentrated about the rood pendants at these latter places; but the combined evidence of the Veteran, Old Glory and Beehive occurences suggests a tendency of the ore solutions to deposit in the porphyry near the roof pendants.

The finding of these roof pendants in the ore porphyry would be regarded, however, merely as a favorable condition, near

which other stronger ore localizing agencies would have to exist before commercial ore could be confidently expected.

5. Fracturing:

Without exception the porphyry orebodies of the district, wherever exposed at the surface or in underground workings, occur in well fractured portions of the porphyry masses. Where the porphyry, however, is not exposed, and its presence is disclosed only by drilling, the other ore guides enumerated above will be more likely to reveal themselves than will the fracturing, and will serve as more effective guides in searching for porphyry orebodies.

But in underground exploration the encountering of a strongly fractured area in the ore porphyry may be regarded as a generally favorable condition, which justifies search for other more specific, short range guides.

B. Expression of Mineralization Above the Ore

1. Sericite "Shells":

The "shells", or envelopes, of sericite, mentioned on page i, surround the disseminated porphyry ore of this district as they do in numerous other disseminated porphyry copper camps. But here the exposures of ore porphyry are more limited in size than is usual, and the sericite in most cases is co-extensive with exposures of the ore porphyry. The sericite therefore does not constitute an ore guide independently of the ore porphyry itself.

Its chief application in this district probably would be in a negative sense; that is, the finding of a moderately large mass of ore porphyry that is not sericitized, would leave little hope for commercial ore there.

2. Leached Outcrops:

When sulphides, such as pyrite, chalcopyrite, or chalcocite are leached, they generally leave specific limonite products at the point of sulphide oxidation to disclose their former presence. The leached products, or limonites, derived from pyrite are distinct in most cases from those derived from chalcopyrite; and those from chalcopyrite are in turn usually distinct from the ones derived from chalcocite or other sulphide. The distinctions are especially well defined in a gangue of moderately slow neutralizing power, such as the monzonite of this district.

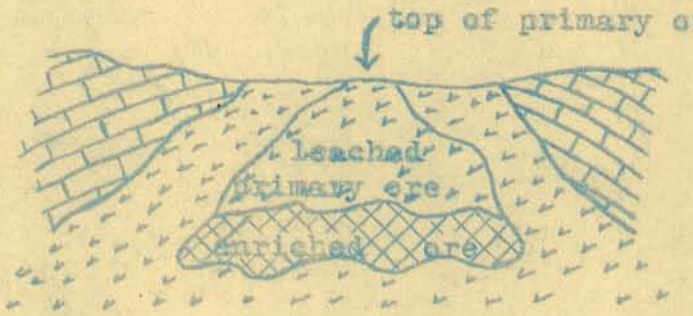
The present geologic force at the mine is familiar with the distinctions between the various limonite products of this district; and those products therefore are not discribed here.

Since most of the porphyry ore close to the surface has been found and delimited, large scale application of the leached

outcrops data in this district is no longer possible. In some of the less thoroughly prospected porphyry areas, however, as along Beehive Gulch, the leached outcrops information may serve to direct remaining exploration to the most favorable places.

A point to note is that in this district there has been less erosion below the top of the original primary ore than in such districts as Bingham, Bisbee, Ray, Tyrone, Morenci, or Chino. It is clear from the evidence of the leached outcrops that in certain places, as at the Morris-Brooks and the Ruth mine, the present surface coincides closely with the tops of the original primary copper bodies, and leaching of copper sulphides never has occurred through a greater distance than a few hundred feet above present known chalcocite orebodies.

The condition is illustrated in the sketch below:



Generalized sketch section, showing relation of present surface to such porphyry orebodies as the Morris-Brooks and the Ruth.

A good chance therefore exists that the ore may "spread" beneath certain of the smaller leached outcrop areas exposed at the surface, or that blind tops may be found which do not reach the present surface at all. While this latter feature is a possibility, it is rather a remote one, and blind prospecting is not likely to prove profitable. In the absence of leached outcrops, structural

features, such as the horizontal "bulges" in the ore porphyry, usually will determine the portions of a porphyry mass most favorable to explore for orebodies which do not or did not at one time reach the present surface.

There exists one other possibility of applying the leached outcrops data in the porphyry; namely, in exploration conducted from underground workings. Several years ago Boswell and the writer observed at Tyrone the evidence of thoroughly leached chalcocite ore of commercial grade on the 500 and 600 levels in one of the porphyry mines. This leached area lay in a strongly fractured zone adjacent to, and for the most part below the base of, a secondary chalcocite orebody containing several million tons of profitable ore. It was clear from the character of the limonites that this material represented chalcocite ore that had been leached from the 500 and 600 levels, even though it occurred lower than the bottom of the adjacent known chalcocite orebody. Churn drilling conducted from the 600 level in this leached material found near the 800 level a separate chalcocite orebody that importantly augmented the ore reserves of the mine.

There is little present liklihood that such a condition will be repeated in this district. But it is well to examine carefully the limonites and other evidences of leaching underground to ascertain whether the leached material represents a product belonging above, co-extensively with, or beneath the ore. The respective limonite products occurring above and below oxidized copper orebodies usually have entirely different and clearly distinguishable physical features that serve to place their position with respect to the ore. Descriptions of certain limonite products that frequently occur beneath oxidized copper ore are given on pages

GUIDES WITHIN THE LIMESTONE

The term "limestone" as used above, embraces all sediments of the district, specifically including the sandstone and shale. The sandstone and shale, however, carry only small and spotty ore, and even this occurs only where conditions for the localization of ore are especially favorable. At this time it does not seem that either the sandstone or shale need be seriously considered as ore carriers except insofar as they contain local horizons of limestone.

A more detailed description of particular horizons known to carry ore is given below under "Favorable Limestone Horizons".

A. Structural Features

1. Fracturing:

Just as the known porphyry copper ore of the district occurs in well fractured portions of the porphyry, so does the known limestone copper ore occur in well fractured portions of the limestone.

The outstanding major fracture zone of the district that has served to localize orebodies is the Sandstone fault zone already mentioned.

Along this fault zone occur various large fault blocks, on both sides of the central line of dislocation; and each of the major fault blocks thus far studied has its individual locus of maximum fracturing which localizes the ore. Thus in the Veteran block, intrusion of the porphyry kidney coincides with the most highly fractured portion of the block, and here occurs both the porphyry and the limestone ore in an intricately criss-cross faulted area. In the Richards mine the oxidized orebody of the 600 and 700 levels occurs in what, from a limited study of the ground, seems to be an

inverted, irregular cone or "funnel" of fracturing which contains numerous faults of small displacement. At the Ruth mine occurs a complicated system of both flat and steep faults which throw Chainman shale, lower Ely limestone, and Rib Hill sandstone discordantly together. And the most complexly faulted and most highly fractured portion of the area coincides with intrusion of the porphyry and deposition of both the porphyry and the limestone ore. (See Plate 3)

Basil Prescott has presented conclusive evidence that some of the large lead-silver and lead-zinc orebodies of Mexico were deposited in the limestone independently of faulting and fracturing. He shows that in some cases the orebodies cut directly across faults and fracture zones without increase in diameter of the ore and without change in metal content or value. The writer has seen two moderately small lead-zone deposits in the Black Range of New Mexico where this condition obtains; and one near San Javier, in the Yaqui River country of Sonora. And has observed a small body of primary chalcocite in the limestone of the Cole mine at Bisbee that shown no recognized relation to fissuring or fracturing.

On the other hand, at Eureka (Nevada), at the Ophir mine and at Park City (Utah), in the lead deposits near Milford (Utah), and at numerous other places, the lead-silver and lead-zone ore of the limestone is clearly localized in fractured areas or along well defined mineral fissures.

But irrespective of the evidence in the cases cited above, the writer knows of no limestone <u>copper</u> district in Western North America where the primary copper is wholly or predominantly chalcopyrite - as it is at Ely - in which ore deposition was not closely controlled by fracturing. And it is worth noting that wherever sulphide orebodies have been reported deposited independent of fissuring and fracturing, the sulphides are those generally re-

garded as having been deposited under relatively low temperature conditions, rather than under moderately high temperature conditions, as is the case at Ely where chalcopyrite, pyrite, pyrrhotite, magnetite, and garnet are in many places intergrown.

In any event, the evidence is that in this district all known copper orebodies are closely associated with well fractured rock.

The major fracture zones of the district, and the individual fractured areas, are many times larger than the ore, and in some cases, as with the north portion of the Keystone fault zone, are probably entirely barren of mineralization. Although the copper ore of the district is intimately related to fracturing, the fractured areas therefore must be regarded as long range guides only, within which search must be conducted for other more specific, short range guides that lead directly to the ore.

2. Jasperoid Zone:

The jasperoid zone consists chiefly of a brownish-yellow, iron-stained silicification of the limestone, sandstone, shale, and locally of the porphyry. It coincides in a general way with the Sandstone fault zone, but is more irregular and locally extends out into the fractured limestone independently of that zone. It manifestly represents an overflow of the silica, iron, and other minerals which accompanied the ore deposition, and for that reason the jasperoid area as a whole shows closer relation to the copper ore of the district than does the fracturing of the district as a whole. The jasperoid, however, is so much more extensive than the ore, that it serves only as a long range guide. Locally it contains certain features, such as thorough brecciation and re-silicification of the jasperoid, presence of primary hematite, and oxidized residuals of the copper minerals, which point more specifically to possible ore

beneath. These are discussed below as separate ore guides.

Exploration of the jasperoid beneath the surface is too limited and too irregular to permit safe generalizations regarding its habits of ore localization. The Richards sulphide body suggests that the inner contact of the jasperoid against the porphyry may be an ore locus. This is substantiated, in a measure, by the fact that the Veteran and Old Glory limestone ore occured at a similar contact. But at these places, the porphyry ore and limestone ore constituted continuous orebodies, so the comparison is not strictly analagous. The occurrence, however, of these three orebodies in the limestone at the inner contact of the jasperoid against the porphyry - even though two were continuous with the porphyry ore - points to the inner contact as a probable ore localizer.

The outer contact of the jasperoid with the surrounding unaltered limestone seems likely to prove a specific ore locus, since both the Richards oxidized ore on the south side of the jasperoid zone, and important bodies of the Alpha ore in the Bonanza fracture zone on the north side of the jasperoid, occur along or adjacent to that contact. The ground lying within 200 to 300 feet on both sides of such contact of an alteration zone with unaltered limestone has proved an important locus for both primary and secondary ore in various limestone copper districts; and present limited evidence points to a probable repetition at Ely. It is evident from the Alpha maps that little exploration has been conducted in the unaltered limestone north of and contiguous to the jasperoid zone. Should this ground prove to be well fractured, it would constitute a favorable area for exploration.

A study of maps and sections of the Alpha mine suggests that orebodies may be present locally within the jasperoid without necessarily coming close to either contact. This suggests a possible

repetition of the "re-entrant" orebodies of the Morenci garnet zone discussed on page iii. But conditions at Ely during actual ore deposition do not at present point to as turbulent a state as existed at Morenci; and orebodies well within the jasperoid probably will prove to have been localized by individual strong fractured areas. Until the Alpha lower levels become accessible so that the ore occurrences may be studied as a unit, no firm opinion regarding this point is in order.

The jasperoid zone is one of the major structural features of the district and has been explored only to a limited extent. More or less blind churn drilling has been done along it locally, but it has received comparatively little exploration by the ordinary underground methods, which are the ones most likely to yield results in that type of ground.

Although the jasperoid zone reveals a probable ore locus at or near its outer contact on both the north and south sides, and may reveal other loci at the inner contact or even well within the jasperoid itself, promiscuous exploration of those contacts would not be attempted. Careful working out of the Alpha geology when the lower levels become accessible is almost certain to show that the ore along the contacts occurs in particular limestone horizons or in particular highly fractured sections of ground. And the use of specific, short range ore guides is advisable at all times when planning exploration in so comprehensive and vague an ore locus as the jasperoid zone.

3. Ore Trends Within the Porphyry:

A guide that may prove useful in selecting areas within the jasperoid zone for prospecting, is the trend of ore within the porphyry. This seems the more likely, since to a large extent ore is localized in both the porphyry and the limestone by fracturing

within those rocks. In certain limestone districts - notably Bisbee - the porphyry ore-trends point directly to the major ore occurences within the limestone, though they do not necessarily point to them in a straight line. The relationship, as it exists at Bisbee, is discussed below under "Individual Ore Loci".

To date the possibility of using the ore trends in the porphyry as a guide to possible ore in the limestone has not been investigated in the district. A series of closely spaced sections through the Old Glory, Veteran, and Alpha areas, and through the Morris-Brooks and Richards areas, might reveal relationships useful not only for further prospecting there, but conceivably of value for projecting exploration into the Munroe country south of Nevada Consolidated pit.

4. Ore - Localizing Faults:

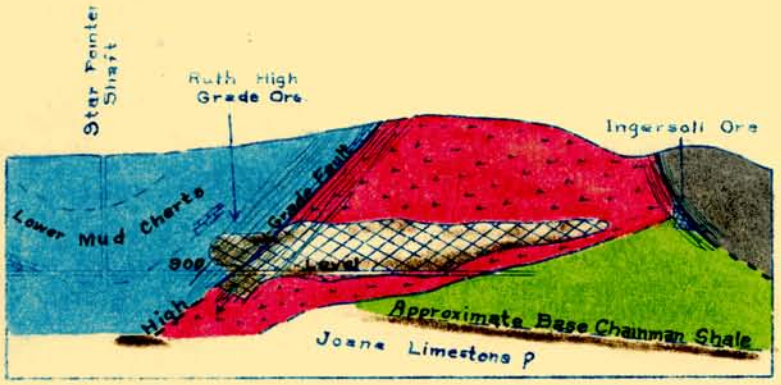
The Master faults have not to date been found ore bearing except insofar as they localize intrusion of the ore porphyry, and insofar as the Sandstone fault zone, as a broad belt of fracturing, serves as the major copper locus of the district.

But certain of the subsidiary faults carry ore. The high grade secondary chalcocite of the Ruth mine is localized along the Ruth High Grade fault which brings lower Ely limestone against the west side of the Ruth ore porphyry mass. And this fault likewise localized the primary ore at the same place, since a marked diminution of primary mineralization outward from the fault into the limestone is evident. The fault itself carries only a small part of the ore; but it is the nucleus of a broad zone of thoroughly fractured limestone and porphyry on the west slope of the Ruth porphyry mass, within which especially rich ore is localized.

The lower grade chalcocite ore of the Ingersoll mine is

Plate III.

GENERAL SECTION, looking NORTH, through RUTH and INGERSOLL MINES showing RELATION of ORE to LARGER STRUCTURAL FEATURES.



Chainman Shale | Ely Limestone | Rib Hill Sandstone | Ore Porphyry | Ore | Fault | Strong Fissuring and Fracturing

0 500 1000
Scale in Feet.

Position of ore and porphyry sketched by H.T. Marshall.
Section not accurate as to detail.

Consolidated Coppermines Corporation, Kimberly, Nevada
Geological Department November 1928
Drawn by: E.A.R. Checked: R.B. No. Z 9.

localized by a corresponding fault which throws Rib Hill sandstone against the east side of the Ruth ore porphyry mass.

The high grade Alpha oxidized copper orebodies of the Bonanza zone are localized in part along a fault which occurs within the jasperoid near its north contact with the unaltered limestone. This fault is not at present accesible for examination, but its position is shown in the maps and sections of Probert's report. The fault, projected from the mine workings to the surface, does not coincide with the position of the Sandstone Master fault for this area, but lies roughly parallel to it between that fault and the Alpha fault farther to the south. Like the Ruth High Grade fault, it forms the nucleus of the belt of fracturing, 400 feet wide, which constitutes the Bonanza ore zone within the larger Sandstone Fault zone.

The three faults above discussed are all local structures occurring within the larger Sandstone fault zone. They constitute specific short range ore guides within that zone.

The Pilot Knob fault, which intersects the Sandstone fault zone between the Veteran and Alpha mines, and thence runs easterly through Pilot Knob and the north portion of Weary Flat, may be regarded in a large way as an ore localizing fault. Ore porphyry is localized along it on the Napoleon, Veteran, and Hearst claims, and the north side of the Weary Flat peanut porphyry follows it rather closely for a distance of 800 feet on the Sacramento and Gold Bug Claims. Although only small pockets of oxidized copper orebodies at the surface have been found directly on the fault, the Pilot Knob and the untested copper showings on the Gold Bug claim lie immediately adjacent to it. And the Veteran orebody occurs in the angle of shattered footwall limestone immediately back of the

intersection of the Pilot Knob and Sandstone faults.

But nothing in the surface showings along the Pilot Knob fault points to it as a localizer of ore comparable to the Sandstone fault zone. Its present promise is at best for only moderately small orebodies.

It is one of the ironies of copper mineralization in limestone that faults which occur in broadly shattered areas are themselves less likely to carry ore than is the shattered rock 50 to 100 feet on either side. This is particularly true as regards occurrence of the primary ore. The reasons for it are not well understood, but the fact itself is clearly demonstrated in various limestone copper districts. Even though specific ore localizing faults are found, it therefore usually becomes necessary to run systematic crosscuts for 100 feet, or even more, out into the limestone on one and often on both sides of the fault before the area may be considered tested. Such crosscutting would of course be done to intersect first the known favorable limestone horizons.

5. Flat Faults:

The faults thus far referred to are all relatively steeply dipping ones; that is, faults which along most of their course dip between 45 and 90 degrees.

In addition to them there are numerous flat faults, whose dip is less than 45 degrees, and in some instances does not exceed 10 or 15 degrees. For the most part they constitute the under side of thin slices of sandstone or other rock, not exceeding several hundred feet in thickness, that were broken off and thrown out of position during the period of deformation, and which now lie as a thin cover over the more solid and persistent blocks of limestone

and other sediments in depth.

Such thin slices of sandstone or shale are known to overlie portions of the Ruth-Ingersoll, Emma-Nevada, Richards, Morris-Brooks, and Alpha mines, and to occur elsewhere in more poorly mineralized areas, as in the vicinity of the Cliff claim. (See Section BB, Plate 2.) In areal extent they range from masses a few hundred feet in diameter to bodies fully ½ x 1 mile in maximum dimensions. Since they give an erroneous conception of the rocks to be expected at several hundred feet greater depth, they are not in a true sense guides to ore, but rather a serious deterrent to the finding of it.

Not only do these thin slices of sandstone or other extraneous rocks give a false impression, from the surface, of the rocks to be expected at greater depth, but in a number of instances the mineralization evidences above the ore, such as occurrences of the silica breccia, seem to have followed the under side of those flat masses for distances of at least several hundred feet, and now occur at the surface at points which do not at all correspond to the mineralized areas in depth to which they presumably are related.

The more vigorously mineralized limestone copper districts frequently exhibit this phenomenon of flat faulting, but the writer knows of no district in which it is so extensively developed as at Ely. It is one of the reasons why the detailed working out of the specific relation of surface evidences of mineralization to the ore beneath is likely to be a slow process, with frequent "misfires" in the direction of exploration during the early stages; a reason why the churn drilling results in the limestone areas furnish an inadequate record of the geology of the areas thus explored; and a reason why a greater amount than usual of ordinary underground development

in the limestone areas is needed in this district before exploration in such areas may be effectively planned.

There are two features of an encouraging nature: (1) Such evidence as is at present procurable, suggests strongly that the flat faulting is closely related to the horizon of the present surface, even though the faulting took place a long time ago; and that once the structure and position of the beds have been determined beneath these known flat faults, that structure probably can be depended upon at greater depths. This assumption will have to be checked against the evidence in the Alpha workings below the 1000 level before it may be accepted with full assurance; but available information points to much less disturbance in depth than exists near the present surface. (2) The areal extent, and the approximate thickness, of these slices of sandstone or other extraneous rocks have been for the most part determined in the work carried on during the past summer; and determination of the structure and beds lying beneath has likewise been accomplished in the Ruth, Emma-Nevada, Richards, and Morris-Brooks mines, and in the Alpha mine down to and including the 1000 level. That does not mean that all will be "easy sailing" from now on; but it does aid greatly the effective planning of further prospecting in any of those areas.

For the Munroe country south of Nevada Consolidated pit, less assurance is felt that beneath the large overturned block of sediments blind faults may not come in as disturbing factors.

The presence of so excessive an amount of flat faulting imposes a handicap for this district beyond that ordinarily attending exploration of limestone areas; but a handicap that will have to be accepted unless the exploration of a large section of ground promising for copper ore is to be abandoned.

6. Mineral Fissures:

Mineral fissures, as commonly considered, are fissures or cracks in a rock along which ore solutions have traveled, but along which little or no displacement of the rock has occurred. They are thus distinct from faults, which imply a noticeable displacement of the rock on one side with respect to that on the other. This is the principal distinction between them and the ore-localizing faults already discussed.

Specific mineral fissures in the proved copper bearing portions of the Ely district are not known.

But in the Munroe area, the small bodies of high grade lead-silver ore at the Carbonate and Munroe shafts occur directly upon mineral fissures. Further prospecting beneath the flat-lying block of Upper Massive Limestone - between the Munroe shaft and the Munroe fault to the south - may conceivably reveal further mineral fissures of this sort.

In the Lane City area, and in the Matilda country, the small lead-silver orebodies likewise are closely associated with specific mineral fissures, or with faults of small displacement.

These areas, with the possible exception of the Munroe country, are less highly fractured than the known copper bearing portions of the Sandstone fault zone.

A rather close relation therefore seems to exist in the less highly fractured portions of the district between mineral fissures and the lead-silver deposits. But the relationship has not been demonstrated to exist in the case of the copper deposits, which occur in the more highly fractured portions of the district.

7. Embayments in the Porphyry:

Well defined embayments of limestone into the ore porphyry masses are known at only a few places in the district. Several limestone bodies that form apparent embayments on the surface map are merely crusts of limestone lying on top of the porphyry.

One well defined embayment is that between the Ruth ore porphyry and the Star Pointer shaft. It is approximately 1000 feet across, and its limestone is highly shattered and altered. It contains numerous faults of small displacement, and these faults show no regular trend. Its eastern portion is the most highly shattered, and in this portion, which contains the Ruth High Grade fault, lies the Ruth high grade chalcocite orebody. (See Plate 3.)

Another embayment less obvious on the surface map but clearly defined when viewed from the Wedge Shaft, is the large mass of lower Ely limestone underlain in part by Chainman shale, that projects into the steam shovel workings of the Liberty pit (west portion of Nevada Consolidated pit) on the Ora and Josie Claims. The shattered limestone here is intruded by many small tongues of the encircling porphyry mass, and this limestone carries some of the richest known primary copper ore of the district. Because the limestone ore here constitutes part of the Liberty pit operations it is not usually thought of as an embayment of limestone in the porphyry. But it is one of the best defined embayments in the district.

An embayment occurs in the ore porphyry at Whiskey Gap in the Morris-Old Glory area, but has yielded only a small ore tonnage.

Another, consisting of Pilot shale and Nevada limestone, in the peanut porphyry at the Dewey shaft immediately south of the Taylor shaft, carries most of the known Taylor ore.

The reasons for ore favorability of limestone embayments

are not entirely obvious. But the fact that the limestone usually is shattered, and that it commonly is exposed to the porphyry over a large surface area, and is often intruded by tongues of the porphyry, explains in part its hospitality for ore. In any event, limestone in such embayments when poorly fractured is not usually receptive to ore; while, on the other hand, the well fractured limestone is usually best mineralized when the embayment exists in both horizontal and vertical projection, so that a large surface area of the porphyry comes in contact with a large surface of the limestone.

Independently of other guides, limestone embayments in the porphyry are not likely to be productive. In association with other specific guides that point to ore, they constitute especially favorable places for prospecting.

8. Dikes and Sills:

Distinct dikes and sills of the ore porphyry are rare in the district. Spencer and Probert mention some occurring in the Alpha and Old Glory workings, but the ground involved is not accessible.

Most of the known dikes are irregular, small tongues of porphyry that extend from the larger porphyry bodies a few hundred feet up into the overlying fractured sediments. Such porphyry tongues are present in the limestone embayments at the Ruth mine, and the primary mineralization is concentrated near them to a marked degree. They are present also in the large limestone embayment of the Ora and Josie claims. Similar tongues or dikes are present in the Chainman shale of the Emma-Nevada 6470 level, with local concentration of copper mineralization near them.

At the Benson tunnel in the Munroe country occurs a small,

flat-pitching sill of the ore porphyry which shows pyrite mineralization; but no ore has been found along either its upper or lower contact.

Evidence from the various limestone copper districts with which the writer is familiar is that ore is more likely to be associated with dikes, sills, and tongues of the ore porphyry where they possess numerous curves and irregularities, than where they cut straight across the country rock. One reason probably is that the curves and irregularities usually occur where the intruded rock is highly shattered, and such ground would be receptive to ore even without the porphyry. Another reason may be that the ore solutions are sometimes trapped within such irregularities of the porphyry. But t also seems to be established by the evidence from many districts that ore solutions tend to follow irregular porphyry tongues and dikes up into the intruded rocks, and for ore to be precipitated especially near the tops or upper halves of such tongues.

From the limited evidence available, it seems that in a general way these conditions will apply in the Ely district. But more of such porphyry structures will have to be available for examination before generalizations may be safely drawn.

9. Basin Structures:

Basin structures, or structures in which the sediments dip inward and downward from opposite sides, often localize orebodies. The entire basin is rarely ore bearing, but mineralization frequently shows a decided concentration in some portion of the structure.

Such a basin is formed by the limestones surrounding the ore porphyry mass at Nevada Consolidated pit (See Section CC, Plate 2)

Another basin exists in the limestone embayment at the

Ruth mine (see plate 3), and the high grade chalcocite is concentrated in its most highly fractured portion, near the Ruth porphyry ore.

A poorly defined basin in which the sediments dip in a low syncline toward each other exists at the Emma-Nevada in the Chainman shale on the 6470 level. Into this basin are intruded the porphyry tongues, already discussed, with which is associated much of the low grade copper mineralization of the shale. Exploration is not adequate to show whether the basin structure persists into the overlying Ely limestone.

The basin structures here referred to are the ones that existed eitherbefore, or were formed at the time of primary mineralization. They should not be confused with basins produced by Oxidation Collapse, discussed on page

These basin structures have been shown in some districts - as at Bisbee, and at Mt. Katmai in Alaska - to be the result of retreat of the underlying porphyry, with consequent dropping down, or collapse, of the sediments into the vacated area. In other cases they are formed by irregular and local rising of the porphyry mass around the area involved, with consequent turning up or doming of the sediments around the outer edges of that area. A very imperfect basin usually is formed in such case, and this is presumably the type to which the Emma-Nevada example belongs. In still other cases, as at Nevada Consolidated pit, faulting may be largely or wholly responsible for the existence of the basin.

But the final result, in any of these cases, is usually the breaking up or fracturing of the sediments within the basin, and often the intrusion into them of irregular tongues of porphyry.

It is these latter conditions, rather than the shape of

the basin itself that presumably localize the ore. The basin merely affords a structure favorable to the search for locally shattered and mineralized areas.

10. Garnet and the Marble Line:

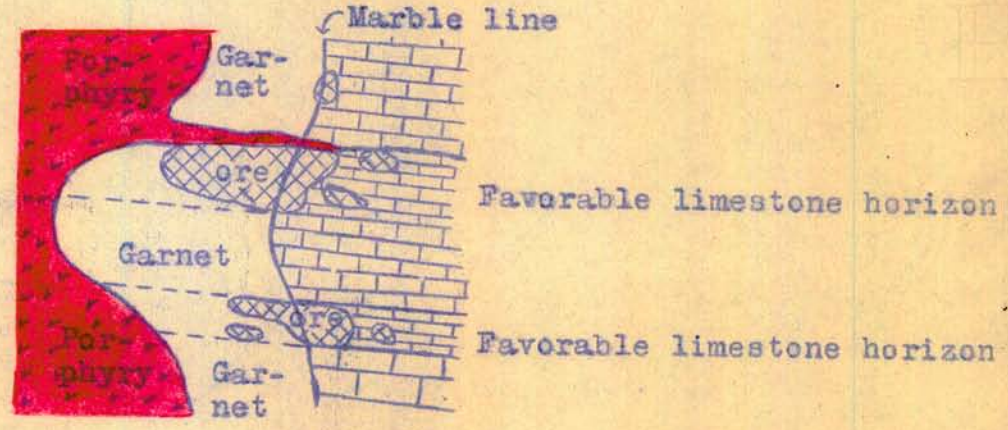
Reference was made in the Preliminary Statement, page ii, to the localization of ore along the marble line of garnet areas in certain limestone copper districts.

Garnet is of widespread occurrence in this district, constituting in places an estimated 5% to 10% of the jasperoid areas. But it is imperfectly developed. Instead of occurring as large bodies of massive garnet, it grades more or less imperceptibly into and out of the usual iron-stained silica of the jasperoid zone. Ordinarily the jasperoid must be carefully examined to ascertain whether or not garnet is present. Some of the best developed moderately large areas of garnet occur on the north and northeast slopes of Old Glory Hill, on the 6660 level of the Emma-Nevada, and on the Ora and Josie claims of the Nevada Consolidated pit. At Old Glory, ore is known to occur in association with the garnet, but the workings are not accessible, and the maps furnish little pertinent information as to the position of ore with respect to the garnet. They do not show whether the ore is directly associated with garnet or with the ordinary silica jasperoid, or whether it occurs at the outer edges, under side, or within the garnet itself. At the Emma-Nevada on the 6660 level a long crosscut within the garnet has failed to yield ore. The garnet here lies within the lower part of a limestone basin that is underlain at probably shallow depths by peanut and ore porphyry; and the marble line has not been encountered. On the Ora and Josie claims ore is present within the garnet mass but so much rock has been excavated that correlation of present ore with

a possible marble line, if one ever existed, is not possible.

There consequently is insufficient evidence at this time to determine just what relation, if any, the poorly developed garnet of this district bears to ore.

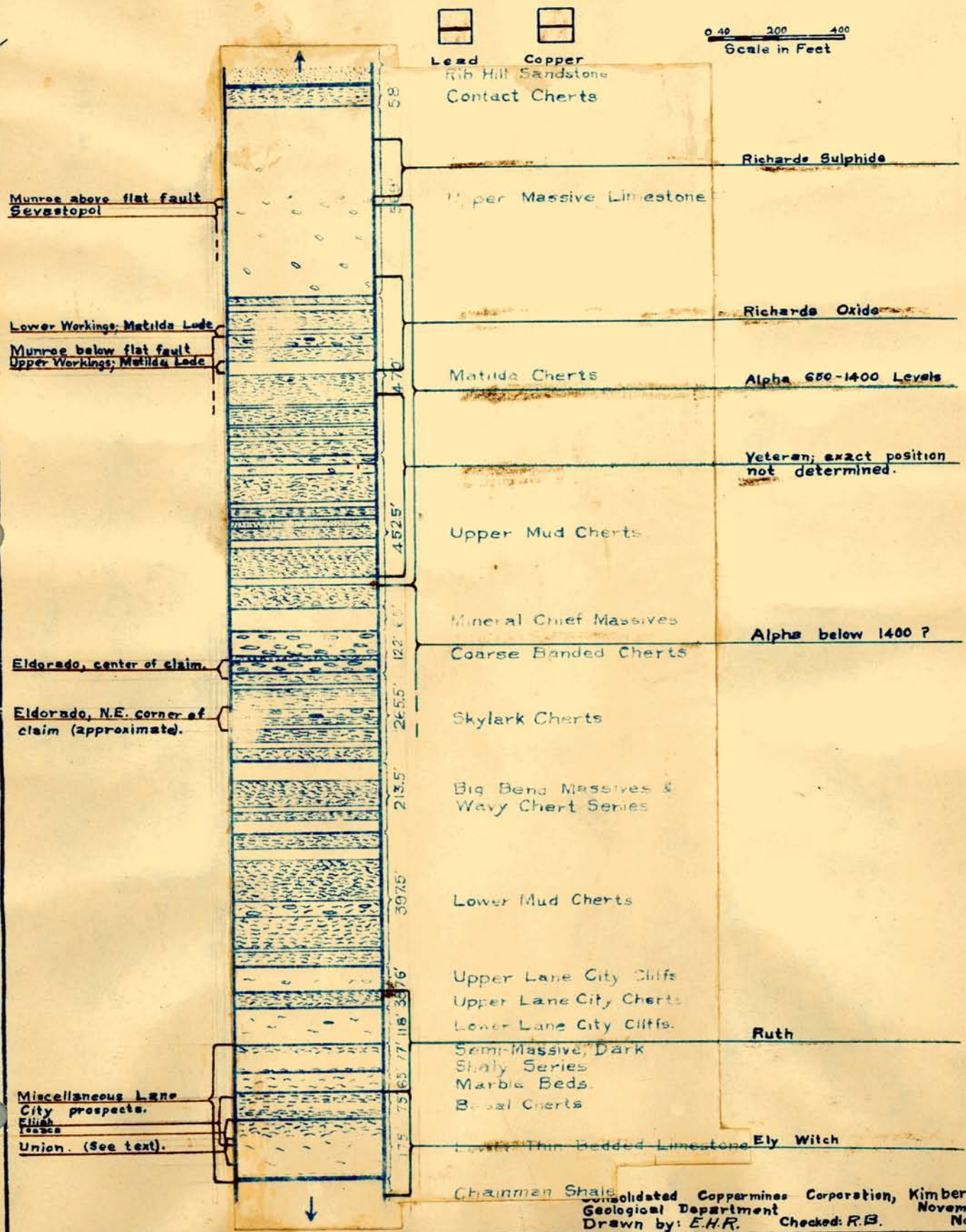
Evidence previously presented shows that the outer contact of the jasperoid zone with the unaltered limestone probably is a major ore locus in this district. On that basis, the marble line of the garnet areas ought to be a locus, since the garnet constitutes a part of the jasperoid zone. But even should this prove to be the case, it does not follow that all parts of the marble line would be productive. At Christmas, where the marble line constitutes the one outstanding ore locus, it is not in itself necessarily ore bearing. Ore is most likely to occur on the marble line within an embayment in the porphyry, though even that rule is not invariable. With that combination of conditions, the ore is further confined chiefly to certain favorable limestone horizons. And within such horizons the largest and richest ore often is found beneath thin sills of the fine grained porphyry. The condition is illustrated in the sketch below:



Generalized sketch section, showing relation of ore to the marble line, and to other structural features, at Christmas, Arizona.

Plate IV

GEOLOGIC COLUMN through the ELY LIMESTONE showing HORIZONS FAVORABLE to KNOWN COPPER and LEAD ORE.



Consolidated Coppermines Corporation, Kimberly, Nevada
Geological Department November 1928
Drawn by: E.H.R. Checked: R.B. No. Z 11

Because of the imperfect development of garnet in the Ely district, much doubt exists that either the garnet areas, or their marble line, will prove especially productive, except insofar as the outer contact of the jasperoid zone in general is productive. But the marble line at least ought not to prove less productive than that outer jasperoid contact; and wherever exposed, it merits careful search for specific, short range ore guides.

II. Favorable Limestone Horizons:

Ore occurs in the sediments of the district as follows:

A. Copper Ore

Richards Sulphide Ore:

Upper half of Upper Massive Limestone. Not all of area accessible for examination. Occupies horizons that lie between 100 and 250 feet below the Contact Cherts.

Richards Oxide Ore:

Occupies horizons which constitute the lower 75 feet of the Upper Massive Limestone and the upper 200 feet of the Matilda Cherts.

Veteran Limestone Ore:

Not accessible for examination. Old records furnish no relevant information. From known position of ore with respect to limestone beds outcropping at surface, the Veteran limestone ore is judged to occupy the horizons constituting the lower 200 feet of the Matilda Cherts and the upper 350 feet of the Upper Mud Cherts. There is no way of determining which portions of these horizons are most productive. No reason for suspecting more than minor faults in Veteran ore block to invalidate above assumption.

Alpha Oxidized Ore:

The Bonanza zone in the Alpha mine is not at present accessible. Limestone beds immediately south of the ore on the 770 and 1000 levels are Matilda and Upper Mud Cherts. Projection of these beds into the ore area shows that the Upper Massive Limestone - Matilda Chert contact should lie centrally

in the ore on the 1200 level. In other words, ore in the Alpha between the 600 and 1400 levels should occur in the horizons which constitute the lower 300 feet of the Upper Massive Limestone, all of the Matilda Cherts, and the upper 300 to 350 feet of the Upper Mud Cherts.

This assumes that no faulting with more than minor displacement occurs between the beds south of the ore on the 770 and 1000 levels and the ore itself. No reason is known at this time for expecting large displacement along the ore-localizing fault of the Bonanza zone, discussed on page 21.

With the beds thus persisting, there remains a stratigraphic thickness of 1750 feet of Ely limestone below the Alpha 1400 level before the Chainman shale would be encountered.

Ruth Limestone Ore:

Occupies lower portion of Lane City Cliffs, and all of the Dark Shaly Series and the Marble Beds. These horizons constitute the limestone lying from 550 to 250 feet above the base of the Ely limestone.

Ely Witch Copper:

Non-commercial low grade pyritic mineralization in Limestone with small lenses of higher grade copper. Occupies Basal Cherts and Lower Thin Bedded Limestone, and extends as very low grade pyritic mineralization a short distance into the Chainman shale. Not accessible. Judged from position of beds at surface and from material on dump brought up from 300 foot shaft.

Old Glory Limestone Ore:

Not accessible except locally at outer edges of ore area. From position of ore as revealed by maps, and from knowledge of surface rocks, the Old Glory limestone ore is judged to occur within the upper 300 feet of the Joana limestone.

Pilot Knob Copper:

Consists of small pockets of oxidized copper concentrated along a fault between shale and magnetite. The magnetite probably replaced Joana limestone. Copper occurs at place corresponding to horizon approximately 200 feet below top of Joana limestone.

Taylor Copper:

Occurs at Pilot shale - Nevada limestone contact, chiefly in upper 10 to 20 feet of the Nevada Limestone. Ore in the fissure zone immediately at and north of the Taylor shaft occurs in a limy layer

of the Pilot shale approximately 100 feet above the Nevada Limestone.

Mitchell Copper:

Spotty oxidized copper bodies occur in horizons believed to constitute the area 75 to 500 feet below top of the Nevada Limestone.

Ingersoll Mine:

The secondary chalcocite ore in the Rib Hill sandstone and Chainman shale of the Ingersoll fault zone is not credited with a specific horizon, since primary mineralization here is very low grade, and the copper now constituting the ore may have been derived largely from the porphyry, or from overlying sediments since eroded. (See Plate 3.)

B. Lead Ore

Sevastopol Claim:

Several small lead bodies occur just below middle of the Upper Massive Limestone, and persist erratically along different fussures nearly to its base.

Matilda Claim:

Ore of lower workings along Matilda lode, and along fissure at shaft in northeast corner of overlapping Standard claim, occupies horizon 75 to 100 feet below top of Matilda Cherts. Ore of upper workings along Matilda lode occupies horizon 175 to 200 feet below top of Matilda Cherts.

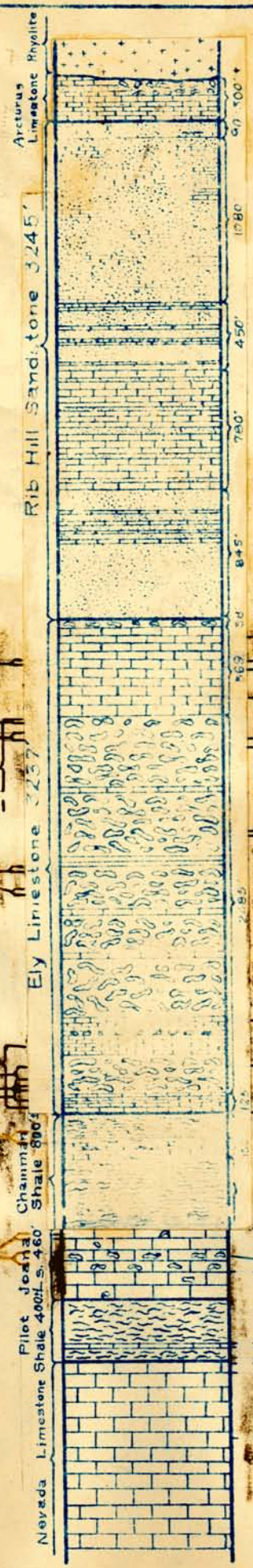
Munroe and Carbonate Area:

Small pockets of lead ore along fissures in the flat fault block overlying Matilda Cherts occur centrally within the Upper Massive Limestone. This is judged from fact that the limestone of this block is the upper central half of the Upper Massive Limestone, and the Munroe and Carbonate ore of that block lies near the base of the block. Position corresponds closely with principal lead occurrences on the Sevastopol claim.

Lead ore discovered to date below the flat fault block occurs distributed through the horizons lying 100 to 200 feet below top of Matilda Cherts.

Plate V

GEOLOGIC COLUMN from ARCTURUS to NEVADA LIMESTONE showing HORIZONS FAVORABLE to KNOWN COPPER, LEAD, and GOLD ORE.



* See text.

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Geological Department November 1928.
Drawn by:- E.H.R. Checked: R.B. No. Z 10.

Eldorado Claim:

Principal lead showing in northeast corner of claim occurs in the Skylark Cherts. Exact position not yet determined. Showing in center of claim occurs in lower half of Coarse Banded Cherts.

Elijah Claim:

Lead ore at the various showings occupies horizon extending from near top of Basal Cherts to a point approximately 50 feet down into the Lower Thin Bedded Limestone.

Isaacs Claim:

Lead showings occur in horizon extending from extreme base of Basal Cherts to point 60 feet down into Lower Thin Bedded Limestone.

Union Claim:

Lead ore occurs in Lower Thin Bedded Limestone. Exact position not determined, but probably 50 to 125 feet above the base.

Miscellaneous Small Lead Bodies near Union Claim:

Various small pockets of lead ore occur erratically distributed from base of the Lower Lane City Cliff down to the Chainman shale.

C. Gold Ore

Saxton Ore:

Detailed examination was not made of the Saxton gold deposit. The shaft collar is probably near the base of the Ely linestone, and encounters ore in the limestone at a depth of 185 feet after having passed through Chainman shale most of the way. The gold-bearing limestone therefore corresponds to the limestone beds which occur in the Chainman shale 150 feet below the base of the Ely limestone.

Chainman and Revenue Ore:

A well mineralized bed, 20 feet thick, occurs from 40 to 60 feet below the Chainman shale. Another more strongly mineralized bed, at least 70 feet thick, comes in a hundred feet lower, or at 160 to 230 feet below the Chainman shale.

The Joana limestone near Lane City is exposed at the surface for a thickness of not exceeding

250 feet, and it is not certain whether the entire formation is only 250 feet thick there (as against 460 feet at Kimberly), or whether faulting has deleted part of the column.

It is to be noted, though, that the 70 foot thickness of Joana limestone which carries gold ore, corresponds closely in distance below the Chainman shale with the Joana limestone near or within which the Pilot Knob copper occurs; and corresponds closely with the portion of the Old Glory Joana limestone which carries much of the Old Glory limestone copper ore.

The above descriptions show that the 3237 foot thickness of Ely limestone has yielded most of the limestone copper ore to date; that the ore is well distributed through the upper and lower portions of the limestone, and may prove, from occurrences not now accessible in the Alpha mine, to be well distributed likewise through the central portion. The evidence, further, suggests that no special preference is shown by the ore for either the massive or cherty horizons; ore deposition seemingly being controlled more by the degree of fracturing, and by general proximity to ore porphyry masses or to the individual "hot centers" of mineralization discussed below.

It is entirely likely that when geologic sections have been made through all principal mine workings, certain narrow horizons - such, for example, as the upper 200 feet of the Matilda Cherts - will be found especially hospitable to ore. But all rock in the Ely limestone is sufficiently homogeneous in composition to make it seem likely that the entire series will prove more or less receptive to ore provided fracturing and other ore localizing agencies are present.

These observations apply with equal force to lead mineralization. For the lead ore found to date, though small in volume, is distributed through the Ely limestone almost as diversely as is

the copper ore.

There is nothing in the record of the Joana limestone to create a prejudice against it as an ore carrier; though its failure in various places to alter the jasperoid where adjacent Ely limestone is thoroughly altered, suggests that it may have proved somewhat less receptive to mineralization than did the Ely limestone.

Nevada limestone thus far has been disappointing. This may be due to the fact that it is not exposed in the principal jasperoid zone, nor in the Sandstone fault zone; or it may be due to natural inhospitality for ore. Exploration to date does not justify an opinion in the matter.

The shales have been prospected sufficiently to show that ore is likely to be found in them only where special conditions, such as the thorough fracturing adjacent to the Ruth ore porphyry mass at the Ingersoll mine, permits exceptionally strong concentration of secondary ore. But the gold occurrence at the Saxton mine, and the small primary and oxidized copper occurrences at the Taylor mine, prove that the limestone layers within the shale may be ore bearing.

The Rib Hill sandstone has yielded no important ore to date, except under the conditions discussed for the shale at the Ingersoll mine. Its limy layers are in many places thoroughly altered to jasperoid, and these layers may prove to be ore bearing under favorable conditions of fracturing. But the fact that the Rib Hill limy layers are in general sandy, reduces somewhat their attractiveness for prospecting. In a large part of the sandstone area south of the Sandstone fault, however, Ely limestone is known to occur only a few hundred feet beneath the surface; and this adds at least one more incentive to prospecting that sandstone area than

would otherwise exist. (See Section BB, Plate 2.)

In using the favorable limestone horizons as a guide to prospecting, one point should not be overlooked: In limestone districts different limestone horizons often show marked differences in favorability for ore at opposite ends of the district, even when all horizons are present at both ends. Under such conditions, the favorable beds for each portion of the district must be ascertained from known ore occurrences, or by experiment. But it usually happens that proved favorable beds at any given place will prove to some extent productive under similar conditions of mineralization anywhere within a mile or two of the place in question. Such evidence as is at hand - as, for example, the localization of lead ore in the upper 200 feet of the Matilda Cherts at such widely separated points as the Matilda prospect and the Munroe country - suggests that this district probably will not show marked differences in ore favorability of given horizons. It is a matter, though, to which attention must be paid in laying out exploration work.

12. Outcrops of the "Far Traveling" Type:

If a few small pockets of oxidized copper ore are excluded, all known copper deposits of the district are either associated intimately with the principal jasperoid zone, or with isolated patches of jasperoid along parallel faults that show irregular copper mineralization along their strikes. The copper deposits are not known to make off at right angles into the limestone for any considerable distance from the faults or from the principal jasperoid area.

On the Gold Bug claim, north of Weary Flat, occur mineralized outcrops of a different type. Here exists a zone of steep

fissuring, 800 feet wide, that makes out into the unaltered limestone directly at right angles to the Pilot Knob fault and at right angles to the trend of the peanut porphyry at that place. Of this 800 foot width, approximately 350 feet is strongly fissured, and the fissures show well defined and persistent silicifications that extend 100 to 150 feet to the north, where they pass under alluvium. The silicifications vary from 1/8 to 1½ inches in thickness, and except at their extreme south end immediately against the peanut porphyry, carry little or no jasperoid. Copper stains are prominent along them locally, and associated with them at several places are small amounts of hematite.

This type of outcrop, with its copper-stained fissure silicifications in marbleized and unaltered limestone, is the type overlying the "far traveling" limestone copper deposits of the Bisbee district; that is, those deposits lying from 1000 to 5000 feet outward from the porphyry stock at Sacramento Hill, and from the alteration halo which immediately surrounds Sacramento Hill on its south, or limestone, side. The orebodies of the Southwest, Shattuck, Cole, Nighthawk, and Briggs mines occur beneath such outcrops at depths of 300 to 1800 feet; and the high grade orestrikes which Calumet and Arizona have been making for the past two years in the Denn-Campbell zone occur beneath similar outcrops.

The principal difference between the Gold Bug surface showings and those overlying the Bisbee orebodies named, is (1) At Bisbee the zones have greater length, and persist along their strikes from one-half to a mile; (2) The outcrops at Bisbee have associated with them conspicuous occurrences of manganese, and somewhat larger amounts of hematite.

The manganese at Bisbee is not an invariable associate

of the ore, and in no sense is it a requisite. Its common presence in the outcrops there results from the fact that by the accident of mineralization it happened to come up at the same time and place as did the copper solutions. Its absence in the Gold Bug showings is therefore in no way unfavorable.

The limited occurrence of hematite, as discussed on page 51, is unfavorable. And most unfavorable of all is the failure of the fissure silicifications to persist an important distance out into the limestone. Alluvium covers up the fissures at from 75 to 150 feet from the porphyry; but they are weaker where local outcrops through the alluvium show them reappearing 150 to 200 feet farther out into the limestone; and they do not reappear at all beyond the alluvium in outcrops 600 to 800 still farther up the hill.

Another dissimilarity is that at Bisbee the fissures and fissure silicifications make out directly from the alteration halo, or from what corresponds to the principal jasperoid zone of this district; while on the Gold Bug claim the fissures make out from the Pilot Knob fault, which is at best of secondary importance as an ore locus; and they make out from the Weary Flat mass of peanut porphyry instead of from the ore porphyry.

A third dissimilarity is that at Bisbee the fissure silicifications occur in the proved ore bearing limestone. On the Gold Bug claim they occur in Nevada limestone, which thus far has not been found to carry more than small spotty pockets of copper ore at the Taylor and Mitchell mines, and which has yet to demonstrate its capacity as an important ore carrier.

It is clear, therefore, that the surface showings on the Gold Bug claim - which if more sustained along their strike would be distinctly favorable at Bisbee and would justify sinking a shaft

and carrying on extensive development - are of limited promise here. They do not at this time justify the sinking of a shaft, though they do justify the putting down of several drill holes to depths of 800 to 1000 feet, so spotted as to intersect the fissure silicifications at those depths.

The presence on the Gold Bug claim of these outcrops of the "far traveling" type, establishes their existence in the district, and suggests that such fissure zones may conceivably extend at right angles out into the limestone from the principal jasperoid zone, beneath some of the flat faulted blocks of sandstone which lies at the surface. The finding of such fissured areas in the limestone beneath the sandstone surface cover near the jasperoid zone would be of much greater signigicance, from an ore standpoint, than is their existence on the Gold Bug claim. But since no such fissured zones show at the surface near the jasperoid zone, their occurrence beneath the thin sandstone fault blocks must be regarded at best as a remote conjectural possibility, rather than a reasonable expectation.

13. Individual Ore Loci:

Although the Sandstone fault zone and the jasperoid zone serve as a general locus for the major copper ore of the district, it is clear from occurrence of known orebodies that the copper ore favors certain portions of those zones.

The more important copper orebodies are associated in a general way with particular areas that carry an abundance of the high temperature minerals, such as garnet, pyrrhotite, and magnetite. The volume of these high temperature minerals has not been observed to have a direct relation to the volume of the ore; nor

do the orebodies necessarily increase in size or number with approach toward the central points of these high temperature areas. But the ground lying within the jasperoid zone and within well fractured portions of that zone, is much more productive within a half mile of these "hot centers" than is the ground lying at a greater distance.

Such "hot centers", or areas containing the larger masses of garnet, pyrrhotite, and magnetite, occur near the Ruth-Ingersoll mine, on the Ora and Josie claims at Nevada Consolidated pit, and on both the northeast (Pilot Knob) and northwest (Veteran slopes of Old Glory Hill. The ore does not make out equally in all directions from those centers; its distribution is governed largely by the degrees and extent of nearby fracturing in the Sandstone fault zone.

While the large ore porphyry mass at Nevada Consolidated pit constitutes a more or less central locus of copper mineralization for the whole district, there exist at least three of these individual ore loci that control more closely the distribution of the copper orebodies within the district. Possibly other loci may be disclosed when the jasperoid zone has been more thoroughly prospected.x

These "hot centers", or individual ore loci, are not peculiar to the Ely district. Numerous limestone copper districts have them, though they have not always been recognized as such. The exploration at Bisbee has revealed 8 of them to date, of which

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x A possible fourth center is suggested by the 75 x 150 foot magnetite body on the Sacramento and Schley claims, between the Taylor kidney and the Weary Flat mass of peanut porphyry, midway between Pilot Knob and the Gold Bug showings. But it seems more likely that this is merely a thin crust of magnetite riding upon the underlying peanut porphyry mass, and represents part of the alteration which produced the large Pilot Knob magnetite body.

3 occur so closely together around the south fringe of Sacramento Hill that ore in that particular area (the alteration halo) is nearly continuous.

Ore in both the porphyry and the limestone in this district is closely related to the "hot centers", being localized chiefly, as already stated, along fractured zones that extend outward from those centers. And by the statement made on page 22 - that ore trends in the porphyry usually point to ore occurrences in the limestone though they do not necessarily point to them in a straight line - was meant that ore trends followed from the porphyry usually lead to the "hot centers", around which, in a broad way, ore in the limestone is localized. The fracturing leading outward from the "hot centers" is seldom evenly distributed in all directions. And this affords one explanation why the orebodies around them are usually irregularly distributed.

But after most of the ore around any one of the individual ore loci has been found and extracted, its relationship to the ore becomes readily apparent. And during the exploration of a limestone copper district the "hot centers" therefore serve in a general wat to point out the areas most promising for copper orebodies, especially in the limestone; even though specific short range guides must be further sought which will lead directly to individual orebodies.

B. Expression of Mineralization Above the Ore

1. Surface Copper Stains:

The Surface map of the district is only partly completed, and in constructing it the emphasis, up to the present, has been placed upon structural features, rather than upon outcrop minerals. It is known, though, from the field work done, that copper stains at the surface are concentrated for the most part within the 5 x 2 mile major copper bearing area previously discussed, and that they are especially prominent along the Sandstone fault zone.

Surface copper stains in limestone districts rarely are useful as short range ore guides. But in numerous districts it has been found that the general area of prominent copper stains at the surface corresponds to the general area of good copper ore; while the general area of isolated and commonly weak copper stains corresponds to the general area of small and spotty copper deposits. Deviations from this rule are to some extent governed by depth to ore beneath the surface; that is, a given ore area 1000 feet below the surface usually shows less prominent surface copper staining than does a similar area 300 feet below.

When the surface map of the district has been completed, it will be desirable to make a special small scale map which emphasizes only surface copper stains and the known ore occurrences. Present opinion is that a close relation will be found to exist between the two. Should this prove to be the case, the map would serve as a useful guide to exploration of the poorly tested and untested limestone areas.

2. Jasperoid

The relation of the jasperoid zone, as a broad struc-

tural feature, to the ore of the district, has been discussed. It has been shown, further, that the principal mineral of the jasperoid is silica, with variable and much smaller amounts of garnet, pyrite, and other associated minerals.

Contact silicates, such as garnet, frequently extend well below the principal ore in limestone copper districts. Uncombined silica, on the other hand - which constitutes most of the jasperoid of this district - usually does not. It is generally coextensive with the ore, or else lies above it; and important ore often extends in well fractured areas to depths of 500 or 600 feet below the lowest of the large silica masses.[x]

Exploration in this district, so far as it can be checked from accessible workings and from maps and records, has not reached the bottom of the jasperoid zone except possibly in isolated instances; and no real basis therefore exists for ascertaining relationship of the base of the zone to ore. But no reason is apparent why the Ely district should prove an exception to the general rule in this respect. And until exploration proves the contrary, it seems reasonable to assume that with other conditions favorable, ore may be expected to persist in the limestone areas at least to the base of the jasperoid zone, and possibly to several hundred feet greater depth.

3. Silica Breccia:

At numerous places the jasperoid shows brecciation of the silicified rock, with re-sillicification of the brecciated particles. It is of two types:(1) A general crackling of the silicified lime-

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[x] Where the silica in copper deposits does extend below the ore, it is usually in the form of bull quartz, rather than the more glassy quartz of the known jasperoid zone in this district.

stone, confined chiefly to the cherty horizons, with thorough subsequent re-silicification of the crackled mass. (2) Brecciation and re-silicification of the jasperoid along fissured areas, 2 inches to 4 feet wide, that cut through to depths of several hundred feet or more from one limestone horizon to another without regard to whether the horizons are cherty or massive.

Good examples of the former type occur at the surface near the Ely Witch shaft and at the east end of the Emma and Elk, and west half of the Manhattan, claims in the Boston-Ely area. This type signifies merely that during formation of the jasperoid zone stresses were set up which cracked the more brittle beds, such as the cherty horizons, and that this crackled material was re-cemented with silica as part of the general silicification of the jasperoid zone.

Good examples of the latter type occur at certain places over the Richards, Alpha, and Veteran ground. This type proves by the strength and persistence of the brecciated fissure zones through successive limestone horizons that more vigorous fracturing occured at or near such places; and these fissured areas therefore are more likely to be connected directly with, and to lead down to, the steeply dipping fractured areas in which much of the ore is known to occur.

This latter type of brecciation and resilicification of limestone areas is called silica breccia.

The record of such limestone districts as Morenci, Hanover, and Bisbee is that the more strongly defined silica breccias, especially those that occur along steep fissured areas, generally lead directly to ore.

In this district they have not yet been correlated with the limestone ore sufficiently to permit broad generalizations.

Pennebaker has found them more favorable to ore where they occur several hundred feet out into the limestone than where they occur close to the edge of the porphyry. In several instances there is the further suggestion that their course has been in part determined by the flat faults overlying certain of the limestone ore areas; and that although they connect directly with the limestone ore the connection is by a devious route, so that exposures at the surface do not necessarily lie directly over the ore at depth.

But the silica breccias are much more abundant over known productive limestone areas than over the known barren areas within the jasperoid zone; and they probably will prove to be one of the more dependable short range guides to the limestone copper ore within that area.

4. Primary Hematite:

At various places within the jasperoid zone are small veinlets and nodules of a compact, granular hematite associated with the silica breccia. In certain limestone copper districts this granular hematite has been followed through the oxidized zone down into the primary zone, and proved to be a primary mineral; and invariably it has been associated with the copper ore. Where extensive in amount, it has served as a dependable short range guide to the ore.

In this district the amounts of granular hematite are so small that by themselves they do not constitute a separate ore guide. But because of their known intimate association with limestone copper ore elsewhere, they probably should be interpreted as adding special favorability here wherever they occur associated with the silica breccia.

5. Manganese:

Several small isolated manganese showings are present in the district, but the only prominent one known occurs south of Nevada Consolidated pit near the west end of the Badger claim. Here the manganese occurs along fissures which likewise carry silicifications, and occurs at the edge of the jasperoid zone where prominent copper stains are present. Exploration consists of surface cuts and an inaccessible shaft, estimated from the dump to be probably 150 feet deep. No real basis therefore exists for interpreting the manganese showings in terms of ore.

The geology of this particular area has not yet been worked out in detail. But in any event, enough other ore guides are present - such as proximity to the ore porphyry, outer edge of the jasperoid zone, and faulting and fracturing - that even should ore be found beneath the area, it relationship to the manganese would be difficult to establish.

It therefore seem unlikely that the surface manganese showings of the district will prove a serviceable ore guide.

6. Gossans:

Most of the copper sulphides of the district consist of chalcopyrite and chalcocite, with small amounts of bornite. As stated on page 15, these sulphides, upon oxidation in monzonite, usually leave distinctive limonites that serve to identify their former presence.

Leaching of these sulphides in a limestone gangue leaves a less clear record, for the reason that lime is a very rapid neutralizer; and limonites derived from the individual sulphides become obscured within a mass of "fluffy" limonite which has no spec-

ific origin, but which frequently forms where iron-bearing solutions come in contact with strong neutralizer.

Most of the known copper sulphides in the limestone likewise are intergrown with pyrite, in which the pyrite volume exceeds the volume of copper sulphides from 5 to 20 times. The smeary crusts and other limonite types derived from oxidation of the pyrite in this case have a similar tendency to obscure or obliterate the types derived from the copper sulphides.

A double reason therefore exists why interpretation of the leached material, or gossans, in limestone areas is more difficult than its interpretation in monzonite.

But although the distinguishing features of the "copper" limonites may be to some extent obliterated in limestone gangues, they are never wholly extinguished. And if copper in amounts greater than 0.5% has been leached from a given area, the gossan usually shows distinct evidences of it in the form of the "copper" limonites, even though a true record of the amount of copper leached may no longer exist.

Ground beneath a gossan which shown none or only minute amounts of the "copper" limonites, therefore offers little inducement for prospecting. Most of the gossans on the 770 and 1000 levels of the Alpha, between the Giroux and Alpha shafts, are of almost everwhelming pyritic origin, and prospecting beneath them is not likely to yield important ore. But the writer recalls having seen, during a brief visit in 1920, distinct cellular limonites of chalcopyrite origin in the gossan of the now inaccessible Bonanza fracture zone north of the Giroux shaft. And ground within and beneath such gossans would merit prospecting even if other good evidences of copper mineralization did not exist there.

One type of limonite derived from the copper minerals - known as "relief" limonite - is sometimes confused with the fluffy type because it contains no clearly defined cellular structure as do most limonites of copper derivation. It may be distinguished from the fluffy type through the fact that the fluffy type is always pulverulent, and under the hand lens resembles powdered sugar sprinkled over a surface; while the relief type contains many very minute scales and rosettes of limonite, which, under the hand lens, stand out boldly in relief like objects under the stereoscope. Prospecting within and beneath gossans of relief limonite rarely fails to yield commercial ore.

In the smaller gossans, which do not exceed 200 to 300 feet in diameter, the principal oxidized copper ore usually is concentrated in the central and lower half of the gossan; and the central and lower portions therefore afford the best areas for prospecting. In the larger gossans, such as the Bonanza fracture zone at the Alpha, ore is likely to be marooned throughout the gossan, for reasons explained under the discussion of "Soap"; and it usually becomes necessary to cut up such ground systematically in order to prospect it thoroughly.

The gossans described above, which are extremely porous in texture, and which in the copper areas reveal either relief limonite or the cellular types derived from copper sulphides, should not be confused with the limonite products existing below certain oxidized copper orebodies, described on pages 59-61 .

7. Soap:

The kaolinic and aluminous "soap" found in some of the gossans consists of varying amounts of kaolin, alunite, gibbsite,

and other hydrous aluminous oxides and silicates. In this district it seems to be derived entirely from limestone - chiefly from limestone that is slightly shaly. It represents segregation of aluminous silicates and oxides during oxidation as the result of strong acid attack on the limestone, and consequently denotes that in the vicinity of the soap there has occurred oxidation of a sulphide body high in pyrite content. To this extent the signigicance of the soap in terms of ore is similar to that of the gossans, and unless copper was associated with the pyrite that has been leached, the soap need bear no relation whatever to ore.

But in most places where the soap is prominently developed, as in the Bonanza fracture zone at the Alpha, copper is or has been present in important amounts. And the soap therefore becomes a more direct guide to oxidized copper orebodies than does the larger gossan area. This is particularly true where the soap is copper-stained, since conclusive evidence is afforded by the copper-staining that copper-bearing solutions have traversed the area.

The soap forms principally in those patches of the jasperoid zone that have been least altered or silicified. And as these less altered patches of limestone within the jasperoid likewise are effective in precipitating copper from the oxidation solutions, an explanation is afforded why the soap and the oxidized copper so often are associated. Either may develop without the other. But both usually go together. And the copper-stained soap areas therefore constitute one of the best short range guides to oxidized copper ore.

8. Oxidation Collapse:

When massive sulphide bodies oxidize, a shrinkage in

guishing feature is that rocks or slabs from the overhanging limestone roof have broken off and fallen down on to the gossan; and in nearly all cases these rock fragments, rotated with respect to one another, are enclosed or cemented within a calcite matrix. The final appearance is much the same as if cement had been poured over the jumbled rocks in the bottom of a limestone cave, and the cement had hardened.

A variation from this standard type occurs. Often the limestone roof bends and cracks under the strain, and portions of the limestone slip with respect to other portions without the roof actually sloughing away. Bands and stringers of calcite later cement the crackled mass solidly together. The true oxidation collapse type thus grades into the slumping type described below.

Oxidation collapse, in which fragments of rock are displaced or rotated with respect to one another and later cemented by calcite, is not uncommon above both copper and lead-silver orebodies in the Southwest. It rarely extends more than a hundred feet above the ore, and is usually best developed within 40 or 50 feet of it.

3. Oxidation Slumping:

In some cases the beds above the gossan area do not actrally collapse and slough off, but merely sag downward, with development of strong doming and marginal cracks above and around the outer edges of the gossan. The marginal cracks are known in certain districts to extend 600 to 800 feet nearly vertically above the edges of the gossans. The condition is similar to ordinary mine subsidence over caved areas, but less abrupt. Oxidation slumping may be distinguished from mine subsidence through the fact that in the former the cracks are usually filled and tightly

cemented with banded calcite, while in mine subsidence the movement usually is too recent for calcite to have filled and sealed up the cracks.

The three types of oxidation collpase are most commonly developed in limestone because that rock is readily soluble; but they are not necessarily confined to limestone: a small cave of oxidation collapse, 50 feet long, has been developed in a loose, sandy quartzite at the Piedmont mine northeasterly of Ely.

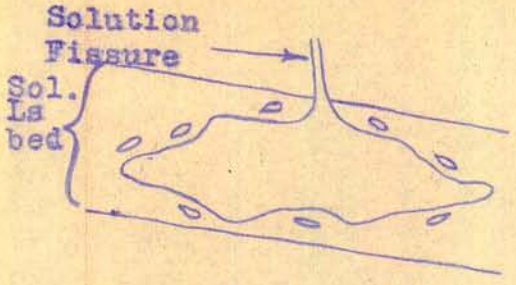
Very little of the ground within a few hundred feet above the gossans of this district is accessible, and the extent of the different types of oxidation collapse in such ground is undetermined. The Bonanza fracture zone at the Alpha mine would seem a logical place for such structures. Probert ascribes the basin at the surface back of the Giroux shaft to oxidation slumping, but the evidence presented is not wholly convincing: the basin lies principally in porphyry unprotected by jasperoid capping, so that erosion naturally would be more active there; and the basin runs at right angles to, rather than along the strike of the Alpha ore. However, oxidation slumping may be in part responsible for the basin.

Caves formed by oxidation collapse and those formed by simple solution of limestone by underground waters are sometimes confused. Below are presented certain criteria for their differentiation:

1. Open Caves:

A. Solution

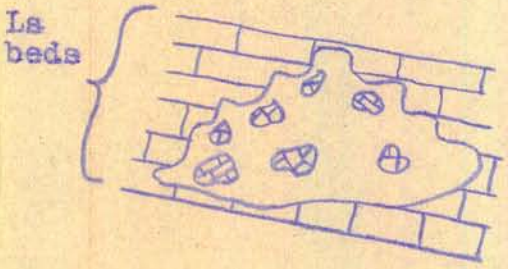
Where collapse of roof has not occurred:



1. Characteristic pitted and rounded surface along cave boundaries.
2. Most of limestone removed from cave, or deposited as stalactites and stalagmites.
3. Cave usually occurs along a particular soluble bed and is connected with solution fissure.

Note: Stalactites and stalagmites not shown.

B. Oxidation Collapse:



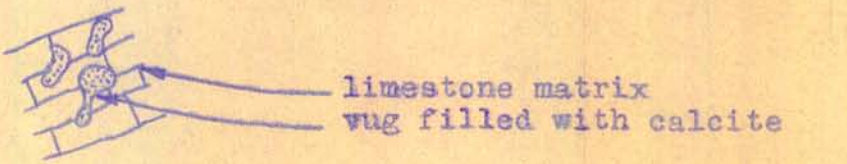
1. Roof of cave is always collapsed.
2. Characteristic jagged roof.
3. Most of limestone remains in cave as broken fragments, many of them rotated with respect to one another.
4. Cave does not occur along a particular bed (fissures, however, may be present).
5. Stalactites and stalagmites common to both solution and oxidation collapse caves.

Where collapse of roof in solution cave has occurred, the cave cannot be differentiated from one formed by oxidation collapse unless some other criteria are present showing evidence of ore.

2. Jumbled Ground:

A. True jumbled ground (oxidation collapse):

B. Pseudo-Jumbled Ground (solution)



E.H. Wisser has done more than anyone else in working out the mechanics, and the criteria for recognition, of oxidation collapse. His article in December, 1927 Economic Geology merits reading.

Oxidation collapse does not necessarily mean ore beneath; it may overlie a gossan derived from pyrite only. But the history of the collapse structures is that they usually do overlie ore. When gossans within or beneath such collapse show limonites of copper or lead derivation, the underlying area becomes especially inviting for prospecting. And under such conditions oxidation collapse constitutes one of the mose dependable short range guides to oxidized orebodies.

C. Expression of Mineralization Below the Ore

Only at the Ruth and Richards mines is ground directly below the limestone orebodies accessible. At the Ruth this lower ground consists of porphyry that is itself mineralized, and therefore furnishes no clue to conditions within the limestone below the ore. (See Plate 3.)

1. Earthy Limonite and Wad:

On the Richards 800 level, locally beneath the Richards oxidized orebody and in the raises above the level, occurs a thoroughly kaolinized limestone soaked with a buff to yellowish limonite, with infrequent patches of black to dark brown wad. This material differs from the ordinary gossans above the ore in that it contains little or none of the cellular, crusted, or granular limonite products, and that it is not irregularly open-textured, or porous, as are those products. It is essentially a uniform, highly kaolinized limestone with fine, earthy texture, and with buff to yellow limonite stain almost evenly permeating through it. The wad, consisting of manganese oxide, is more irregular in occurrence. Where present, it gives to the product a black, earthy appearance.

These products, locally present on and above the 800 level, below the orebody should not be confused with the naturally yellow limestone and the black shaly layers, of the Matilda horizon, which they somewhat resemble.

The fine, uniformly earthy limonite with its associated wad, is a common product beneath oxidized copper orebodies of pyritic areas in the less highly altered limestone. It represents

Example of botryoidal limonite crusts.

moderately strong acid attack upon fresh limestone by solutions derived from an overlying source, and therefore usually denotes that directly above it a massive or semi-massive pyritic body has been leached. It may exist beneath a leached pyrite body that was entirely barren of copper. But with other conditions present which point to possible copper mineralization at such place, untested ground above the earthy limonite and wad occurrences constitutes an area favorable for prospecting.

2. Botryoidal Limonite Crusts:

In some districts the limestone beneath massive sulphide areas contains rigid masses of botryoidal, submetallic limonite crusts intergrown with earthy limonite. Individual crusts are often an inch thick, and contain many shrinkage cracks. The product resembles somewhat the rigid limonite on the Alpha 770 level between the Giroux and Alpha shafts, but differs from it in containing no cellular limonite, in possessing well developed botryoidal limonite texture, and in usually having associated with it an equal or greater amount of earthy limonite. This type of limonite is more common in altered than in fresh limestone; and although not visible in accessible workings in the Ely district, is described here because it may conceivably exist in the inaccessible Alpha workings and other portions of the jasperoid zone.

The botryoidal limonite crusts denote an acid attack during oxidation so strong as to overwhelm the neutralizing power of the limestone. For this reason they occur usually in the altered zone where the limestone, through silicification or other alteration, has lost part of its neutralizing power. But they may occur also in the fresh limestone where essentially solid masses

of sulphide have oxidized.

To some extent the botryoidal limonite crusts are erratically marooned throughout the leached areas, without specific relation to ore. But the larger masses (50 feet or more across) usually have been found only at the base of the gossan areas. They consequently correspond to the earthy limonite occurrences described above; and in areas otherwise favorable for copper ore, untested ground overlying them warrants prospecting.

3. Siderite Boxwork:

On the Richards 800 level, beneath the Richards oxidized ore, are scattered occurrences of a coarsely cellular product known as siderite boxwork. This product has a sharply defined angular pattern, with the walls of the boxwork consisting largely of secondary siderite, but locally carrying intermixed limonite and unleached sulphides. It is derived from the oxidation of massive or semi-massive sulphide bodies through replacement by secondary siderite along fractures of the underlying limestone, and subsequent dissolving out of the unreplaced residual limestone fragments.

Since the secondary siderite boxwork means merely the oxidation of previously overlying massive or semi-massive sulphide bodies, there is no reason why it should necessarily mean ore; it may have been derived from pyrite bodies wholly barren of copper. But at Bisbee, where the siderite boxwork is extensively developed, four out of five of such occurrences do show oxidized copper orebodies lying directly above them. And the fact that the one known occurrence in this district at the Richards mine likewise has an oxidized copper orebody lying above it, suggests that siderite

boxwork may prove an effective short range guide to ore in areas otherwise favorable to copper mineralization.

One point should be noted: limonite and siderite oxidation products once formed below orebodies, or at the base of gossans, are generally stable. It is therefore conceivable that the oxidized ore might migrate to lower depths, leaving the earthy and botryoidal limonite and the secondary siderite products marooned above the ore.

But oxidized copper orebodies, when once precipitated within limestone - particularly in the fresher limestone - migrate very slowly except immediately below the surface. Although it therefore is possible under exceptional conditions for the earthy limonite, the botryoidal limonite crusts, and the siderite boxwork to occur above the oxidized ore, the writer knows of no case where such products were developed extensively, in which reversal of ore position has occured.

4. Low Grade Pyrite Bodies:

The three guides above described deal with oxidized ore only.

As previously stated, limestone copper districts do not usually show much evidence of mineralization below the primary orebodies; and nothing now known about this district points to its being an exception. More exploration in the primary zone will have to be done before a firm opinion in the matter is in order.

In other districts low grade pyritic bodies frequently have lenses or "plums" of copper ore scattered through them, and most of the "plums" generally occur within the favorable limestone horizons.

The finding within a well fractured area, of a low grade pyrite body either above or below a known favorable limestone horizon, therefore would justify extension of the prospecting to include that horizon.

MISCELLANEOUS

Secondary Enrichment

Detailed microscopic work on the oresof the district has not yet been done to establish the precise dependence upon secondary enrichment to make particular orebodies commercial; but visual inspection suffices to permit certain observations:

1. Porphyry Ore:

Ore in the Veteran, and in the Morris-Brooks down to and for some distance below the 360 level, depends importantly upon secondary enrichment to make it commercial. But a part of the Morris-Brooks porphyry ore at greater depth is nearly free from chalcocite enrichment, and the primary ore itself is commercial.

At the Ruth mine, most if not all of the porphyry ore depends on secondary enrichment for its commercial value.

At Nevada Consolidated pit most of the ore (estimated at not less than 4/5ths; possibly more) likewise depends upon secondary enrichment for its commercial value. But in portions of that orebody, especially at and near the limestone embayment on the Ora and Josie claims, and at several other places well within the porphyry itself, chalcocite is wholly or almost wholly lacking, yet the grade of the chalcopyrite ore at those places equals or exceeds the average for the pit.[x]

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[x] Chalcopyrite may be a secondary mineral. But the experimental work done with this mineral at the Geophysical Laboratory, together with the field observations of many geologists, shows that definitely proved chalcopyrite of secondary origin is not known except as thin tarnish films, as occasional minute specks, and as small flocculent nodules of the mineral precipitated in swampy ground by bacterial action. Chalcopyrite occurring in the quantities existing in the Ely district, especially in close association with pyrite, pyrrhotite, and garnet, cannot well be regarded as of other than primary origin.

It is evident from examination of leached outcrops that the primary ore of the porphyry never extended much above the present surface. At the Morris-Brooks and the Ruth mines, and in portions of Nevada Consolidated pit, it reached the present surface only as tips (see sketch, page 14). And it is proved by exposures in the pit, and in accessible workings of the Ruth and Morris-Brooks porphyry orebodies - corroborated by churn drill data - that much of the primary sulphide in the more favorable porphyry structures carries upward of 0.65% copper. Leaching of copper to bring about secondary chalcocite enrichment, has not in most places occurred through a vertical range of more than a few hundred feet.

An excellent example of how secondary chalcocite enrichment is just beginning at the horizon of the present surface, is afforded by the leached outcrops of the Sunset-Kimbley Hill ore porphyry mass. Here most of the outcrops show only limonites of pyrite and chalcopyrite derivation, but in the more highly fractured portions those limonites are intermixed with ones of chalcocite derivation. And the chalcocite limonites increase slightly toward the base of the hill.

The significance of this, from the ore standpoint, is that since primary mineralization in the porphyry is higher grade than in such districts as Miami and Bisbee, less secondary enrichment is needed to bring the ore to commercial grade. And consequently greated incentive exists for exploring porphyry structures now buried beneath the surface.

2. Limestone Ore:

The column of oxidized and sulphide ore in the limestone is remarkably variable. At the Richards mine a commercial sulphide orebody occurs between the 300 and 400 levels. Within a

few hundred feet of it oxidized ore extends from above the 600 nearly to the 800 level. At the Alpha mine, 2500 feet distant, oxidized ore is continuous from above the 770 to the 1300 levels, and drilling shows thorough oxidation to persist at least to several hundred feet greater depth.

At certain places, as at the Veteran mine, it seems probable that there has been an importation of secondary copper from the adjacent porphyry, and that this has increased the grade of the limestone ore. At other places, where strong fracturing occurs within the silicified jasperoid zone, as at the Ruth and Alpha mines, copper from overlying limestone areas probably has been leached and re-concentrated locally at greater depth to produce the high grade oxidized ores of those mines. At still other places, where the limestone is only slightly altered and fracturing is but moderate, as in the Richards oxidized ore area, there probably has been no important change in copper content, the primary sulphides merely having been changed to their oxidized equivalents without material addition or loss of copper values. Although an accurate check is not possible because of inaccessibility of so many of the oxidized limestone areas, it seems reasonable to assume that leaching to some extent occurred wherever pyrite was abundant, where fracturing is strong, and where neutralizer, such as fresh limestone, is scarce - as in the Alpha, Ruth, and probably in the Old Glory mines; and that retention of copper was more common where pyrite was not sufficiently abundant to furnish a large amount of acid for leaching during oxidation, and where a large amount of neutralizer, such as the slightly altered limestone of the Richards oxide country, was present to precipitate the copper from solution near its primary

source.

Untested portions of the oxidized zone ought to continue yielding orebodies if explored where structural conditions favor concentration of ore.

But since much of the limestone copper ore depends for its commercial value upon secondary enrichment, and none of it is proved to be entirely free of enrichment, a more important consideration is how seriously the lack of enrichment may affect values in the primary zone.

Almost no work has been done in the primary zone of the limestone areas, and no real opinion is possible. The fact that the Richards oxidized ore probably experienced little concentration of copper; that moderately high grade primary ore occurs in the limestone embayment on the Ora and Josie claims; that the primary ore in the district seems in general of higher grade than is the case in many districts; all these factors are encouraging. And the probability of an important drop in the primary zone of the limestone areas as a whole is not at this time sufficient to discourage exploration in new areas where conditions for ore are otherwise favorable.

Persistence of Ore with Depth

One of the problems is whether or not the Alpha ore will persist with depth. Arguments advanced in favor of such persistence are that (1) numerous moderately small, rich oxidized orebodies have been found between the 770 and the 1300 levels; (2) thorough leaching extends at least locally well below that level; and (3) the known leached area, or gossan - not less than 1000 x 1000 feet in maximum areal extent, is so large that the oxidized ore already found does not reasonably account for all the copper leached

unless the grade of the primary sulphide was much lower than is indicated for other copper areas in the limestone of the district. Therefore, according to these arguments, an important body either of secondary chalcocite or oxidized ore should occur beneath the leached zone.

Argument (3) is not valid. That portion of the gossan on the 770 and 1000 levels lying between the Giroux and Alpha shafts shows by the evidence of its limonites that its primary sulphide was almost wholly pyrite, with only occasional minute occurrences of copper sulphides. Unless that portion of the mineralized area carried much more copper below the 1000 level than it carried above, commercial orebodies could not exist beneath it. (They might of course be carried vertically beneath it by the dip of the adjacent Bonanza fracture zone; but that would have no relation to the gossan in question.) That limits the favorable gossan to the Bonanza fracture zone, which has a known maximum areal extent of only 1000 x 400 feet. The significance of the remaining pyritic gossan on the 770 and 1000 levels, between the Bonanza zone and Alpha shaft, consists chiefly in the fact that so extensive a body of pyrite immediately adjoining a large known copper-bearing section of ground denotes large scale and vigorous mineralization for the area. To that extent only is existence of the large pyrite gossan favorable.

Argument (2) probably is valid, but is not necessarily so. If the gossan below the 1300 level carries appreciable amounts of "copper" limonite, as seems probable, further oxidized or secondary chalcocite ore may be confidently expected. Otherwise such ore below the 1300 level would depend upon whatever copper-bearing solutions filtered through without precipitation in overlying ground. The extent to which such filtration may have occurred cannot be

inferred without examination of the ground.

Argument (1) is the most hopeful factor. Persistence of numerous moderately small, rich oxidized copper orebodies along the Bonanza fracture zone from above the 770 to below the 1300 levels proves an important concentration of copper mineralization within that zone; and in the absence of any known contradictory evidence, raises a presumption in favor of their probable continuance with depth.

It is known that the less silicified limestone of this fracture zone - which to some extent has been altered to the aluminous soap already described - has effected precipitation above the 1300 level of much of the leached copper as copper carbonate, oxide, silicate, and other oxidized forms of copper minerals. And the hypothetical secondary chalcocite zone expected at greater depth has been deprived of a corresponging amount.

When the ore areas of the Alpha mine become accessible, it should be possible to ascertain in a rough way whether most of the copper within a given block of ground has been precipitated as oxidized copper ore within that block, or whether appreciable amounts of the leached copper are likely to have been carried below the 1300 level for concentration at greater depth.

Until such time, only long range conjecture is possible; and that is not likely to lead anywhere. The favorable factor at the Alpha is that even should there prove to be no migration downward of copper solutions from ground overlying the 1300 level, no reason is apparent at this time why any sudden change in the general character of mineralization should occur at the 1300 level; and why oxidized orebodies similar to those above that level there-

fore should not persist below it in the Bonanza zone, regardless of what may or may not have happened above the 1300 level.

One other possibility exists at the Alpha, aside from the oxidized orebodies, and aside from a possible secondary chalcocite zone in depth:

In certain disseminated porphyry copper districts primary ore has proved non-commercial, and ore both in the porphyry and the sediments failed to persist with depth.

In certain other disseminated and limestone copper districts primary ore has proved highly profitable, and commercial ore has persisted to depths of 2500 feet or more below the surface, with the end not yet in sight. United Verde, Magma, and Old Dominion are examples.

It is not known to which class the Ely district belongs. Certainly, ore is not likely to persist with depth in those portions of the district underlain by peanut porphyry.

On the other hand, districts with proved deep commercial primary ore are those in which mineralization occurs along a well defined fault zone, or in strongly defined and sustained fracturing. The Sandstone fault zone of the Ely district conforms to that requirement.

Nothing short of actual exploration in depth will determine the possibilities for deep primary ore in the district. But the Alpha ground, with its strongly mineralized Bonanza fracture zone parallel and immediately adjacent to the central line of dislocation of the Sandstone fault zone; with its freedom from any known peanut porphyry; and with its shaft already down to the 1800 level; offers a combination of inviting conditions for testing the

deep primary ore possibilities of the district by both ordinary underground exploration and by drilling.

Water in Depth

One factor to be considered in deeper mining is inflow of water. In such districts as Eureka (Nevada) and Tombstone (Arizona) ore of the average grade for the district persists strongly with depth at certain places, but cannot be worked profitably because of excessive pumping costs.

It does not seem at this time as though pumping costs at the Alpha will prove excessive. In any event, that is a matter to be settled after the lower Alpha ground has been tested by drilling, and its promise for ore ascertained.

Post-Ore Faulting

In his mapping at the Morris-Brooks, Rott observed movement along the Sandstone fault later than intrusion of the rhyolite. Since all rhyolite of the district probably is of a single age later than the ore, this would mean that post-ore faulting has occurred in the district.

Pennebaker likewise has found ore porphyry faulted against peanut porphyry on Kabooney Hill and on the 6660 Emma-Nevada. But evidence is not yet conclusive that the faulting in this case is later than actual deposition of the ore.

Minor slippage and adjustment would be expected in an area similar to the Sandstone fault zone following intrusion by the ore porphyry or by the rhyolite. And there is thus far no evidence that the post-ore faulting consists of anything more than such minor adjustments within the fault zone; while it is certain that a large

part of the faulting is pre-ore.

Although the full extent of post-ore faulting in the district remains to be determined, there is at present no good reason for thinking that post-ore faulting will seriously complicate the search for ore.

Post-Ore Rhyolite

Much of the rhyolite - probably all of it - is post-ore. Pennebaker's work in mapping it both at the surface and underground suggests that its center of intrusion is along the Sandstone fault zone somewhere near the Beehive country, and that it has been localized to a large extent along the Sandstone fault zone, just as the ore porphyry was localized along that zone. This applies to the intrusive rhyolite, as distinguished from the rhyolite tuff which covers certain outlying areas.

The intrusive rhyolite consequently is closely identified with the principal ore locus of the district. And although later than the ore, may be of service locally in the untested ground in showing where the more deeply-seated and stronger fracturing occurs.

The unfavorable and disturbing factor, as regards the rhyolite, is that since the rhyolite is post-ore and occurs along the principal ore locus of the district, it has in some places cut out the ore both in the porphyry and in the limestone. This has complicated the mining practice and the maintenance of ore grade at several places in the Morris-Brooks porphyry ore. In several instances, also, ground beneath favorable outcrops in the limestone has been tested only to find an intrusion of rhyolite occurring where the ore normally would be expected.

There is hope, based on recent work done by Pennebaker,

that before long the shape and position of the rhyolite occurrences along the Sandstone fault zone may be largely delimited, and this unfavorable factor in the search for ore correspondingly minimized. It probably never can be wholly eliminated.

Gold Ores of Lane City

Work of the past season did not cover the Lane City area except in reconnoissance. Intimate knowlidge of the gold ore occurrences in that portion of the district consequently was not acquired.

It is known (1) that gold ore occurs in the limestone horizon near the top of the Chainman shale, and in the underlying Joana limestone; (2) that it occurs within leached pyritic portions of those limestones, and has not been found to persist commercially into the unleached pyrite below water level; (3) that the better grade of ore occurs in well fractured areas, and averages between $8 and $15 per ton for such areas; (4) that certain of the known ore-bearing fracture zones have been explored at their intersection with only one of the known favorable limestone horizons; and (5) that a sill of peanut porphyry cuts out the favorable limestone horizons for a length of more than a half mile between the Saxton and Chainman mines.

Detailed working out of the ore relations to the geology is needed before an opinion can be expressed as to the possible tonnage and grade of gold ore that may be expected.

Lead and Zinc

Lead ore found in the district to date consists of small

erratic pockets occurring in the limestone along mineral fissures. Part of it is oxidized ore, but galena has been found at most of the deposits. Silver is associated with the lead variably from ½ to 2 ounces per unit of lead.

Lead occurs principally in the Matilda, Lane City, and Munroe areas. The Matilda and Lane City ore occurs at the outer edges of the principal copper-bearing portion of the district, and hence suggests horizontal zoning with respect to the mineralization center of the district. The Munroe lead ore occurs approximately a half mile south of Nevada Condolidated pit. Searles and Joralemon are reported to have expressed the opinion that the Munroe lead ore may r oresent vertical zoning, with the possibility of its leading to copper ore with depth. Nothing in the exploration at the Munroe has been found thus far to invalidate that assumption, and a number of factors have been found which corroborate it.

Several of the Lane City lead occurrences bottom against a thick sill of peanut porphyry. The others are underlain, at depths not exceeding several hundred feet, by Chainman or Pilot shale. In the Matilda and Munroe country the ore occurs in the upper part of the Ely limestone. Favorable limestone horizons therefore may be expected to persist to greater depths there than at Lane City.

The lead possibilities of the district, like the gold possibilities, have been examined to date only superficially. Nothing now known points to the Ely district becoming a major lead producer. But lead deposits in limestone have a habit of opening up abruptly, and it is not improbable that bodies of the ore substantially larger than those now known, may be disclosed.

Zinc mineralization in the district is of spotty occurrence. Small bodies of it have been mined in the vicinity of the Minnesota claim and the Hayes shaft, and likewise on the Easter claim. Its existence locally is revealed also in the Matilda count , in the pyrite gossans of the gold area near Lane City, and in gossans on the Isaacs claim. Known zinc occurrence is small and spotty, but the chances for zinc ore in the district have not been investigated. An opinion as to possible zinc ore in commercial amounts therefore would be premature.

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