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MINING 111A 3B-8.Stockton District, Utah.

J.Gilluly: Geology & Ore Deposits of Stockton & Fairfield Quadrangles,Utah. USGS PP 173, 1932.

In Oquirrh Range,N-S,probably basin range tilted E,uplifted along W by jormal flt. Domiant structure now folding:along concentric ~~xxxxx of~~ folding based on Sheep rock uplift,see Paleotectonic map. Bingham at N end of Range,adjoining.

Within active belt of mts.shown on Spiekers Diagram A;ore deposits may,with Tintic & Binghamm have formed in mid-K orogeny,

In deep Penn.basin concave toward Sheeprock uplift on NE side,also in stem of Beltian-lower Cambrian Y.

Section,for Oquirrh range,based on Gilluly Stockton work:

Pre-Laramide

No K:lowland,Kl,along E mountainous shore,Ku. +

Penn. Bingham qtzite:qtzite with IB ls.....	10,000(top not seen).
IB ls.,shale.....	10,000
Penn-Miss sh.,qtzite.....	1,100
Miss ls.,Madison at base.....	5,500
Devonian dolomite.....	200
Cambrian:dolo.,shl,ls,qtzite.....	2,500
	27,300

4/21/54

Thick but largely competent,especially top half.

11/26/52

Structure: As shown on Sketch,folds swing from SSE to WNW,SE to NW,concentri as stated. Folds assymetric,some moderately overturned to NE,but all open. Minor fltg.accomp.folding. Age: At Tintic & in Wasatch Rge. Eocene cgls unconformably on eroded surface of folds. In Wasatch, lev is folded. Could be Mid-K at Stockton

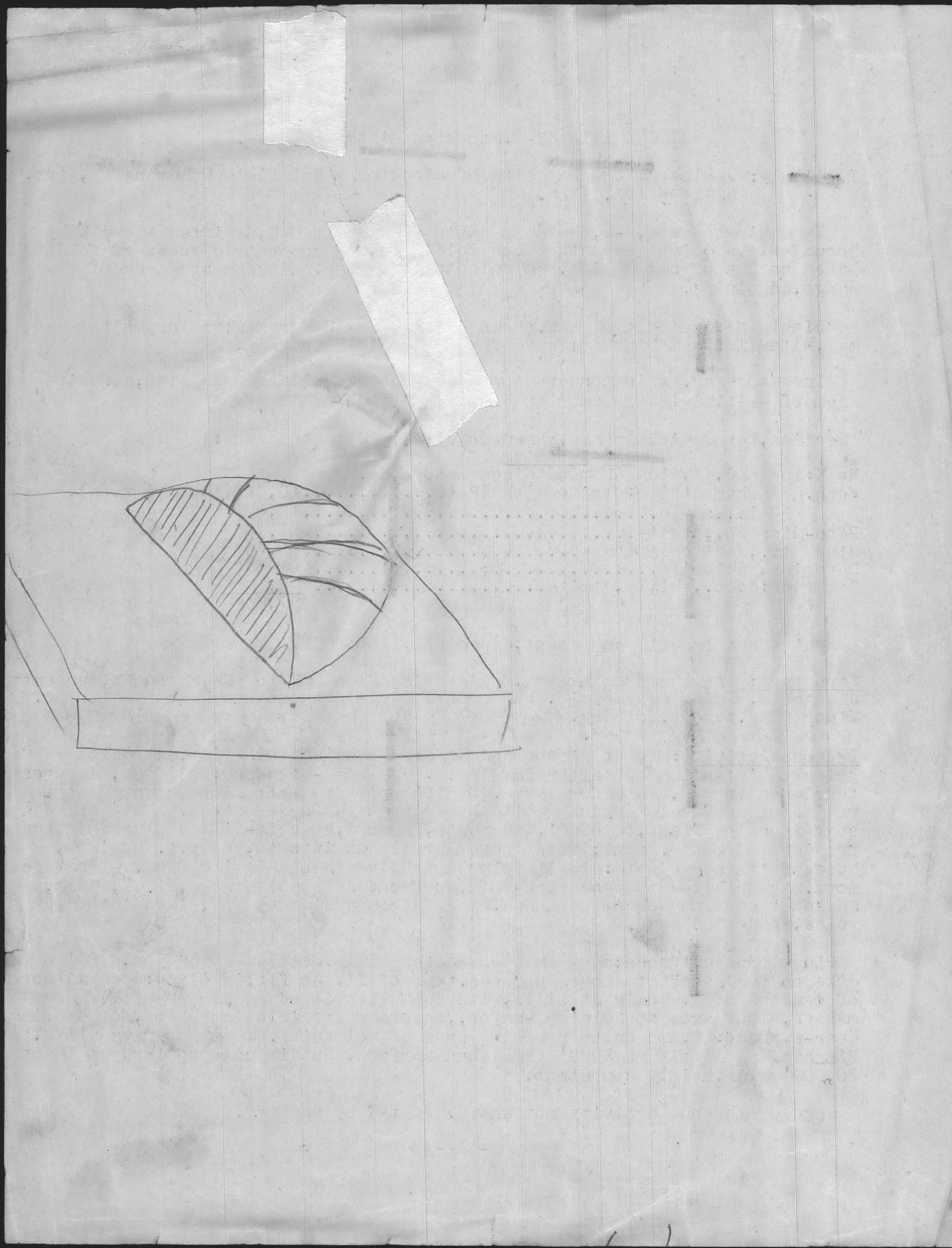
11/22/54

Order: 1. Latite br. 2 " flow 3 Rhy necks, dikes 4 Monz.

Igneous Activity: As at Pioche and in San Francisco District,extrusion prior to intrusion but after folding. Rocks work-hardened,uplifted,fissures tensionao formed,vents for lavas. Uplift prior to extrusion shown by strong relief of surface on which latite breccias & tuffs deposited. Above these corresponding flows,to 3000'.Two vents,NE part,breccia-filled plugs.Ejected previews of monz .magma;latter rose locally ~~up into~~ to,and s.t. up into base of its own ejecta:diorite plug intrusive into a latite flow. Elsewhere monz.magma failed to reach pre-volc.surface. As small stocks,dikes,sills, SW and then S to Mercur as shown.Plugs accompanied by rhy sills & dikes intruded volcs,and Paleo seds.

Plugs crosscut beds;many smaller masses sills.Settlement Canyon,a 20' dike on one caontact shoves up seds.tens of ft. No flt.involved:upward shove of igneous mass. Dominant sills,with shpve mentioged and shape of larger masses,along axis at Soldier Canyon,,suggests forcible intrusion,not stoping. Near-surface:Cf.monzonite reaching base of volcanics, ~~Same for "arysville, Bingham.~~ as little as 3000' from then surface. But it came up thru at least 30,000' seds.mainly competent.

Age of igneous activity not known. Post-K by analogy.



Ophir: While general district structure one of arcuate, open folds, the Ophir anticline has a sharp bump on it-Ophir dome. Plunges to W, off map, plunges to S, less sharply.

A half dome. N side domal, S side formed by ENE synthetic faults (Ophir Canyon faults), N or upthrown side, up 2000', oldest (Cambrian) exposed. Flts. dip 65S, therefore "normal"; synthetic, probably along S side of igneous mass underlying Ophir dome. Gillulyp. 78: "There is evidence in the localiz. of meta. along fissure Not Canyon Flts., that an ign mass is not very far beneath the surface" Might be pre-intrusive in part, like Gold Hill. Step faults, northernmost member has over half the daggregate displacementn (1400'). Notable ls brecciation along the zone. Strictly a local flt., genetically connected with Ophir dome. Ep-anticlinal. Displacement at a max. opposite top of dome. Pre-mineral: calcite-cemented breccia on Opbir flt., s.t Mn-calcite, pyrite-qtz fillings.

Cliff flt., NE branch off ~~Ophir~~ Canyon, mineralized, no PM movement. p.77: "..the flts, of the Ophir Canyon group were in existance before the cessation of the deep-seated igneous activity which was the presumable source of the ore in the district. A pre-mineral rhyolite dike extends south through the Cliff and Canyon faults without offset. Hence these faults are older than the end of the magmatic cycle". Another dike appears offset, hence these faults are later than some igneous activity. Close relation, therefore, between intrusion, faulting, mineralization.

1920

B.S.Butler, Ore Deposits of Utah, USFS PP 111, 376:

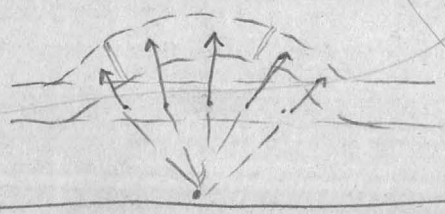
"From Ophir the rocks of the ..anticline dip away in all directions in a pronounced dome...The dips to the north are rather pronounced,..as much as 25-20° just north of Ophir and becoming steeper farther north..

"Faults: ...The imp. Ophir Canyon fault strikes north of east..and dips steeply south. The vertical force that domed the strata apparently caused them to break along the line of this fault and raised the portion to the north more than to the south...The displacement was greatest at the center of the dome and decreased both to the east and west...

Fissures: The limestone was broken by fissures that trend generally north. They show little displacement and are important chiefly as channels for the ore bearing solutions...they appear to be most abundant near the crest of the anticline, and to decrease in importance as ..distance from the crest increases. This is of course the condition that would be normal if they have resulted from..bending of the limestone beds, for the crest of the anticline would be subjected to the greatest strain."

Cf.Little Lost Soldier dome and others,on Charts II,III. Actually the Ophir dome ore fissures in the ls are radial, designed to aid the extension of the domed plate.Plate II-6. Growth of the dome affords good illustration of fault movements concurrent with "folding" or flexing,a la Gold Hill. See Mono Wedge-Shaped Fault Block illustration. Pie-shaped segment, north flank of dome.Block dropped 700';faulting around a corner,in fact,all around the stern of a boat.Keel oversimplified,pitches NW 25o for 1st 300', steepens to 60Obelow. Stria show differential movement roughly normal to this keel (~~right-hand~~ sketch).Mechanically by one deformation or any way impossible/except under one condition.

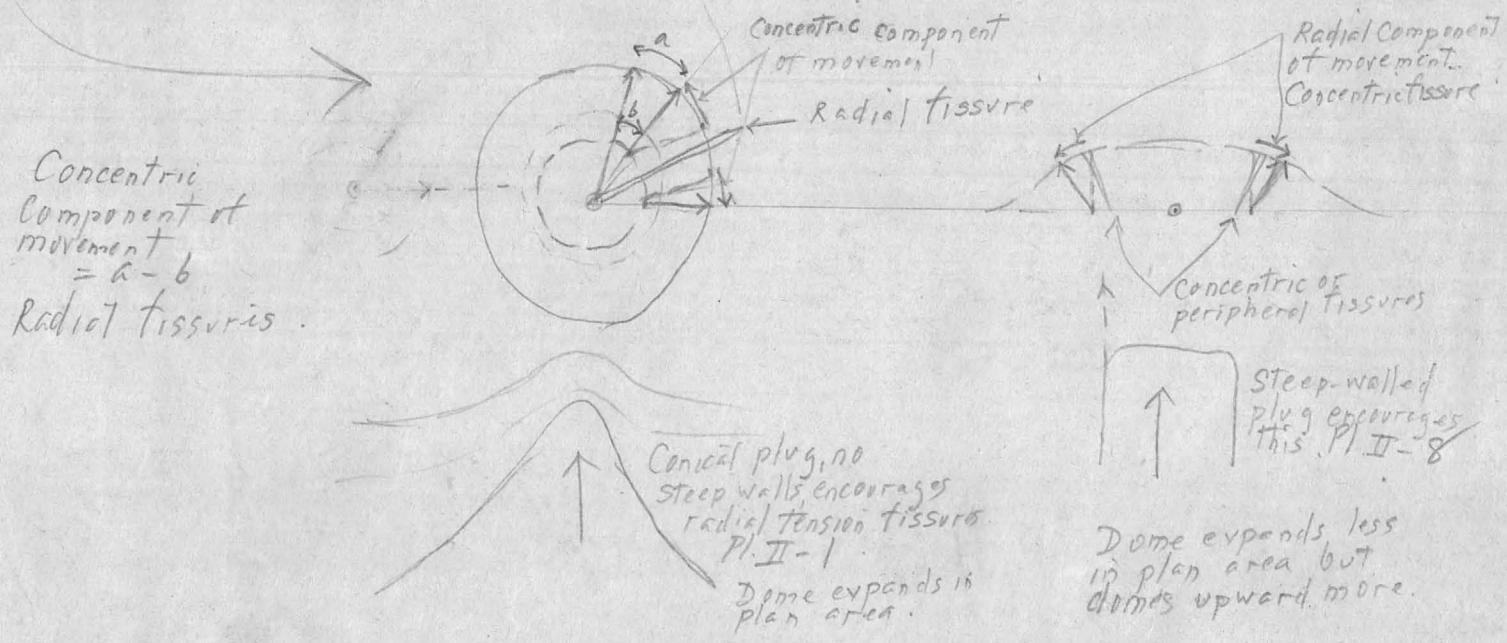
Domes grow upward & outward from a center or focus.



Mechanics of doming somewhat complex. ~~With a sharp,pointed plug shoved up from below,~~

~~Domes may be of two kinds,with gradations:~~

~~1. Moderate or no areal expansion,simple upward growth with plan area not enlarging greatly.Domed plate enlarges by stretching directions visible in X-section~~



INSERT

As discussed under mechanics of intrusion at Gold Hill,where a rising plug utilizes a preexisting fault,or generates one (Plate II-8) it does not dome seds. Ophir Canyon flts,no doming to S,uplift by synthetic fltg. N of the flt,zone,doming needed,and is actually accentuated because the crus crustal plate is straining to adapt itself to the easy,sharp uplift along the lubricated syhthetic flt.zone.

Niagara
Ben Sweetland
KSFV
Zone 9

Resulting fracture type depends on whether concentric or radial component of strain dominates;this in turnmay depend on shape of upper surface of plug below,as shown. At Ophir,probably cone-shaped intrusive; may have been cone-shaped because it climbed high at one central point on Ophir Canyon flt.system.

Ophir radial tension fissures tended to meet toward S;but before they met,these early results of doming (Plate II-9)were discontinuous flaws which did not disrupt the rising half dome into discrete blocks.No fltg. By where two radial fissures met to form a piece of pie-shaped wedge, the stern of the boat,the block would move as a unit,altho it was broken, in this case, by N70E 60-90 S-dipping normal,faults (antithetic flts.owing to arching visible in NW-SE section). Doming is flow,plastic deformation. Since dome would rise most strongly S of the Mono wedge,toward the dome apex, Mono wedge would tend to be left behind;that is,the domed material outside the wedge would continue to move upward and outward from focus of doming,but such movements would not affect the loose wedge.Latter would not sink absolutely,but be carried up by the doming; but surrounding portion of dome would slip past bounding faults of wedge as doming continued.

INSERT

This shows that dropping of such a wedge,also dropping of graben along crest of an arch,may be an accompaniment of uplift,not "crustal collapse,reversal of stress etc.

12/3/51

Fissuring more favorable than faulting esp. where fissure adjoins major fault changed

<u>Ore Deposits</u>: Bedded replacements and veins. Production,1864 thru 1927:

Ophir:	Pb-Ag-Zn...	$20,000,000
Mercur:	Au,Hg.....	19,000,000
Stockton:	Pb-Ag-Zn	10,000,000
		49,000,000

Ophir,main OBs along Cliff flt.,major radial tension fissure;Dry Canyon faults also pre-mineral,showing that doming going on or complete at time

of mineralization.Ore in Devonian dolo.,and lower beds of Madison ls, some distance away from Cliff fault;but largely in Cliff fault zone, where latter cuts thru these favorable formations. Ore along fault zone largely tabulat bodies replacing dolo and ls between branches of Cliff fl flt.But fissure filling along strands of the fault as well. This fault zo zined mined thru vert.distance of 1100'.

4/23/54 Mercur: Au and Au-Hg OBs in Great Blue ls.,Miss.above Madison. Control* led by fissures like Pioche,but little or no ore in the fissures themselves.At Mercur rhy intrusives appear localized along cross-joints connecte with Ophir anticlihe,which pitches S here.Plate IV,1C to 1F. Hg a curiosity:in nearly all Au ores,but commercial in one mine only,Sacramento,and t there a small lens along bedding.Siliceous gangue.

Here again (Gold Hill) epithermal telescoped on mesothermal-probably uplift,erosion during period of metallization.

Basin and Range Fltg.: Block tilted E,main BR fltg along W front range: Lakes of Killarney,W Mercur.Dip 60.Step-flts. En echelon, zone trends N N20W,individual flts N20 to 50W. Lack of persistence along strike.

Some are rejuventaion of movement along older fault planes:Ore in spot along W ,ercur for over 2 mi.Probably not drag.Daisy,La Cigale deposits identical with those of Mercur; here as at Pioche,Gold Hill and San Francisco district, K N-S trends developed and expanded by BR deformation.

BR faulting tilted/erosion surface not older than Oligocene nor younger than mid-Plio.

3/15/17.

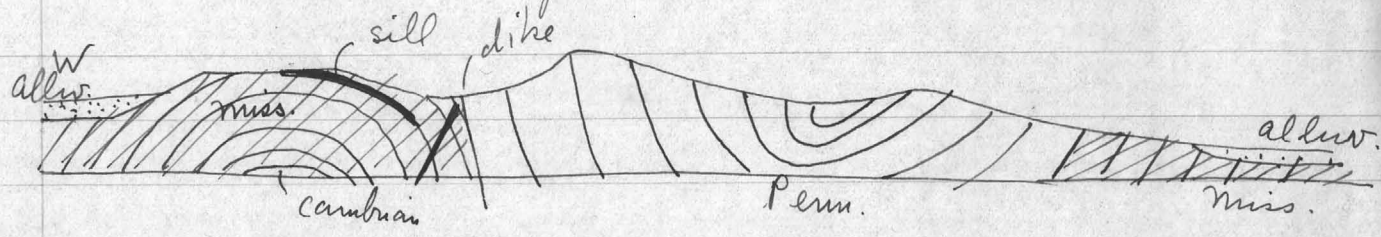
Mercur, Utah.

Silver - gold.

On 1st of basin ranges outside Wasatch range.

(Same range as Bingham Can.)

12000' sed. strata exposed.



Geol. Sect.

Penn.	ss., ls. alt.	5-6000' Top removed.
Miss.	3. Great Blue ls.	5000' + (cont. 2 thin beds of sh.)
	2. Thin bedded ss. & ls.	600'
	1. Dark blue ls.	200' + (base unexp.)

The sh. in the G. Blue determines the emergence of springs.

The general structure is a great NW-SE anticline.

Igneous Intrusives — a few dikes, but mostly as sills ∥ stratification. The sills are mostly of 2 varieties of qtz. porph., confined to the Blue Ls.

Eagle Hill Porph. — splits into 2 sheets ∥ bedding

Upper 250-300

Lower sep. from upper by 700'. Max. t = 300'.

Bird's Eye Porph. — single sheet, several 100' ft. above the Eagle Hill P.

There is a trace of gold in the lower black sh., in the Big Blue; trace in both porphyries (to 1/100 z.) Trace in calcite veins thru ls.

Ore-Bodies.

At contact of ls. with certain porphyry sills. Two classes

Silver Ledge - at contact of silicified ls. ("black qtz") with a sill. Films & seams of horn silver, arg. stibnite, $CuCO_3$, barite as gangue.

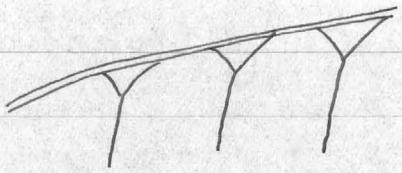
Gold Ledge Embraces both ls. & porphyry (decomposed) [Ag ledge embraces only the ls.] ~~to ts~~ Arsenic, Hg. in diff. compounds, + gold.

Silver Ledge - At contact of lower of 2 main sheets of the Eagle Hill P. On lower side of the sheet. Considerable brecciation & fissuring in ls. near contact only. This formed cavities; some cavities formed by dissolution, later lined by $CaCO_3$ drusses.

Spum Ho't ge formed by waters bearing Ba, ~~Ba~~ SiO_2 & metals, SiO_2 dep. as qtz., Ba as sulfates, metals as sulfides. Ho't action was very brief but intense; waters came from the magma.

The ores are far from the pt. of escape of the magma; the action would imply a very large amount of water; why should dep. occur only at this limited place on the sill?

Gold Ledge 100-150' above Ag ledge.
Follows one of minor sheets of Eagle Hill P. Much decomposed. Mineral of ls. varies from 0-20' away from sill. Fissures beneath sill. Ore forms shoots in connection with the fissures.



2 classes of ore in gold Ledge.
Gossan - cyanided well. Profit
Sulfide - wasting nec.
Ores are all soft can be easily picked. Some realgar AsS, FeS_2, HgS; sulfates in gossan. Barite, calcite, gypsum. Some telluride orig. in ore.

2- Mesothermal 3A
Gold-bearing Replacement
Depo. in Ls.

√ Repl. 1

Mines and Millof the Consolidated Mercur Co.

Roy Allen, EMJ 6-18-1910

Location: Utah, near southern end of Oquirrh Mts, 62 mi south of Salt Lake City.

General Geology. 12000' Carbonif seds, mostly ls, folded into a simple anticline, with axis trending NW. Mercur mines all on NE limb of this fold. OBs near bottom of series, in lower portion of a formation nearly 5000' thick, the Great Blue Ls. Uniform, massive and pure ls, dk gray-blue color, becomes nearly white on weathering. This ls intruded by several sheets of qp, 4-40' thick: sills. Attitude of sills and ls: strike N23W-N55W; dip 10-40 NE.

Ore Deposits. These underlie the sheets of porphyry, and are made up both of altered porphyry and altered ls. Their lines of greatest mineralization coincide in direction with a series of steep fissures trending NE. Minerals supposed to have ascended in gaseous form thru these fissures, depositing ore along lower por contact, impregnating both por and ls, but mostly the ls. Thickness of workable ore 4-70', of which only a few ft at most of the por is mineralized.

Ore Minerals. Primary: pyrite, realgar, cinnabar and gold, both associated with the py and probably as a telluride. Most of ore in por is unoxidized; that in the ls just below is almost completely oxidized. Py in small grains. Realgar and cinnabar sparse.

Alteration of Porphyry. Fresh rk is fine-grained, compact, nearly white, carrying a few inconspicuous phenos of flds, qtz and bi. Near the deps the rk is almost black, soft, and has small gypsum crystals, and on exposure to the air the rk crumbles and looks like dried mud.

Alteration of Ls. The ls where mineralized is hard and cherty, but evidence points to the silicification having antedated the ore minerals.

Brickyard Mine. "Vein" follows under side of a porphyry sheet, and varies from 8 to 40' in thickness; of this 2-4' is the mineralized porphyry, quite as high in gold as the ls, but ore in the por is apt to contain sulphides and must be roasted before cyanidation.

"Veins" in other mines are similar.

(L) Mineralization Ore?

COPY

COMPAÑIA DE REAL DEL MONTE Y PACHUCA
PACHUCA, HGO., MEXICO

Replacements (1)

FOR

Geology of the Honerine Mine, Stockton, Utah.

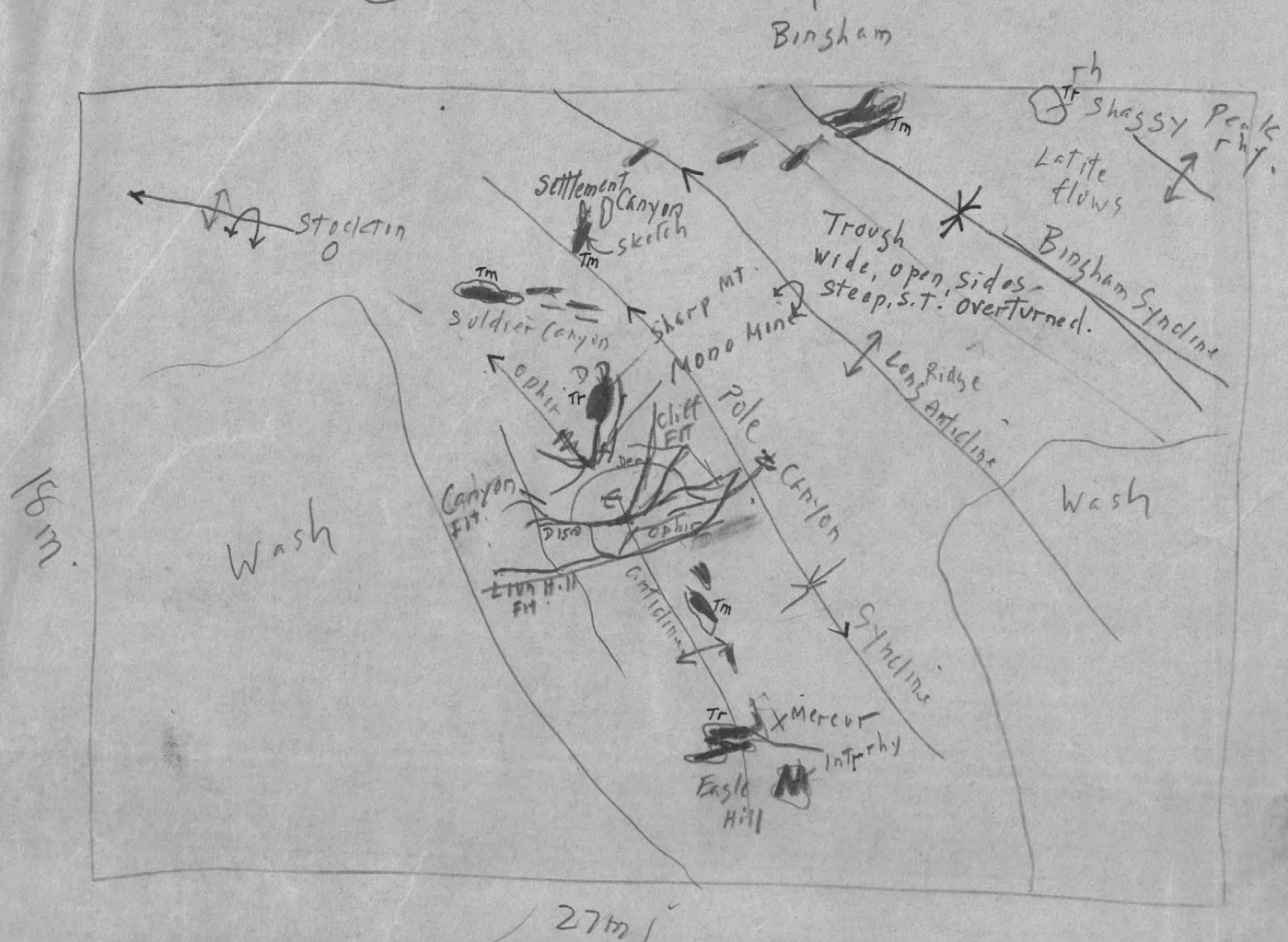
Letter by G.B. Wilson, EMJ 4-25-1908

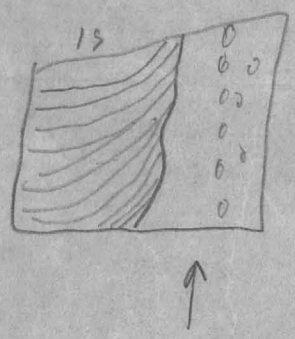
Geology. CR is stratified ls, strikes E-W, dips 65 N. Four thin strata of black ls (rest is gray) contain the orebodies. About 200-300' apart horizontally. Fissure system striking N-S, dipping 70 W cuts seds. Open, little filling except frags. Oxidation in fissures to deepest workings, but sulphs come in in OBs at 560' above this pt. Flting along these planes, W walls moved N. Some dikes roughly parallel the fissures

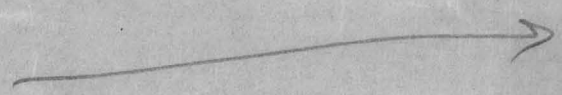
Ore sols traveled along fissures, but ore in fissures themselves in only two cases, and these are extensions of OBs, which occur normally at intersection of fissure and a black ls stratum. Most of each shoot lies on HW side of the fissure. Also replacement most extensive along HW of black ls stratum, giving a feathering out to the W. Indicates ascending solutions. All intersections of fissures with black ls not mineralized. Also all strata of black ls not mineralized where one or more are, but in general occurrence of OBs is uniform.

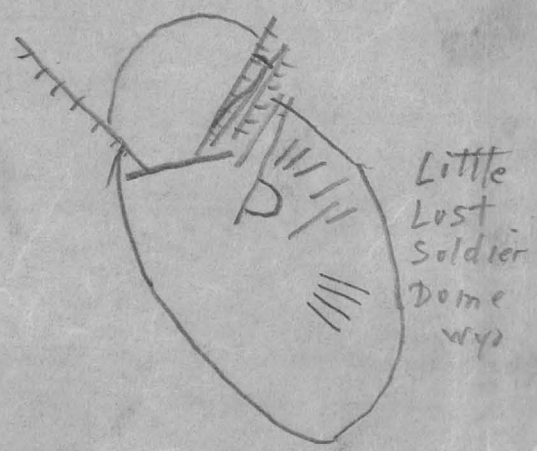
Maxfield Mine, Big Cottonwood Canyon near Salt Lake City, OBs at intersections of fissures with prominent black ls stratum in gray and white ls.

Canyon intrusive; W and SW of that mostly wash but there is a marked line of such intrusives trending SSE from near Stockton thru Ophir.









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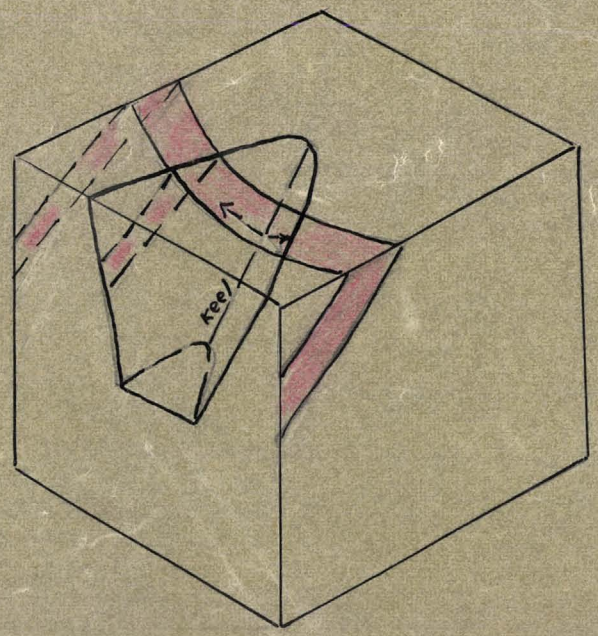
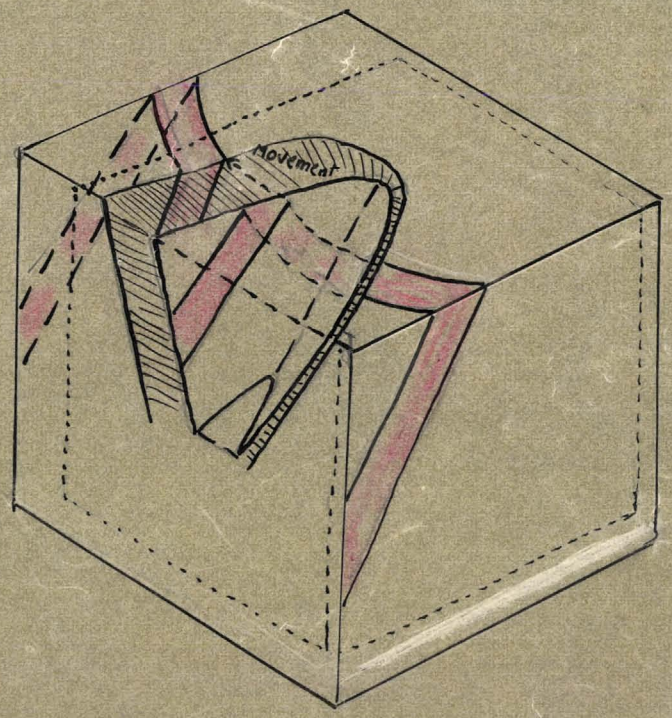
Face p. 1





MONO WEDGE-SHAPED FAULT BLOCK, OPHIR, UTAH.

Beds on north flank of Ophir Dome are dropped about 700' vertically within the fault block with respect to those outside the block, but striations on fault surface are normal to "keel". Mechanically impossible except as follows:

Horseshoe-shaped fault consisted originally of two radial tension fissures formed early in the doming; these joined to form the horseshoe. Cohesion in this part of the north flank of the dome was thus lost around this wedge. Doming, expansion, rising around the wedge continued, while the latter remained stationary in the absolute sense, or rose less than its surroundings, or perhaps dropped a little. Doming plastic, by stretching, flow. Frame of the wedge pushed upward normal to surface of dome and to the domed beds. Displacement as shown. Expansion of dome indicated by larger, solid-lined cube in second figure. Expansion of dome permitted the faulting around the wedge: loose keystone block mechanics.

DOME SUPERIMPOSED ON OLDER ANTICLINE

OPHIR, UTAH.

J.Gilluly:Geology and Ore Deposits of the Stockton & Fairfield Quadrangles, Utah.USGS PP 173, 1932.
B.S.Butler:Ore Deps.of Utah,USGS PP 111, 1920 374-382.

Thick section Paleo,mainly competent limestone,dolomotes,qtzites,

Dome appears to be a superimposed feature on Ophir anticline .Is a half-dome like Matehuala,faulted on S by series of step-faults dipping Sand therefore "normal".The zone is strictly local,genetically connected with the doming.Epaniclinal.Look up. Displacement at max opposite apex of dome;on W cut off by basin-and-range Lakes of Killarney fault,but to E they curve around uplift and die out.See figure. Premineral,but no ore.

Cliff fault,radial fault perp.to structural contours,but on S swings W to join Canyon fault at acute angle;cf.Calico. With regard to these and other faults connected with Ophir dome Gilluly demonsrate s that these faults are older than the end of the intrusive cycle,but younger than some igneous ac ivity;altogether time relations are close between intrusion,faulting and mineralization as postulated by Spurr.

Faults:...

Butler, (1920) p.376:"The important Ophir Canyon fault strikes north of east...and dips steeply south.The vertical force that domed the strat apparently caused them to break along the line of this fault and raised the portion to the north more than to the south...The displacement was greatest at the center of the dome and decreased both to the east and west."

"Fissures:The limestone was broken by fissures that trend generally north.They show little displacement and are imporrant chiefly as channel for the ore-bearing solutions..they appear to be most abundant near the crest of the anticline,and to decrease in importance as ..distance from the crest increases.This is..the condition that would be normal if they have resulted from bending of the limestone beds,for the crest of the anticline would be subjected to the greatest strain."

Lead-silver ore shoots within the dome commonly follow lines of intersection of favorable limestone beds with radial fissures,the ore making out into the ls on either side of the fissure,and also,as in the Cliff mine,forming tabular bodies ~~veinlike~~ replacing blocks of dolo & ls within the fissure zone

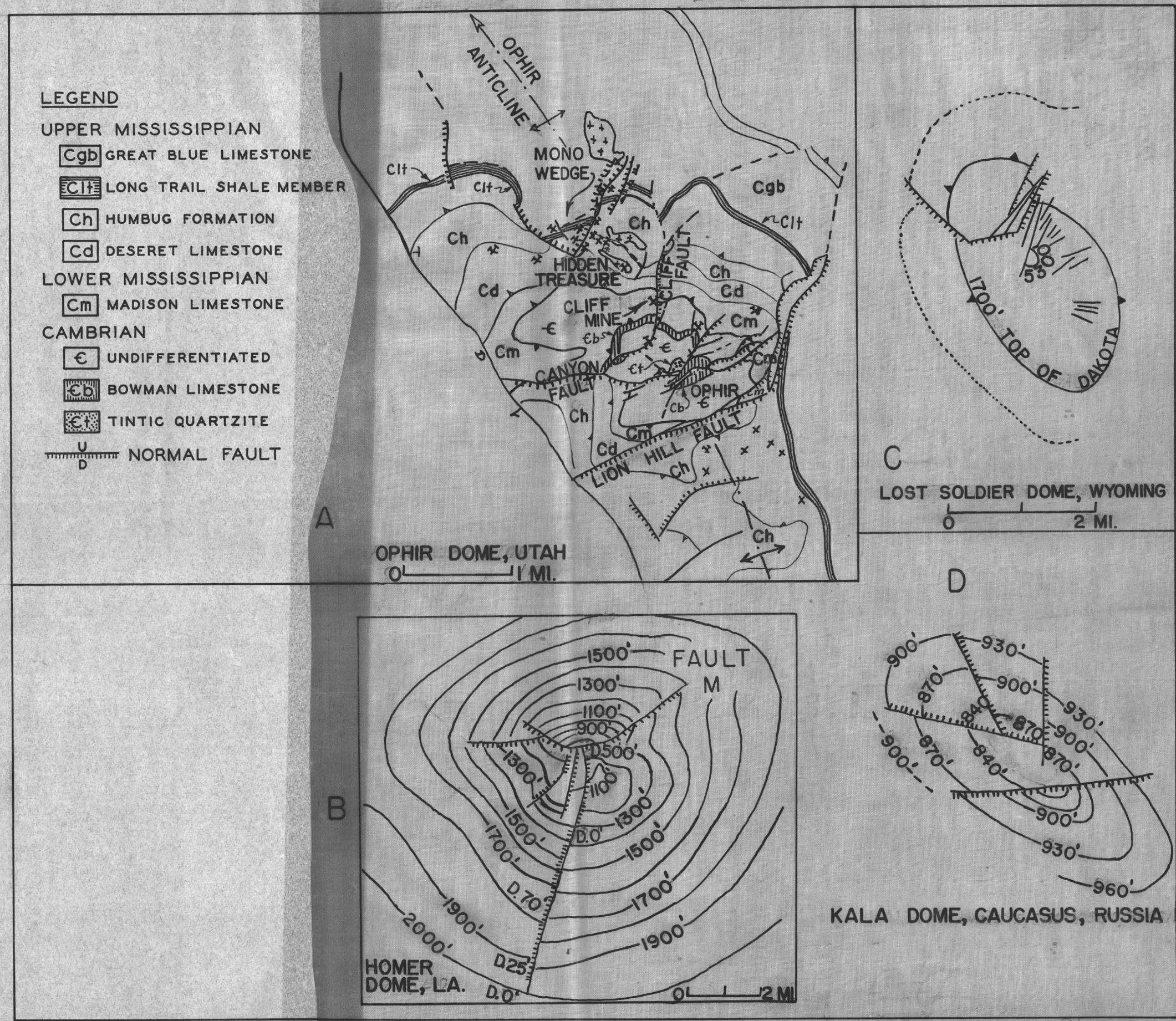
~~ixxeifx~~

Hidden Treasure group.among largest producers: In Madison ls.Strike N75E,dip 35N;on N flank of dome. All OBs localized on vert.N-S fissures, perp.to beds. Hidden Treasure shoot cropped out;just below surface diverged to N on radiating fissures unti.they were 300ft.apart. Ore made along these fissures at intersection with specific horizon in Madison,100' stratigraphically below basal shale of Deseret ls. S.t.100' high,tp 50' wide. Where as wide as this due to several subparallel fissures rather than a sibgle one. Pipes rather than blanket deps.

Chicago on E,pipes along fissures,no regard to any particular bed in the ls. At OC,about 200' below Hidden Treasure,on same fissure. Also splits along E and W fissures.

Mineralization on Cliff fault contains vugs,lined with anhedral pyrite & galena.

Wisser



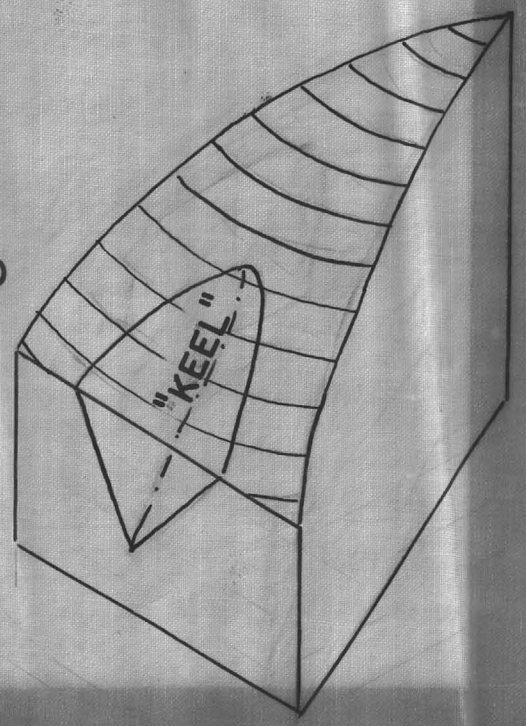
45.9

FIG. 5

MONO WEDGE
OPHIR, UTAH

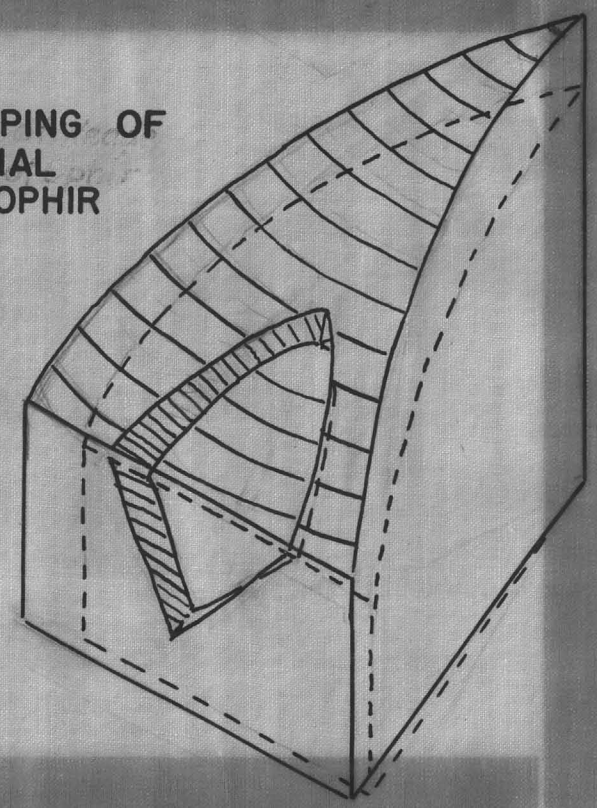
(A)

FORMATION OF MONO WEDGE- BEFORE FAULTING.



(B)

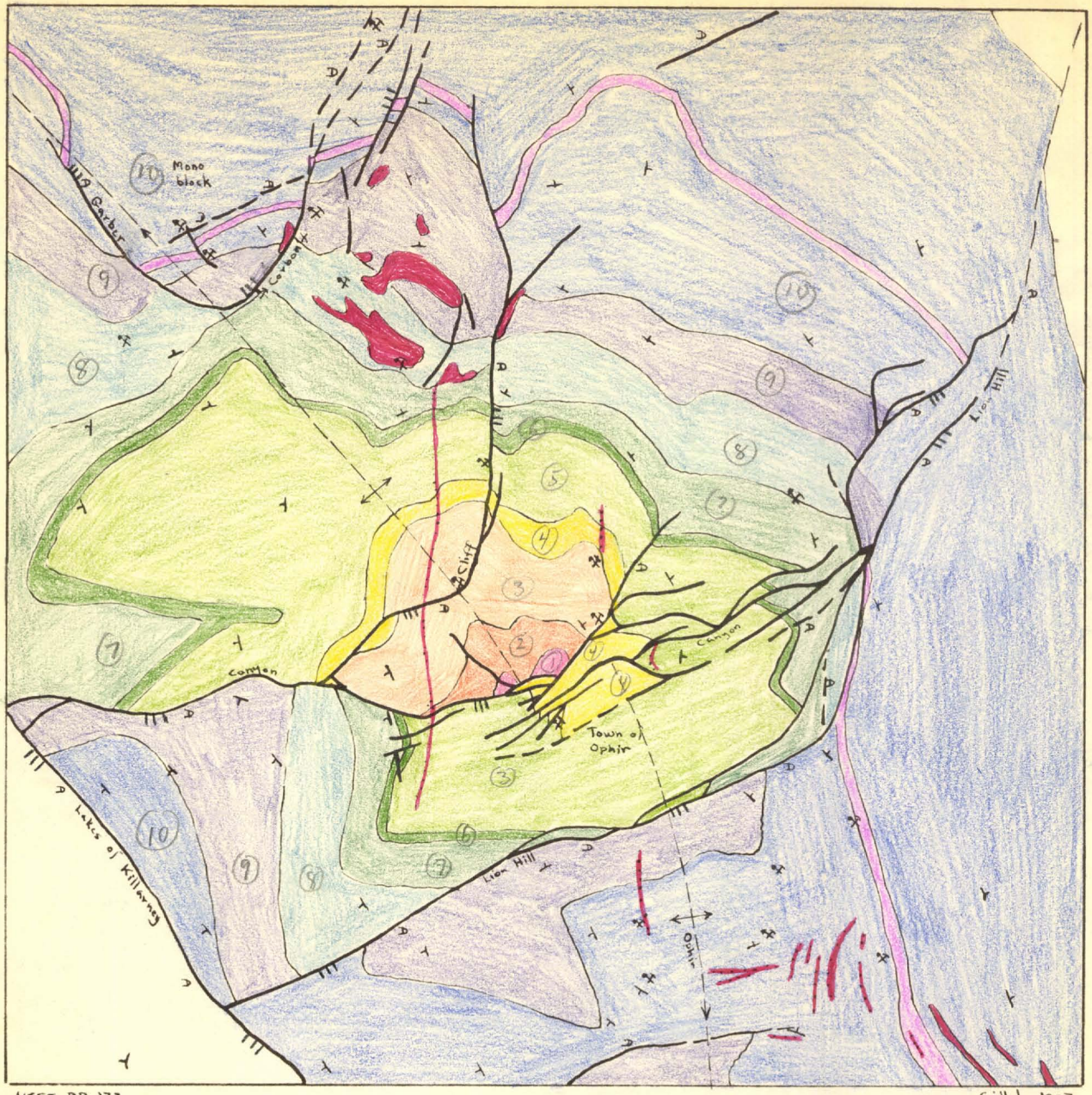
RELATIVE DROPPING OF WEDGE BY RADIAL EXPANSION OF OPHIR HALF DOME.

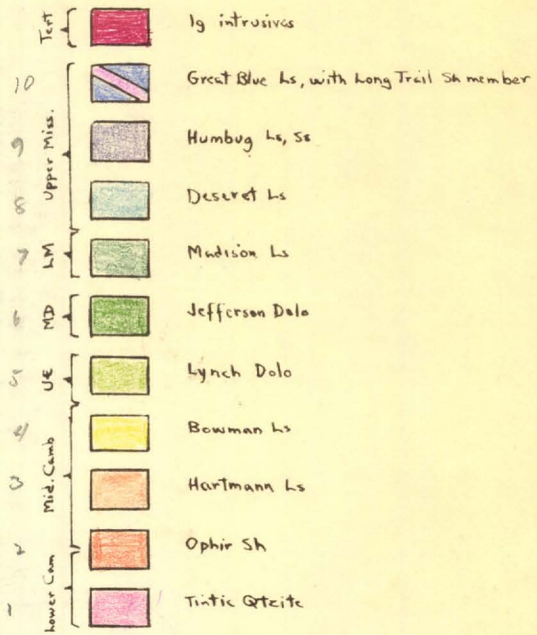


— 4" —

40.2

FIG. 6





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OPHIR AND DRY CANYON DISTRICTS,
OQUIRRH RANGE, UTAH

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R. I. 4181

JANUARY 1948

UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. KRUG, SECRETARY

BUREAU OF MINES
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REPORT OF INVESTIGATIONS

LEAD AND ZINC DEPOSITS OF THE TREASURE HILL MINES OPHIR MINING DISTRICT, TOOELE COUNTY, UTAH

BY

W. C. DUNHAM AND F. H. GUNNELL

R.I. 4181,
January 1948.

REPORT OF INVESTIGATIONS

UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

LEAD AND ZINC DEPOSITS OF THE TREASURE HILL MINES OPHIR MINING DISTRICT, TOOELE COUNTY, UTAH[1]

By W. C. Dunham[2] and F. H. Gunnell[2]

INTRODUCTION

The Treaure Hill mines, situated in Dry Canyon, Ophir mining district, Tooele County, Utah, together with several other properties in the district, were examined by Frank L. Wideman, an engineer of the Bureau of Mines, in September 1942.

In April 1945, development drilling was started on the Treasure Hill mines, which are operated under lease from the Madison Mines Co. The project was continued in 1946 and terminated in 1947.

While the Bureau of Mines project was in progress, the Morgan and Bullion tunnel workings were surveyed by Bureau engineers.

ACKNOWLEDGMENTS

In its program of investigation of mineral deposits, the Bureau of Mines has as its primary objective the more effective utilization of our mineral resources to the end that they make the greatest possible contribution to national security and economy. It is the policy of the Bureau to publish the facts developed by each project as soon as practicable after its conclusion. The Mining Branch, Lowell B. Moon, chief, conducts preliminary examinations, performs the actual investigative work, and prepares the final report. The Metallurgical Branch, O. C. Ralston, chief, analyzes samples and performs beneficiation tests. The work here described was under the direct supervision of Paul T. Allsman, chief, Salt Lake City Division, Mining Branch.

With particular reference to this publication, acknowledgment is given to F. L. Wideman, Millard Gilkey, and W. H. King, who supervised the project at various times. The maps were made by W. A. Young from surveys by F. L. Wideman, W. H. King, Millard Gilkey, and W. A. Young, and interpretations were furnished by F. H. Gunnell, and W. A. Young, all of whom are engineers of the Bureau of Mines. The operators were particularly cooperative during the life of the project. The Tooele County highway department was very cooperative in maintenance of the road to the mine, especially during the heavy s ows.

1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is made: "Reprinted from Bureau of Mines Report of Investigations 4181."

2/ Mining engineer, Salt Lake City, Utah.

SITUATION

The mine is near the head of a steep canyon known as Dry Canyon in the Oquirrh Range, Ophir mining district, at an altitude of 8,000 feet. Its legal description is the NE ¼, sec. 15, T. 5 S., R. 4 W. At this locality the winters are severe and the summers are mild. The area is reached by a mountain road extending for 9 miles between Stockton, Utah and the mine. Stockton is the supply and shipping point on the main line of the Union Pacific Railroad. The road to the mine is well-graded and serves for automotive transportation.

The most noted mine in Dry Canyon is the Hidden Treasure, owned by the U. S. Smelting, Refining & Mining Co. This mine is situated on the property adjoining the Treasure Hill (figs. 1 and 2).

MINING HISTORY AND PRODUCTION

The first ore discovery in the district was made on the St. Louis lode (Hidden Treasure) in 1865 by United States soldiers stationed near Stockton. Other discoveries followed in rapid succession, and several productive mines were developed prior to 1900. A total value of ore produced from mines in the Ophir-Rush Valley area between 1870 and 1927 was $43,060,411. During this early period of mining activity, it is reported by old residents of the area that the Thad Stevens, Bullion, and Deseret workings on the Treasure Hill property produced a small tonnage of ore.

The Treasure Hill property was located and patented by Selah Chamberlain. A recent period of activity on the property commenced in the 1930 decade. Exploration and development were initiated under the leadership of N. G. Morgan and associates, who operated the White Bullion and Madison Mines companies. This activity involved development in the Bullion workings and the Morgan tunnel. In 1940, The Treasure Hill Mines Co. continued development of the property. This company sank the Paulson incline from the 160-foot sublevel of the Morgan tunnel and the No. 4 incline from the Morgan tunnel level and shipped 1,167.65 tons of ore from this development. The Bureau of Mines work was undertaken at the instance and with the cooperation of the Treasure Hill Mines Co. A record of production of the property by this company is given in table 1.

TABLE 1. - Production

Year	Cars	Tons	Ounces		Pounds		
			Au	Ag	Pb	Zn	Cu
1943...	10	531.714	15.950	7,913	54,507	18,340	29,020
1944...	10	533.732	19.144	7,318	44,935		31,186
1945...	2	102.212	4.506	1,985	10,107		6,929
Total	22	1,167.658	39.600	17,216	109,549	18,340	67,135

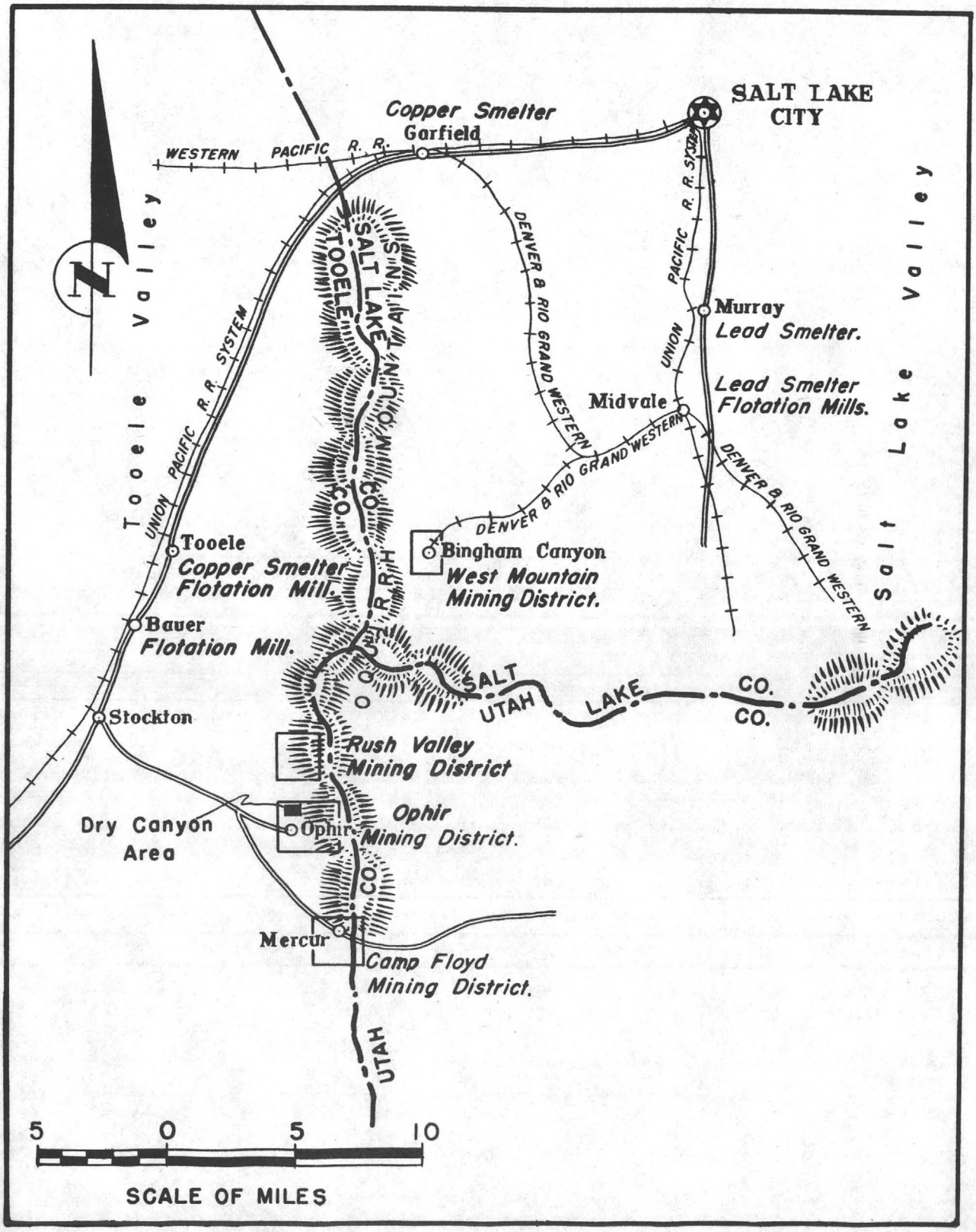

Figure 1. - Location map, Dry Canyon area, Ophir mining district.

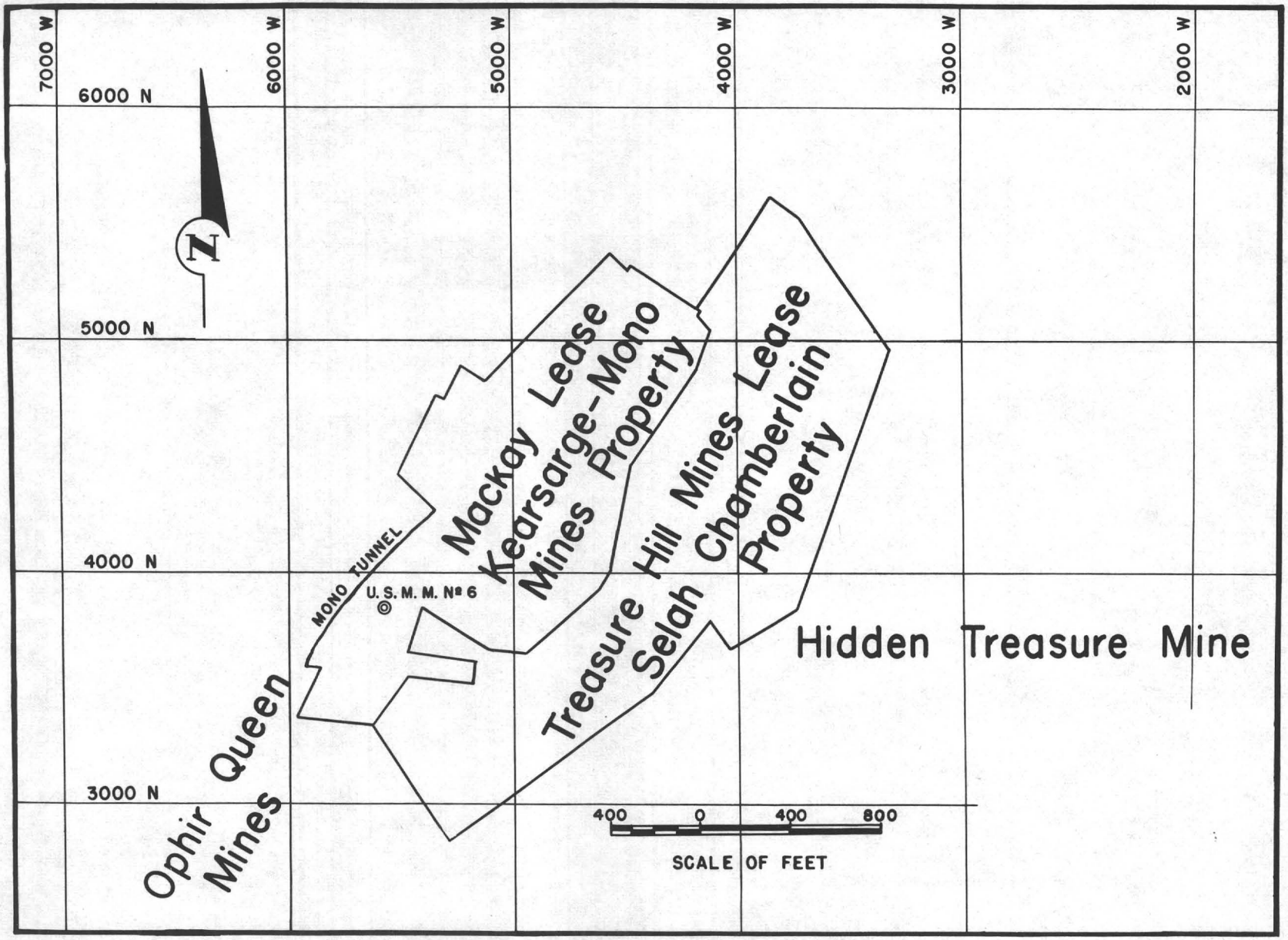

Figure 2. - Property map, Treasure Hill and Mono mines.

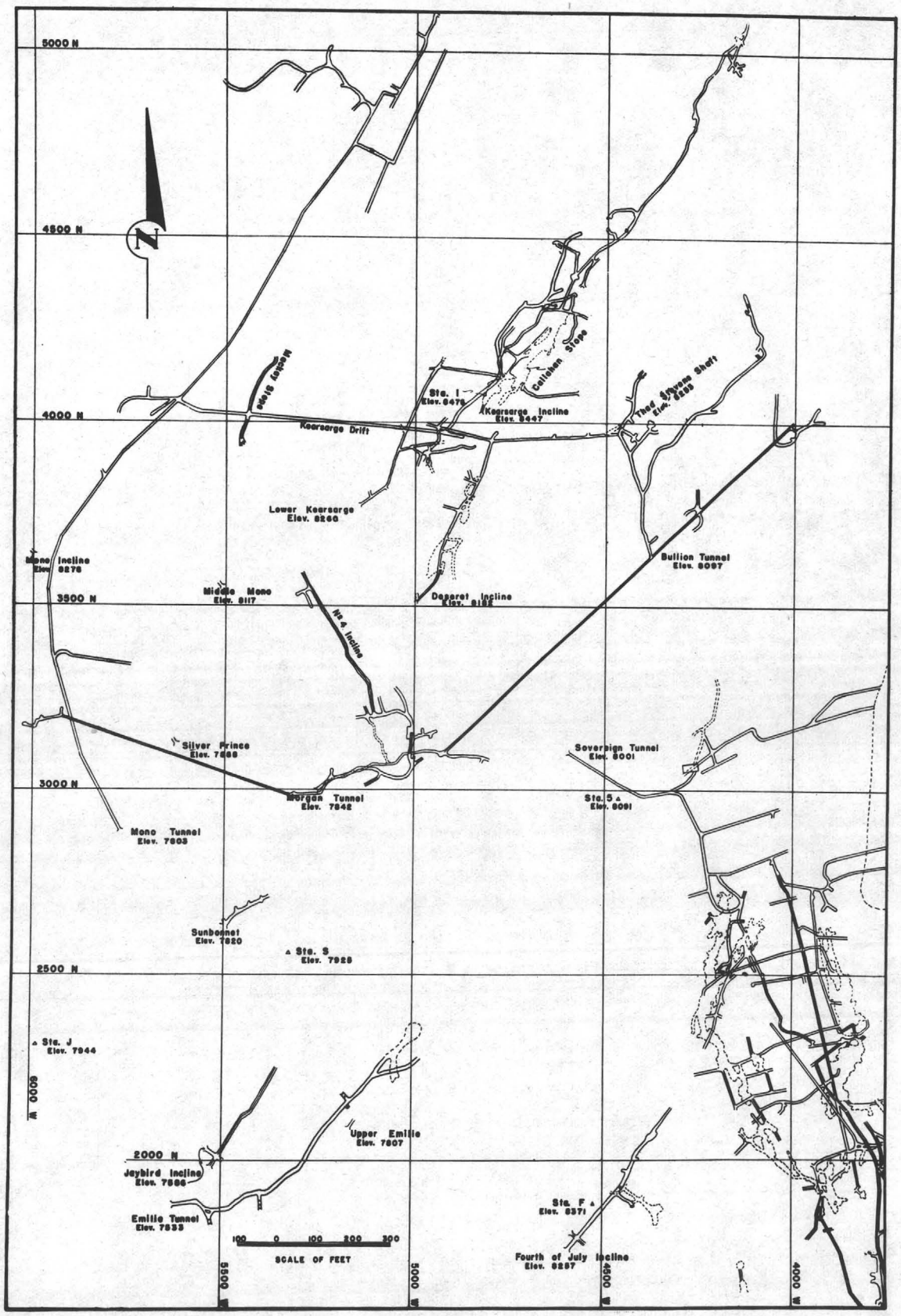

Figure 3. - District underground map, Dry Canyon area, Ophir mining district.

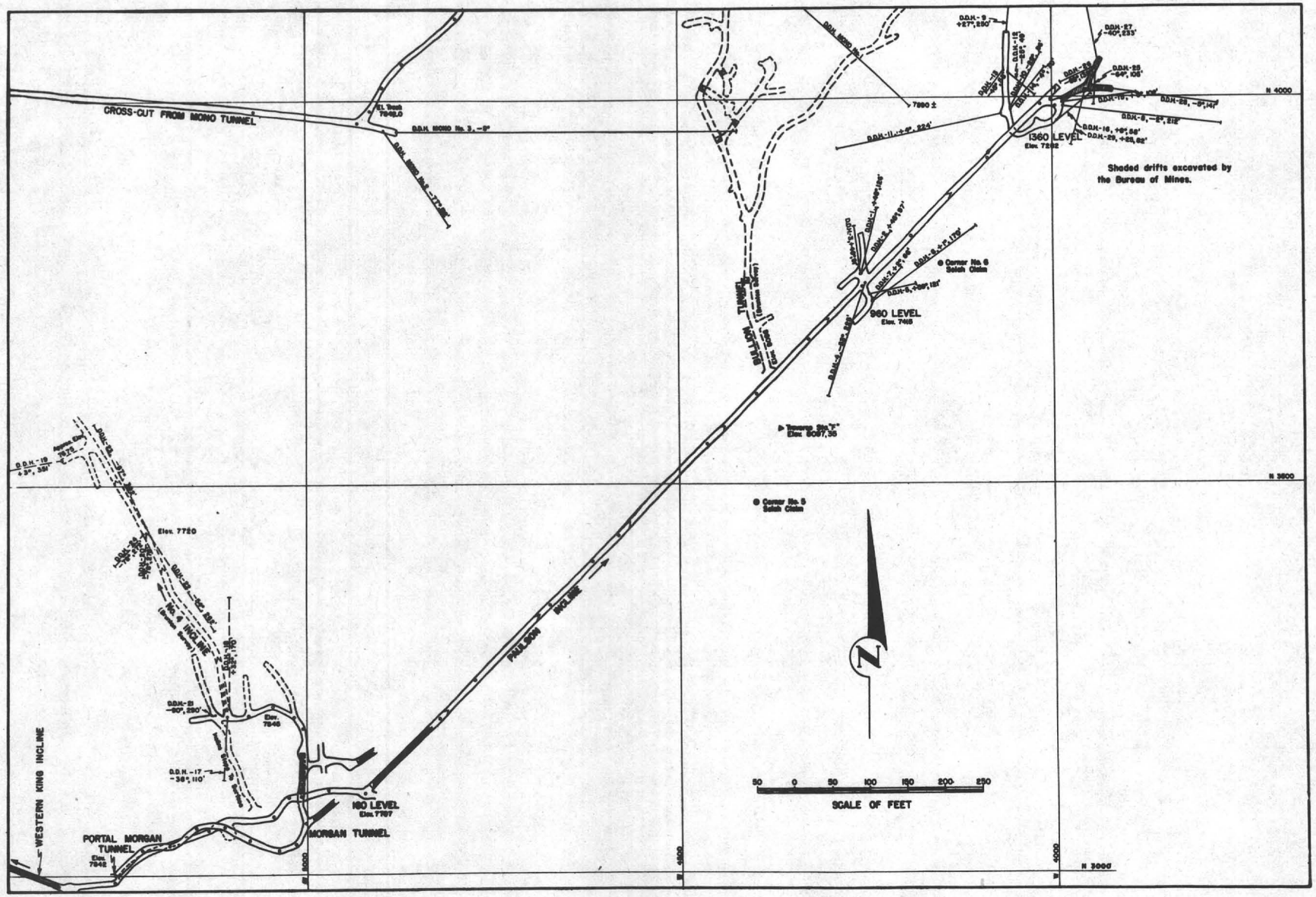

Figure 4. - Underground and drilling map, Treasure Hill mine.

PROPERTY AND OWNERSHIP

The Treasure Hill Mines Co. was formed in 1940 to operate the Selah Chamberlain property. The mining claims in this property are the Selah, Thad Stevens, Arabella, Azure Queen, Shoo Fly East, and Shoo Fly West, containing a total of 57.246 acres (fig. 2). These claims are owned by the Selah Chamberlain estate, which has offices in the Russ Building, San Francisco, Calif. The owners granted a lease and option to purchase these claims to the Madison Mines Co., which in turn has granted a 30-year lease to the Treasure Hill Mines Co.

DEVELOPMENT

The Treasure Hill mines include three main workings - the Morgan and Bullion tunnels and the Thad Stevens shaft (figs. 3 and 4). The Morgan tunnel level is 600 feet long, and from it have been driven several small winzes, drifts, crosscuts, and raises. At a point 390 feet from the portal in the Morgan tunnel, an inclined winze extends to the 160-foot level. This level is a drift 440 feet long, with the Western King inclined winze on the west and the Paulson inclined winze on the east. The Paulson winze extends down the Madison-Deseret contact northeasterly to a total length of 1,360 feet. The Western King incline extends northwesterly 665 feet. A small inclined stope extends from near the face of the Morgan tunnel, up the dip of the beds, along a fissure to the surface, and down dip for 440 feet.

The Bullion tunnel, at an altitude of 8,097 feet, is about 250 feet in altitude above the Morgan tunnel level. The Bullion is a main tunnel approximately 180 feet long, from which extend two drifts or branches. The northeasterly branch is approximately 700 feet long, and the northerly branch is approximately 350 feet long.

The northerly branch of the Bullion is associated with a small area of stopes and is connected with the inaccessible Thad Stevens mine. The main workings of the Thad Stevens is a caved shaft.

In addition to the three main mines of the Treasure Hill property, there are several small workings, and the portal of another important adjoining mine is on the Selah Chamberlain property.

DEVELOPMENT BY THE BUREAU OF MINES

The initial work by the Bureau of Mines in the Treasure Hill mines consisted of diamond drilling from the upper adit level. This work was followed by mapping, diamond drilling, and drifting and crosscutting in the area at the bottom of the Paulson incline. Illustrations of the work are shown on figure 4, and diamond-drilling results are given in appendixes I and II. Two of the diamond-drill holes extending into the Bullion-tunnel area were drilled from the adjoining Mono property by the Bureau. One of these holes, Mono 1, encountered ore on the boundary of the Treasure Hill property. The logs and footage of these two holes are tabulated in the Kearsarge drift report. The total footage of exploration and development completed is outlined in table 2.

TABLE 2. - Work performed by the Bureau of Mines in the Treasure Hill mines

Units	Type	Total footage
29	Diamond-drill holes	5,092
2	Drifting and crosscutting	136

Samples were taken for analysis of the mineralized cores and exposures in the drifts and crosscuts. These samples were assayed in the Salt Lake City laboratory of the Bureau of Mines.

GEOLOGY

The Treasure Hill mines occur in the Madison limestone and Deseret formation of Mississippian age. The Madison limestone in general is a massively bedded, fine-grained, dark bluish-gray limestone with some dolomitic and cherty members. Overlying the Madison is the Deseret formation. The Deseret formation is composed of a variety of limestone members interbedded with shale beds. The attitude of the beds in the two formations is approximately parallel in the mine area.

A section of Madison and Deseret measured by Gilluly3/ is quoted as follows:

Section of Deseret limestone on north side of Ophir Creek

(West from a point about 200 feet north of the St. John & Ophir Railroad, west of the Cliff mine loading bins. Strike N. 40° W., dip 38° SW.)

Humbug formation: Brown, fine-grained, 2-foot quartzite at the base.
Conformable contact.
Deseret limestone: Feet

1. Dark-blue fine-grained limestone with much black chert and some red-weathering shale. The chert nodules and lenses range from half an inch to 3 inches in thickness and occur at stratigraphic intervals of 2 to 3 inches near the base. The limestone contains large nodules of white calcite a quarter of an inch to 4 inches in diameter, distributed irregularly. Toward the top the member becomes more sandy, and sand beds 3 to 4 inches thick appear 131
2. Massive, light-blue, coarsely crystalline limestone weathering light gray. Blocky, poorly bedded, very fossiliferous, carrying many crinoid stems as well as other fossils 13
3. Thin-bedded, limy, poorly laminated shale, carrying large amounts of chert 3
4. Limestone like bed 2 20

3/ Gilluly, James, Geology and Ore Deposits of the Stockton and Fairfield Quadrangles, Utah: U. S. Geol. Surv. Prof. Paper 173, 1932, pp. 23-25.

		Feet
5.	Massive-bedded blue limestone not noticeably fossiliferous; weathers brown in patches owing to small amounts of irregularly distributed sand. Becomes more sandy and cherty upward	168-1/2
6.	Poorly exposed thin-bedded, somewhat sandy limestone	138
7.	Massive, blocky, sandy limestone; beds range from 8 inches to 3 feet in thickness and weather brown but are dark blue-gray on fresh fracture	30
8.	Poorly exposed, cherty, blue limestone	137-1/2
9.	Poorly exposed, black, red-weathering shale with a phosphatic oolite bed at the top	9
		650

Conformable contact.
Madison limestone, very cherty toward the top.

Section of Madison limestone on ridge east of Buckhorn mine

(Strike N. 60° W., dip 28° N.)

Deseret limestone: Dense, blue-gray limestone with a soft carbonaceous and phosphatic shale at base.
Conformable contact.
Madison limestone:

		Feet
1.	Very cherty blue-gray limestone. The black chert is arranged in lenses, which average 6 inches apart stratigraphically and are as much as 6 feet long and 3 inches thick	55
2.	Gray, blocky limestone in beds averaging about 2 inches thick. The member is much veined with calcite and is more coarsely granular than bed 1. Little or no chert is present	29
	Fault of unknown but probably slight displacement.	
3.	Cherty blue-gray limestone, rather massive below, somewhat thinner-bedded above. Black chert lenses occur within the individual limestone beds as well as between them. The chert lenses are spaced perhaps 2 feet apart stratigraphically and range from knife edges to 2-1/2 inches in thickness and several feet in length. The limestone beds are considerably broken and recemented with white calcite. The member forms a ledge	109-1/2
4.	Very light bluish-gray, dense limestone, very fossiliferous, pure except for subordinate brown shaly streaks, thin-bedded at the base, where the beds range from 1 to 5 inches in thickness, but becoming thicker-bedded and somewhat more coarsely crystalline upward. Some of the beds near the top are as much as 8 feet thick	268-1/2
		462

Irregular surface of unconformity.
Jefferson (?) dolomite: Light-gray dolomite at top.

Horizons in this stratigraphic sequence of economic importance are referred to stratigraphic positions indicated in the following section.

Formation members, Gilluly classification	Horizon name	Approximate position	Economic elements
Unit 1-Deseret formation(?)	Thad Stevens(?)	Top part of formation(?)	Ag-Pb
Unit 3-Deseret formation	Mackay	530 ft.± above formation base	Ag-Pb-Zn-Cu
Unit 7-Deseret formation	No. 4	150 ft. - 180 ft.± above formation base	Ag-Pb-Zn-Cu
Unit 8-Deseret formation	Mercur Dome (vanadium)	20 ft.± above formation base	V
Unit 9-Deseret formation	Phosphatic oolite	5 ft.± above formation base	P
Unit 1-Madison limestone	Hidden Treasure	Top part of formation	Ag-Pb-Zn-Cu
Unit 3-Madison limestone	Fourth of July	300 ft.± above formation base	Ag-Pb
Unit 4-Madison limestone	Buckhorn	Basal part of formation	Ag-Pb

In the Teasure Hill mines, ore has been shipped from the Thad Stevens, No. 4, and Hidden Treasure stratigraphic ore horizons. The Mercur Dome vanadiferous shale and phosphatic oolite horizons have been cut in the Morgan tunnel unit of the mines. At the place of exposures of these beds in the workings, the tenor of the vanadiferous shale and phosphatic oolite is too low for current consideration of their exploitation. These beds are useful as key markers for correlation purposes.

The relationship of the workings to the stratigraphy is shown on figures 5, 6, 7, 8, and 9.

In the Bullion mine, a mass of rhyolite porphyry, subtabular in horizontal outline, classified as a dike, occurs along the west side of the Bullion tunnel (fig. 5). The dike is cut by the north branch of the Bullion tunnel, and along the easterly branch of the Bullion tunnel the dike is in contact with limestone.

In the north crosscut at the lower end of the Paulson-incline unit of the Morgan tunnel is an exposure of contact metamorphic limestone grading into an intrusive. This exposure is indicative of intrusive igneous rock in the vicinity (fig. 6). This type of metamorphosed limestone was encountered in several of the diamond-drill holes from stations in the lower end of the Paulson incline.

There are several exposure of rhyolite porphyry on the surface of the Treasure Hill property, but these cannot be described because the surface was not mapped.

The regional structure of the area is formed by a series of northerly dipping strata with an average dip of 30°. This structure is modified in the Bullion mine area by a porphyry intrusion. The Bullion tunnel and its easterly branch traverse a fault system ranging in strike from slightly west of north, near the tunnel portal, to northeasterly in the northeast part of the workings and dips easterly at a high angle. This fault system is subparallel to the rhyolite porphyry dike and along the hanging wall of the dike. A strongly brecciated zone containing two fissure systems, and one striking northerly

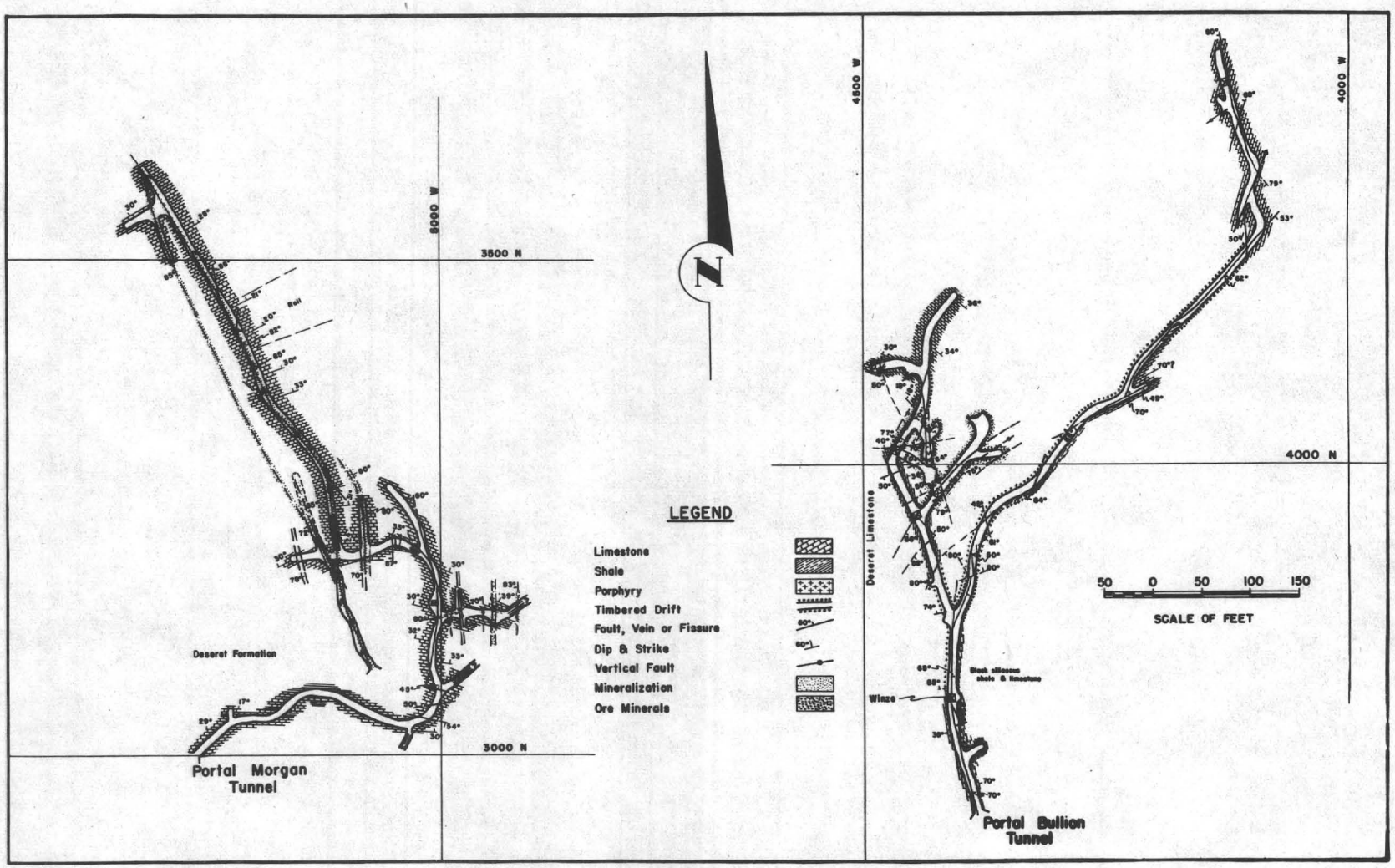

Figure 5. - Geologic plan map, Morgan and Bullion tunnels, Treasure Hill mine.

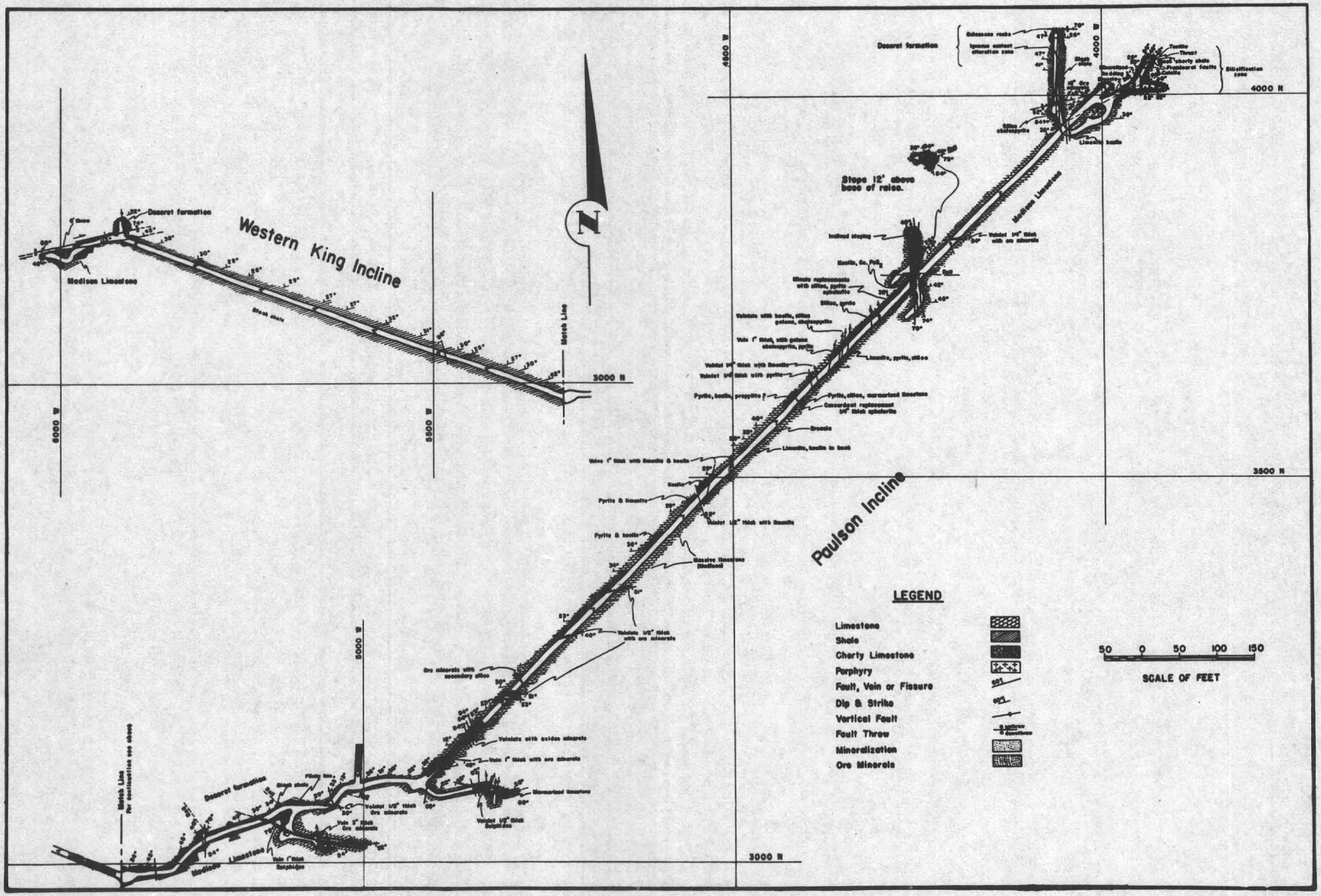

Figure 6. - Geologic plan map, 160 level, Treasure Hill mine.

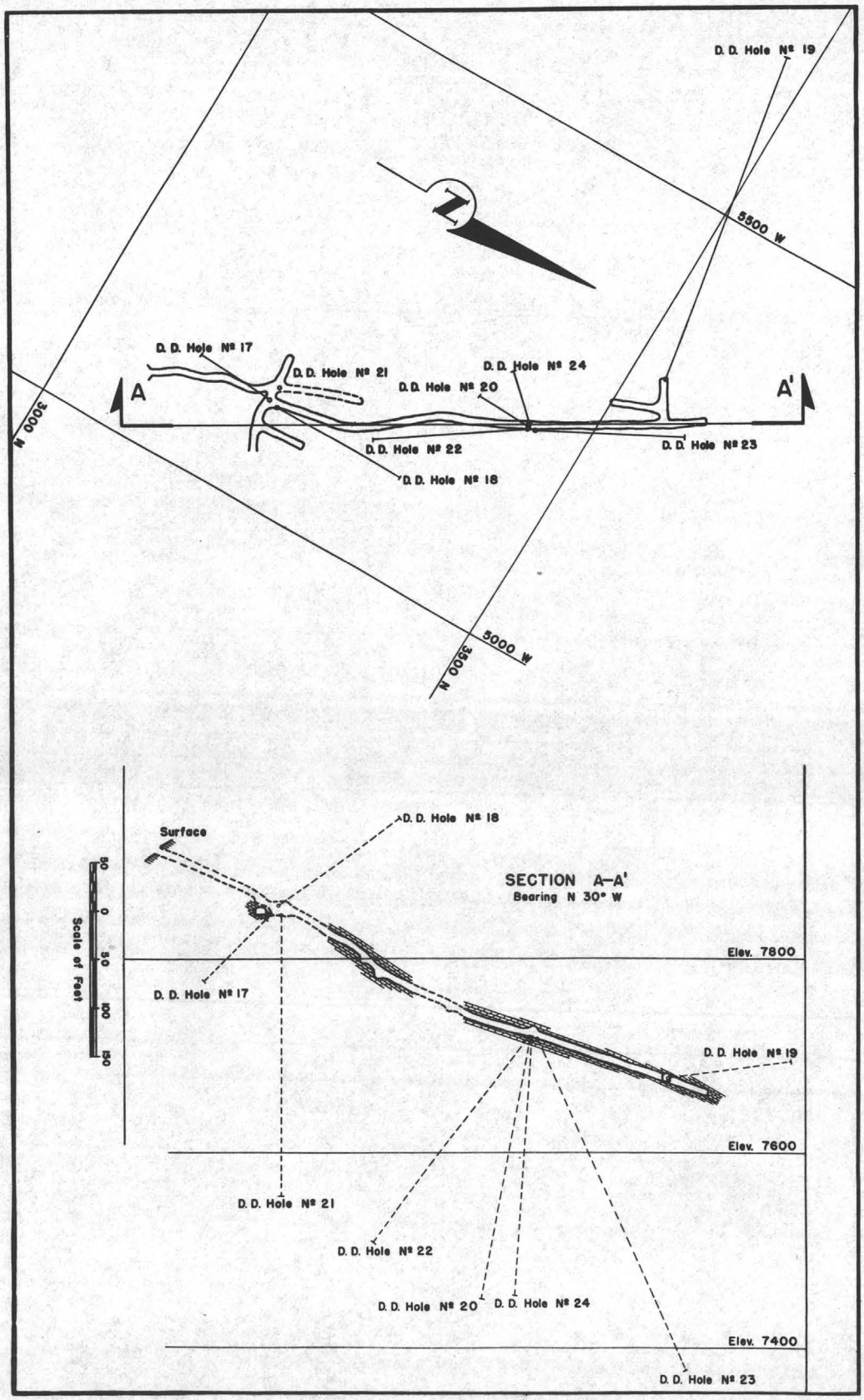

Figure 7. - Plan and section, No. 4 incline, Treasure Hill mine.

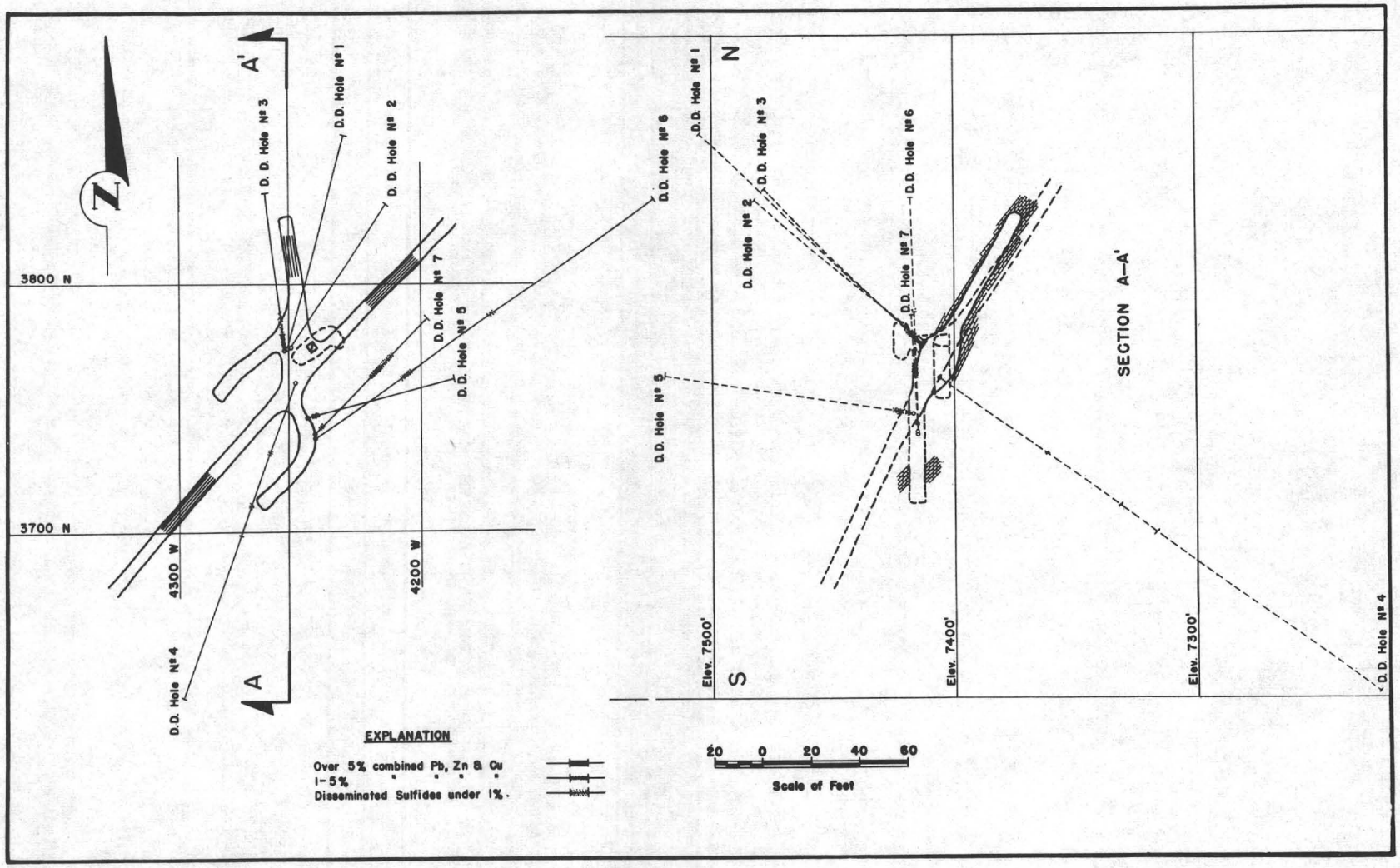

Figure 8. - Plan and section, 960 level, Treasure Hill mine.

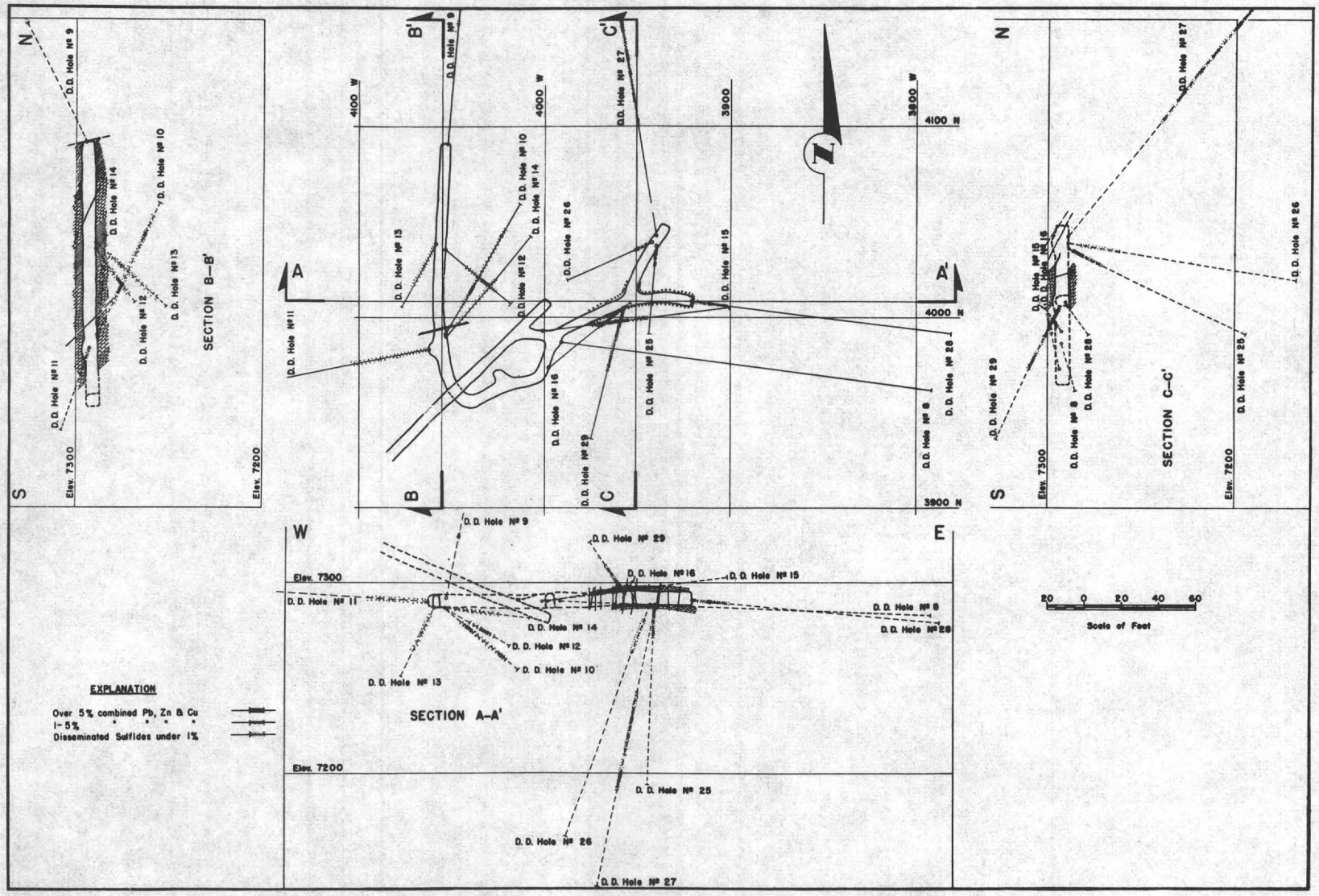

Figure 9. - Plan and section, 1,360 level, Treasure Hill mine.

and the other easterly, occurs in the north-branch area of the Bullion tunnel on the footwall side of the rhyolite porphyry dike.

In the Morgan tunnel workings, the beds conform to regional structure with some local variations. The major variations are two rolls and three fault systems. These rolls are subparallel to the strike of the beds at N. 75° E. One occurs on the 960 level of the Paulson incline and is manifest crossing the No. 4 incline and at the bottom of the Western King incline, where it is broken and becomes a thrust fault with a 4-foot displacement. The other roll is exposed in the bottom of the Paulson incline and extends along the strike of the beds. There are four significant fault systems. One is exposed in the Deseret formation on the Morgan tunnel level and No. 4 incline. This system ranges in strike from north to northwest and dips westerly at a high angle, but it is not strongly manifest in the Madison in the lower workings. The ore in the bottom of the No. 4 incline on the adjoining property appears to be controlled by this fault system. A second fault system ranges in strike from north to northeast with a dip essentially vertical. The exposed faults of this second fault system are of small displacement and can be seen on the 960 level of the Paulson incline. This system appears important as an ore control. A third fault system with an easterly strike and a northerly dip is exposed in the north crosscut at the bottom of the Paulson incline. This system appears significant as channels for mineralizing solutions.

On the 160 level of the Morgan tunnel workings, a southeasterly striking fissure system containing ore minerals is exposed. This is representative of the fourth fault system. All of these structural features are illustrated on figures 5 and 6.

These faults and fissures were too small for the formation of large ore deposits in the explored areas.

Aside from the moderately intense contact mineralization in the area at the bottom of the Paulson incline in which garnet, diopside, collophane, and wollastonite were developed, the strength of mineralization as observed elsewhere is classified as weak. This is indicated by small amounts of silica, kaolin, and pyrite observed in the explored areas and the virtual absences of sericite, hydromuscovite, propylite, or other minerals characteristic of more intensely mineralized mines.

The more mineralized areas of the Morgan unit, based on geological inference, are as follows:

1. The contact metamorphic area at the bottom of the Paulson incline.

2. The areas in the No. 4 horizon intersected by northerly striking fissures such as at the No. 4 incline, the Thad Stevens fissure, the 960 level fissures, and the 1360 level fissures. The Mackay horizon at these same fissure intersections also may be mineralized.

3. The down-dip extensions on the Madison-Deseret contact along the northerly striking fissures.

In the Thad Stevens-Bullion unit, some oxidized lead-zinc-silver ore occurs as scabs on the small stopes, and galena remnants occur intermittently in this area along the Thad Stevens fissure zone. In diamond-drill hole Mono 1, a fissure was encountered that contained a 1-foot thickness of low-grade ore. This is probably a downward and northerly extension of the Thad Stevens mineralization. The most intensely mineralized area in the Thad Stevens-Bullion workings appears to be along the strike and dip of the Thad Stevens fissure zone (figs. 5 and 6).

Sulfide deposits in the Treasure Hill mines include pyrite, argentiferous galena, and sphalerite. These deposits are of uncertain economic value because of their small size, tenor, and position. Small veinlets and sparsely disdeminated deposits of these minerals occur intermittently throughout the mines, as shown on the geologic maps. The greatest abundance of metallic minerals occurs in the areas of the lower Paulson and No. 4 inclines. In these areas occur small filled fissures, veinlets, and small bedded replacements consisting of sulfide-ore minerals.

The ore minerals have been injected into the sedimentary host rocks and may have a genetic relationship with the porphyry intrusions. It appears that the localization of ore minerals is determined by structural, stratigraphic, and mineralizing factors. The factor of secondary enrichment appears of little importance, because oxidation of the ore minerals penetrated the area a relatively short distance.

Structurally the area of ore deposition appears to be determined by the intersection of the northerly striking fissures with the northeasterly striking fissures in the vicinity of a warp or roll in the strata. Stratigraphically, the favorable beds for ore deposition are those horizons listed in the section on stratigraphy. At least two of these horizons occur in the property, one at the top of the Madison and another about 180 feet above the base of the Deseret formation. In a regional consideration, the strength of mineralization increases down the dip along favorable structural and stratigraphic zones.

APPENDIX I. - DIAMOND DRILL LOGS

Hole 1
Coordinates: 3772 N., 4256 W.
Elevation: 7,415 feet
Bearing: N. 15° E., Dip: +46°
Depth: 126 feet

Feet From-	Feet To-	Description
0	4	Siliceous blue limestone
4	15	Altered blue limestone
15	21	Highly altered white limestone with calcite, hematite, rhodachrosite, and small amount lead carbonate
21	23	Altered blue limestone
23	26	Altered blue limestone mineralized
26	28	Altered blue limestone
28	34	Altered blue and white limestone
34	38.5	Altered mineralized white limestone
38.5	44	Altered blue limestone
44	51	Altered white limestone
51	54	Green to blue limestone
54	60	Siliceous gray and white limestone
60	74	Blue limestone
74	126	Black argillaceous limestone interbedded with black shale

Hole 2
Coordinates: 3772 N., 4256 W.
Elevation: 7415 feet
Bearing: N. 36° E., Dip: +45°
Depth: 97 feet

0	5	Mineralized limestone
5	34	Limestone brecciated at 15 feet, fault at 28 feet
34	40	Mineralized limestone (breccia zone)
40	62	Limestone
62	76	Limestone (breccia zone)
76	80.5	Mineralized black shale
80.5	84	Limestone
84	88	Limestone (breccia zone)
88	97	Limestone

Hole 3
Coordinates: 3772 N., 4256 W.
Elevation: 7,415 feet
Bearing: N. 7° W., Dip: +46°
Depth: 90.5 feet

Feet From-	Feet To-	Description
0	4	Gray banded limestone, several zinc-sulfide and lead-sulfide stringers
4	9	Do.
9	18	Mainly gray limestone, some banding and sulfides banding at 60° to 70° with hole
18	38	Dense blue limestone, small stringers of calcite, little mineralization
38	39	± 50 percent calcite in irregular streaks, also blue and gray limestone, some crystalline
39	48	Gray and blue limestone, partly crystalline, some banding at 55°, a few small calcite stringers
48	58	Dense blue limestone (mainly), some crystalline, calcite in irregular stringers and spots
58	65	Gray crystalline limestone, traces of lead sulfide
65	73	Blue limestone, calcite stringers
73	78	Blue shale, irregular calcite stringers
78	90.4	Dense blue limestone, calcite stringers
90.4	90.5	Blue shale

Hole 4
Coordinates: 3760 N., 4252 W.
Elevation: 7,410 feet
Bearing: S. 20° W., Dip: -53°
Depth: 225 feet

0	4	Fossiliferous blue crystalline limestone with stylolites
4	9	Do.
9	46	Do.
46	76	Do.
76	92	Do.
92	124	Do. Fault at 108 feet
124	159	Do.
159	184	Do.
184	200	Do.
200	225	Do.

Hole 5
Coordinates: 3746 N., 4245 W.
Elevation: 7,418 feet
Bearing: N. 79° E., Dip: +59°
Depth: 121 feet

Feet From-	Feet To-	Description
0	4	Limestone, gray, little calcite
4	9	Limestone, gray, some banding at 75°, considerable zinc sulfide and lead sulfide in stringers
9	52	Limestone, gray, some greenish gray to greenish blue, calcite stringers, little mineralization
52	57	Limestone, greenish blue with calcite stringers
57	62	Limestone, gray, some banding at 75° to 85°
62	72.6	Limestone, blue with calcite giving mottled appearance (brecciation?)
72.6	88.7	Limestone, dark gray to black, calcite stringers
88.7	90.7	Limestone, dark gray, crystallized
90.7	95	Limestone, dark gray to light gray
95	99	Shale, black
99	104.5	Limestone, gray, calcite streaks, solution cavities
104.5	121	Limestone, gray, few calcite stringers

Hole 6
Coordinates: 3736 N., 4240 W.
Elevation: 7,418 feet
Bearing: N. 55° E., Dip: +1°
Depth: 170 feet

0	4	Limestone, dark gray to black
4	44.5	Limestone, dark gray to black, some crystalline
44.5	47	Limestone, gray, irregular zinc sulfide and lead sulfide, also showing iron and copper oxide
47	60	Limestone, dark gray to blue, cut by thin calcite stringers at 90° with bedding and apparently striking north. These stringers carry strong zinc sulfide and lead sulfide mineralization.
60	87.5	Limestone, gray, greenish gray and black, some calcite in stringers
87.5	88.3	Limestone, greenish gray, a few zinc sulfide and lead sulfide stringers
88.3	117.5	Limestone, greenish gray, some calcite stringers
117.5	158.5	Limestone, black, with calcite stringers
158.5	170	Limestone, black and greenish black, with calcite from 1 in. to 4 in. wide

Hole 7
Coordinates: 3739 N., 4240 W.
Elevation: 7,418 feet
Bearing: N. 45° E., Dip: +2°
Depth: 66 feet

Feet From-	Feet To-	Description
0	3	Limestone, dark gray to black
3	33.5	Limestone, dark gray to black, some crystalline, little calcite, 1 in. of zinc sulfide and lead sulfide at 5 feet
33.5	37.5	Limestone, gray and greenish black, several stringers of zinc sulfide and lead sulfide
37.5	66	Limestone, gray and greenish gray, little calcite, some zinc sulfide and lead sulfide at 39, 43, and 45 feet

Hole 8
Coordinates: 3988 N., 3985 W.
Elevation: 7,285 feet
Bearing: S. 83° E., Dip: -2°
Depth: 212 feet

0	3	Limestone, gray, considerable white crystalline calcite, some zinc sulfide and lead sulfide at 3 feet
3	212	Limestone, greenish black, little mineralization, very few calcite stringers, crystalline. Several open fissures between 10 feet and 30 feet.

Hole 9
Coordinates: 4084 N., 4060 W.
Elevation: 7,286 feet
Bearing: N. 6° E., Dip: +27°
Depth: 250 feet

0	3	Limestone, light gray, some banding, spotted with iron oxide
3	7.6	Limestone, dense, blue, calcite in bands and stringers
7.6	16	Limestone, blue and white, mottled with calcite
16	24	Limestone, blue dense, irregular calcite stringers
24	29	Limestone, dark gray, some calcite on bedding and in irregular stringers
29	32	Limestone, blue and white, shaley
32	61	Limestone, bluish gray to blue, mostly dense, some crystalline, some calcite mostly along bedding
61	67.7	Limestone, gray crystalline
67.7	103.7	Limestone, blue, mostly dense, some irregular calcite, also considerable blue calcarious banding to 1 inch thick, 1/8 inch lead sulfide and zinc sulfide on bedding at 70 feet, crossed fissure at 69 feet

Feet From-	Feet To-	Description
103.7	117.5	Limestone, mainly light gray, some dark gray with banding, some coarser crystalline in light gray
117.5	129	Limestone, dark gray cherty, light gray calcite bands at 60°
129	212	Quartzite? calcarious (highly silicified limestone?), light gray to white, banding at 50 to 70°, some disseminated zinc sulfide between 165 and 180 feet
212	240	Limestone, light gray to white, thin dark gray bands on bedding at 60°, zinc sulfide and lead sulfide stringers on bed at 227 and 229 feet
240	250	Limestone, dark gray to blue, some crystalline

Hole 10
Coordinates: 3987 N., 4055 W.
Bearing: N. 31° E., Dip: -25°
Elevation: 7,283 feet
Depth: 86 feet

0	4	Limestone, dark gray, some pyrite and crystalline
4	8.6	Limestone, dark gray, some zinc sulfide, banding at 10 to 30°
8.6	9	Zinc sulfide and lead sulfide, some chalcopyrite, angle of intersection indefinite
9	18	Limestone, dark gray and blue, little mineralization
18	29	Limestone, light gray, crystalline, spotted with coarse pyrite crystals, little lead and zinc
29	33.5	Zinc sulfide and lead sulfide in altered limestone, bluish gray
33.5	65.6	Limestone, dark gray, some crystalline, little pyrite, zinc sulfide, lead sulfide
65.6	66.6	Zinc sulfide and lead sulfide in altered limestone, bluish gray
66.6	86	Limestone, dark gray to light gray, altered some light brown iron oxide

Hole 11
Coordinates: 3978 N., 4068 W.
Elevation: 7,285 feet
Bearing: S. 79° W., Dip: +4°
Depth: 224 feet

0	3	Limestone, dark gray, dense, silicified
3	42.9	Limestone, dark gray, some small crystals, some silicification, some calcite in veinlets generally passing through core at 60 to 90° with horizontal and striking north, scattered zinc sulfide and lead sulfide mineralization crossed 1 inch north-south zinc sulfide and lead sulfide fissure dipping west at 26+ feet

Feet From-	Feet To-	Description
42.9	44.2	Limestone, altered, iron stained, gray, brown, blue, white
44.2	83	Limestone, dark gray to black, thick bands of white calcite between 99 and 101 feet, some scattered zinc sulfide and lead sulfide mainly between 71 and 83 feet
83	224	Limestone, blue, crystallized, no sulfide

Hole 12
Coordinates: 4031 N., 4058 W.
Elevation: 7,283 feet
Bearing: S. 52° E., Dip: -25°
Depth: 49 feet

0	4	Limestone, black, dense
4	23	Limestone, black and gray, dense, very little mineralization
23	27.5	Limestone, white (silicified) with gray banding, banding at 45° with hole
27.5	32.5	Limestone (low grade zinc sulfide and lead sulfide ore) gray color, gray and white banding at 50° with hole, zinc sulfide and lead sulfide appears to be bedding deposition
32.5	49	Limestone

Hole 13
Coordinates: 4033 N., 4065 W.
Elevation: 7,283 feet
Bearing: S. 40° W., Dip: -45°
Depth: 53 feet

0	3	Limestone, black, banding at 50 to 60° with hole
3	17.7	Limestone, gray and black
17.7	18.6	Limestone, dark gray with zinc sulfide and lead sulfide stringers
18.6	31.8	Limestone, dark gray and blue, little zinc and lead
31.8	32.6	Limestone, brown and gray, altered banding at 60°
32.6	53	Limestone, black and gray, fine crystallization traces of zinc and lead sulfide

Hole 14
Coordinates: 3984 N., 4055 W.
Elevation: 7,283 feet
Bearing: N. 41° E., Dip: -4°
Depth: 70 feet

0	3	Limestone, gray
3	45	Limestone, gray and white, some brown oxide stain, little zinc sulfide and lead sulfide (in thin stringer and disseminated)
45	70	Limestone, greenish black, considerable calcite mainly as thin bands

Hole 15
Coordinates: 3992 N., 3987 W.
Elevation: 7,284 feet
Bearing: N. 84° E., Dip: +5°
Depth: 102 feet

Feet From-	To-	Description
0	3	Limestone, gray, altered, silicified, 1 foot of strong zinc sulfide and lead sulfide mineralization from 1 to 2 feet
3	38.8	Limestone, dark gray, crystalline, little zinc sulfide and lead sulfide mineralization
38.8	46.6	Limestone (low grade zinc sulfide and lead sulfide ore) altered and pitted, brown and yellow oxide stain
46.6	53	Limestone, white and gray, altered, heavily mineralized with fine black sulfides zinc lead and iron similar in appearance to material in hole 10 from 29 to 33.5 feet
53	79.3	Limestone, gray, crystalline, some zinc and lead, drill hole going up thru bedding at 5 to 10°
79.3	102	Limestone, black, dense, many thin calcite bands and stringers

Hole 16
Coordinates: 3968 N., 3994 W.
Elevation: 7,284 feet
Bearing: N. 52° E., Dip: +8°
Depth: 58 feet

0	5	Limestone, gray and black, crystallized
5	38	Limestone, black and gray, some banding at 10 to 30° with hole, no zinc or lead
38	39.3	Zinc sulfide and lead sulfide ore in blue-gray limestone
39.3	49	Limestone, gray, green, brown, heavily mineralized with zinc, lead, and iron pitted, some oxidation
49	56	Limestone, gray and white, crystallized, some zinc sulfide and lead sulfide
56	58	Limestone, black, dense, conspicuous veinlets of calcite

Hole 17
Coordinates: 3203 N., 5116 W.
Elevation: 7,845 feet
Bearing: S. 3° W., Dip: -38°
Depth: 110 feet

0	5	Limestone, gray, crystallized, silicified
5	18	Do.
18	23.5	Limestone, black shaley banded at 70°
23.5	34	Limestone, silicified (quartzite?) gray, crystallized
34	89	Limestone, black, shaley, thin calcite stringers
89	105	Limestone, black and white, mottled appearance
105	110	Limestone, black, shaley, thin calcite stringers

Hole 18
Coordinates: 3213 N., 5102 W.
Elevation: 7,852 feet
Bearing: North Dip: +32°
Depth: 170 feet

Feet From-	To-	Description
0	3	Limestone, gray altered, brown iron stain
3	21	Limestone, gray and blue-gray, pitted, brown stain
21	26.7	Limestone, black, dense thin calcite stringers
26.7	33	Limestone, gray, pitted, brown and red
33	41	Iron stain, calcite seamed to 41
41	47	Gray limestone shows leaching action
47	55	Do.
55	65	Do.
65	76	66.0 lost water, sands to 99.0 possible limestone boulders
76	84	Limestone shows leaching, possible limestone boulders
84	94	Do.
94	104	Do.
104	112	Gray and black limestone with calcite seams, mottled
112	120	Do.
120	130	124 to 126 core ground, altered limestone from 124 on
130	140	Coarse crystallized altered limestone
140	148	Do.
148	155	Do.
155	161	156 to 170 red iron in fractures and seams in altered cherty limestone
161	170	Do.

Hole 19
Coordinates: 3533 N., 5325 W.
Elevation: 7,677 feet
Bearing: S. 80° W., Dip: +3°
Depth: 351 feet

0	11	Core not available
11	21	Crystalline gray limestone, calcite seams
21	37	Blue dense limestone
37	41	Grayish black argillaceous limestone
41	71	Crystalline gray limestone, calcite seams
71	101	Grayish black mottled dense limestone
101	134	Crystalline gray limestone, calcite seams (sample 103.2 to 104.2 feet)
134	143	Silicified and fractured dark blue limestone (sample 139 to 143.6 feet interbedded gray limestone)
143	149	Finely crystalline blue-gray mottled limestone
149	185	Crystalline gray limestone, calcite seams, interbedded bluish gray limestone (sample 222 to 223 feet)
185	351	Crystalline gray limestone, calcite seams

Hole 20
Coordinates: 5440 N., 5214 W.
Elevation: 7,720 feet
Bearing: S. 3° W., Dip: -78°
Depth: 276 feet

Feet From-	Feet To-	Description
0	29	Limestone, mineralized 18 to 20 feet
29	52	Limestone, calcite seamed
52	70	Limestone and shale, 1 foot breccia at 57 feet
70	79	Limestone, fractured 70 to 73 feet
79	111	Black shale and limestone, brecciated 84 to 87.5 feet, trace of sulfides
111	127	Limestone
127	135	Black shale, graphitic, sulfides 127 to 130 feet
135	180	Black shale and limestone, 164 to 165 feet brecciated, 175 to 180 feet fractured shows trace of sulfides
180	276	Top of Madison, blue fossiliferous mottled crystalline limestone, copper stained seam at 229 feet

Hole 21
Coordinates: 3206 N., 5122 W.
Elevation: 7,845 feet
Bearing: - Dip: -90°
Depth: 290 feet

0	7	Gray, finely crystalline limestone, mottled and banded with grayish blue limestone
7	10	Dense blue limestone banded with grayish limestone and calcite trace of disseminated pyrite
10	28	Gray crystalline limestone banded with calcite, trace of sulfides
28	63	Dense blue limestone banded with gray limestone and calcite seams
63	95	Gray finely crystalline limestone banded with bluish limestone and calcite
95	116	Brecciated zone, black, blue, and gray limestone cemented with calcite
116	140	Black limestone interbedded with thin bands of black shale and veinlets of calcite
140	159	Gray dense limestone banded with veinlets of calcite
159	164	Black argillaceous shale
164	170	Blue dense limestone banded gray limestone and calcite veinlets
170	205	Black calcareous shale interbedded with blue dense limestone and cut with calcite veinlets
205	221	Black dense limestone interbedded with blue dense limestone and calcite veinlets
221	290	Blue fossiliferous mottled crystalline limestone, top of Madison, banded with calcite, abundant stylolites

Hole 22
Coordinates: 3440 N., 5210 W.
Elevation: 7,720 feet
Bearing: S. 35° E., Dip: -54°
Depth: 262 feet

Feet From-	To-	Description
0	43	Grayish blue, crystalline limestone interbedded with dense blue limestone and cut with calcite veinlets
43	57	Dense bluish black limestone with disseminated finely crystalline pyrite, cut by calcite veinlets
57	63	Blue crystalline limestone cut by calcite veinlets with a calcite vein at 59 feet
63	110	Brecciated zone, dense bluish black limestone with fossiliferous blue limestone cemented with calcite and impregnated with finely crystalline pyrite
110	160	Dense bluish black limestone, interbedded with fossiliferous blue and dense blue limestone and black shale. Cut with calcite veinlets and impregnated with pyrite (sample at 159 feet)
160	177	Black argillaceous limestone, phosphatic oolite at 167 feet cut with bands of calcite impregnated with pyrite
177	262	Blue fossiliferous mottled crystalline limestone, top of Madison, at 181 feet a band of flint containing pyrite

Hole 23
Coordinates: 3448 N., 5213 W.
Elevation: 7,720 feet
Bearing: N. 30° W., Dip: -67
Depth: 372 feet

0	39	Grayish blue crystalline limestone interbedded with dense blue limestone cut with calcite veinlets
39	41	Dense blue limestone cut with calcite veinlets
41	50	Gray crystalline limestone cut with calcite veinlets
50	93	Dense blue limstone interbedded with a grayish blue limestone cut with calcite veinlets (sample at 89 feet)
93	111	Dense bluish black argillaceous limestone interbedded with fossiliferous blue limestone cut with calcite veinlets
111	113	Blue brecciated limestone
113	131	Blue fossiliferous limestone interbedded with a dense blackish blue limestone
131	170	Dense blackish blue brecciated limestone cemented with calcite
170	274	Dense bluish black limestone interbedded with dense blue limestone and black shale cut by calcite veinlets impregnated with pyrite
274	372	Top of Madison, fossiliferous blue crystalline limestone with stylolites

Hole 24
Coordinates: 3439 N., 5218 W.
Elevation: 7,720 feet
Bearing: S. 43° W., Dip: -78°
Depth: 272 feet

Feet From-	Feet To-	Description
0	33	Grayish blue crystalline limestone interbedded with dense blue limestone cut with calcite veinlets
33	61	Dense blue limestone, cut with calcite veinlets
61	62	Brecciated blue limestone
62	82	Fossiliferous blue limestone interbedded with dense blue limestone cut with calcite veinlets
82	113	Brecciated dense blackish blue limestone cemented with calcite
113	192	Dense bluish black limestone, interbedded dense blue limestone and black shale cut with calcite veinlets, impregnated with pyrite
192	272	Top of the Madison, fossiliferous blue crystalline limestone with stylolites

Hole 25
Coordinates: 4036 N., 3942 W.
Elevation: 7,282 feet
Bearing: S. 5° W., Dip: -64°
Depth: 105 feet

0	6	Dense blue limestone with calcite veinlets
6	22	Mottled gray to light green contact metamorphic limestone. Mineralized with galena, sphalerite, pyrite (samples from 6 to 11, 11 to 15, and 19 to 20 feet)
22	105	Fossiliferous blue crystalline limestone with stylolites

Hole 26
Coordinates: 4038 N., 3943 W.
Elevation: 7,282 feet
Bearing: S. 67° W., Dip: -68°
Depth: 132 feet

0	4	Contact metamorphic light gray limestone, traces of sulfides
4	10	Crystalline blue limestone, cut by calcite veinlets
10	30	Contact metamorphic light gray limestone, banded with calcite and impregnated with minute amounts of sulfides, including lead and zinc
30	132	Fossiliferous blue crystalline limestone with stylolites, minute amounts of sulfides, oxidized copper stain at 122 to 123 feet

Hole 27
Coordinates: 4044 N., 3938 W.
Elevation: 7,282 feet
Bearing: N. 10° W., Dip: -40°
Depth: 233 feet

Feet From-	Feet To-	Description
0	4	Dark blue finely crystallized limestone, cut by calcite veinlets
4	11	Light gray contact metamorphic limestone impregnated with sulfides in minute amounts
11	52	Blue dense limestone cut by calcite veinlets and containing minute amounts of pyrite, galena, and sphalerite
52	82	Dense gray contact metamorphic limestone with minute amounts of pyrite, lead and zinc sulfides (sample at 80 to 81 feet)
82	88	Finely crystallized blue limestone cut by calcite veinlets
88	194	Dense gray to light green contact metamorphic limestone with minute amounts of lead and zinc sulfides (samples at 94 to 95.5, 111 to 113, 144 to 147, 149 to 150, and 153 to 155 feet)
194	233	Fossiliferous blue crystallized limestone with stylolites

Hole 28
Coordinates: 4009 N., 3920 W.
Elevation: 7,285 feet
Bearing: S. 83° E., Dip: -5°
Depth: 141 feet

0	33	Dense gray to light green contact metamorphic limestone (samples 0 to 3, 10 to 14, 19.6 to 23.6 feet)
33	141	Fossiliferous blue crystallized limestone with stylolites

Hole 28a
Coordinates: 4011 N., 3920 W.
Elevation: 7,283 feet
Bearing: -
Depth: 19 feet

0	19	Dense blue to light green metamorphic limestone, disseminated sulfides in small amounts

Hole 28b
Coordinates: 4007 N., 3920 W.
Elevation: 7,287 feet
Bearing: -
Depth: 12 feet

0	12	Dense blue to light green metamorphic limestone, disseminated sulfides in small amounts

Hole 29
Coordinates: 4005 N., 3957 W.
Elevation: 7,287 feet
Bearing: S. 15° W., Dip: +25°
Depth: 82 feet

Feet From-	Feet To-	Description
0	35	Hydrothermally altered contact metamorphic gray limestone, mottled by limonite and impregnated with lead and zinc sulfides (samples 1 to 5, 7 to 12, 12 to 17, and 30 to 35 feet)
35	82	Fossiliferous blue crystalline limestone with stylolites

APPENDIX II.

Assay Results of Diamond Drilling

D. D. Hole No.	Footage From -	Footage To -	Type of sample	Oz./ton Au	Oz./ton Ag	Percent Cu	Percent Pb	Percent Zn	Percent P_2O_5	Percent V_2O_5	Percent Mo	Percent Ni
1	74	80	Core						0.39	0.07		
2	76	82	Core						0.39	0.05		
3	0	9	Core	Trace	0.5	0.27	0.75	2.00				
	73	78	Core						0.43	0.06		
6	44.5	47	Core	Trace	1.2	0.19	1.90	1.30				
7	36	37.5	Core	Trace	1.15	0.27	2.60	3.75				
9	166	167	Core	Trace	0.1	0.02	<0.1	0.75				
10	18	29	Core	Trace	0.4	0.10	0.30	0.40				
	29	33.5	Core	Trace	1.8	0.50	2.30	5.00				
	65.6	66.6	Core	0.005	3.65	0.26	9.00	8.00				
12	27.5	32.5	Combined	Trace	2.53	0.50	5.75	4.87				
15	38.8	46.6	Combined	Trace	1.31	0.23	2.90	3.50				
16	38	39.3	Core	Trace	1.50	0.22	3.60	4.90				
	39.3	49	Core	Trace	0.85	0.46	1.80	2.50				
18	74	84	Sludge	Trace	0.2	0.02	<0.1	<0.1				
19	103	104	Core	<0.005	4.3	0.44	0.3	<0.1				
	139	143.6	Core	Trace	<0.05	<0.02	<0.1	<0.1				
	222	223	Core	Trace	0.15		<0.1	<0.1				
21	144	150	Sludge	0.005	0.8	0.1	<0.1	0.4		0.15		
	194	200	Sludge	Trace	0.1	<0.1	<0.1	0.2		0.03		
	200	203	Sludge	0.005	0.9	0.1	<0.1	0.5		0.05		

1953

D. D. Hole No.	Footage From-	Footage To -	Type of sample	Oz./ton Au	Oz./ton Ag	Percent Cu	Percent Pb	Percent Zn	Percent P_2O_5	Percent V_2O_5	Percent Mo	Percent Ni
22	58.5	63	Core	Trace	0.1	<0.1	<0.1	<0.1				
	159	161	Core	Trace	0.2	<0.1	<0.1	<0.1		0.03		
	169	175	Core	Trace	0.1	<0.1	<0.1	<0.1		0.02		
23	89	90.5	Core	0.01	0.1	<0.1	<0.1	Trace				
25	7	12	Sludge	0.005	0.9	0.18	1.0	1.2				
	6	11	Core	Trace	1.5	0.22	3.4	2.1		0.44	0.04	0.06
	11	15	Core	Trace	0.2	0.16	0.1	0.3			0.03	
	19	20	Core	Trace	0.8	0.02	1.65	0.45				
27	1.0	3.5	Sludge	Trace	0.1	0.10	<0.1	0.3				
	52	58	Sludge	<0.005	0.2	0.03	<0.1	0.1				
	58	63	Sludge	<0.005	0.3	0.03	<0.1	0.1				
	78	83	Sludge	<0.005	0.1	0.03	<0.1	0.45				
	80	80.5	Core	<0.005	1.3	0.36	2.35	8.5				
	93	98	Sludge	<0.005	0.1	0.03	0.2	0.9				
	94	95.5	Core	Trace	0.4	0.04	0.35	1.6				
	111	113	Core	Trace	1.3	0.06	1.2	1.5				
	122	127	Sludge	<0.005	0.4	0.03	0.25	0.75				
	127	132	Sludge	Trace	0.2	<0.05	0.2	0.55				
	142	147	Sludge	Trace	0.2	<0.05	0.6	1.75				
	144	147	Core	Trace	0.8	0.10	1.7	4.0		0.45		
	147	152	Sludge	Trace	0.3	<0.05	0.35	0.9				
	149	150	Core	<0.005	2.0	0.12	4.9	7.55				
	153	155	Core	Trace	0.9	0.34	1.55	1.1				
28	0	3	Core	Trace	0.3	0.16	0.5	1.05				
	4	9	Sludge	0.005	0.2	0.06	<0.1	0.25				
	9	10	Core	<0.005	3.5	0.62	10.7	13.7				
	9	14	Sludge	<0.005	1.6	0.32	3.3	3.0				
	10	14	Core	Trace	0.9	0.20	1.7	0.15				
	14	19	Sludge	<0.005	0.1	0.18	0.25	0.3				
	19	24	Sludge	<0.005	0.6	0.20	1.1	1.1		0.09		
	19.6	23.6	Core	Trace	0.6	0.20	0.9	1.0				
	24	29	Sludge	<0.005	0.4	0.06	0.3	1.0		0.17		
	29	34	Sludge	<0.005	0.3	0.06	0.4	0.7		0.22		
	71	76	Sludge	Trace	Tr.	<0.05	<0.1	<0.1				
	76	81	Sludge	<0.005	Tr.	<0.05	<0.1	0.1				

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D. D. Hole No.	Footage From-	Footage To -	Type of sample	Oz./ton Au	Oz./ton Ag	Percent Cu	Percent Pb	Percent Zn	Percent P_2O_5	Percent V_2O_5	Percent Mo	Percent Ni
29	1	5	Core	<0.005	2.9	0.30	7.05	5.8				
	3	7	Sludge	<0.005	0.2	<0.05	0.1	0.3				
	5	12	Core	<0.005	1.1	0.28	1.9	3.0				
	7	12	Sludge	<0.005	1.6	0.30	3.25	3.75				
	12	17	Sludge	<0.005	1.0	0.16	1.35	1.75				
	12	17	Core	Trace	0.6	0.16	1.1	1.65				
	25	30	Sludge	Trace	0.2	<0.05	<0.1	0.2				
	30	35	Sludge	Trace	0.6	0.07	0.5	1.3				
	30	35	Core	Trace	1.0	0.07	1.4	1.9				

1953

Drift Samples and Assays
(1360 Level)

No.	Place	Cut	Oz./ton		Percent		
			Au	Ag	Cu	Pb	Zn
4615	1360-L-2D Sta. 48 + 25	3 ft.	<0.005	1.3	0.25	2.8	3.7
4616	1360-L-2D Sta. 48 + 39	4 ft.	<0.005	1.6	0.30	3.1	1.85
4624	1360-L-2D Sta. 48 + 69	2 ft.	0.005	1.1	0.20	2.0	2.6
4623	1360-L-2D Sta. 48 + 75	20 in.	0.005	0.5	0.09	0.65	2.2
4617	1360-L from mouth of drift 2D 20 to 25 ft.	*CGS	<0.005	0.2	0.05	0.15	0.55
4618	1360-L from mouth of drift 2D 39 to 43 ft.	CGS	<0.005	0.4	0.10	0.5	0.75
4622	1360-L from mouth of drift 2D 64 to 69 ft.	CGS	<0.005	0.5	0.1	0.5	0.75
4619	1360-L from mouth of drift 3D 0 to 5 ft.	CGS	<0.005	0.9	0.15	1.8	2.55
4620	1360-L from mouth of drift 3D 5 to 10 ft.	CGS	<0.005	1.4	0.22	2.7	2.6

*CGS = car grab sample.