MINE MANAGEMENT
OPERATIONAL CONSULTING

MINE EXAMINATIONS
MINING ENGINEERING

INVESTOR'S REPORTS
EFFICIENCY STUDIES

J. H. WREN & CO.

CONSULTING MINING ENGINEERS

CABLE ADDRESS
WRENCO

PHONE GLADSTONE 6-0922
4297 D STREET
SACRAMENTO, CALIF.

NOVEMBER 4, 1960

TYBO MINE REPORT

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NOVEMBER 4, 1960

MR. W. T. CARSON, SR., PRESIDENT
CARSON LAND & DEVELOPMENT CORP.
POST OFFICE BOX 346
HUGHSON, CALIFORNIA.

DEAR MR. CARSON :

HEREWITH CONTAINED IS,VOLUME NUMBER ONE OF A TWO VOLUME GENERAL REPORT RELATIVE TO THE TYBO MINE, NYE COUNTY, NEVADA. INCLUDED WITH THE STUDY ARE TWO MAP TUBES AND VARIOUS AND VARIOUS EXHIBITS.

TECHNICAL REFERENCE RESEARCHED FOR THE TYBO MINE IS AS FOLLOWS :

A). "GEOLOGY OF THE TYBO DISTRICT, NEVADA",BY DR. H. G. FERGUSON.

B). "MINING DISTRICTS AND MINERAL RESOURCES OF NEVADA", BY DR. FRANCIS CHURCH LINCOLN.

C). "MILLING METHODS AND COSTS AT THE LEAD-ZINC CONCENTRATOR OF THE TREADWELL YUKON CO., LTD., AT TYBO, NEVADA". U. S. BUREAU OF MINES PAPER, I. C. 6430, BY W. H. BLACKBURN, ONE OF THE U. S. BUREAU OF MINES' CONSULTING ENGINEERS AND H. M. LEWERS, SUPERINTENDENT OF THE TYBO DIFFERENTIAL FLOTATION PLANT.

D). MINE OFFICE REPORTS TO TREADWELL YUKON CO., LTD. SAN FRANCISCO, CALIFORNIA MANAGEMENT HEADQUARTERS.

E). TECHNICALLY PREPARED MAPS BY THE TYBO MINE ENGINEERING DEPT.

F). MARKETING SETTLEMENT SHEETS OF THE HALL BROS. LEASE.

THIS REPORT WILL BE FOLLOWED BY SUPPLEMENTAL ASSAY CHART MAPS AND ECONOMIC TONNAGE EVALUATION IN DETAIL AS REHABILITATION ALLOWS SAMPLING ON THE BASIS OF THE PRESENT ECONOMIC CUT-OFF POINT.

THE REPORT SUPPLEMENT WILL ALSO CARRY RESULTS OF : A). OLD TYBO MINE SLAG BENEFICIATION METALLURGY. B). MILL TAILINGS UP-TO-DATE METALLURGICAL TEST.

VERY TRULY YOURS,
J. H. WREN & CO.

BY *James H. Wren*
JAMES H. WREN.

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TYBO MINE REPORT

BY

J. H. WREN

LOCATION :

THE TYBO MINE IS SITUATED IN THE HOT CREEK RANGE IN THE NORTHEASTERN PART OF NYE COUNTY, NEVADA. THE PROPERTY IS SOME 70 MILES NORTHEAST OF TONOPAH, NEVADA, BY ROAD. SEE FIGS. 1 AND 2 SHOWING THE GEOGRAPHICAL POSITION.

ROAD CONDITIONS TO THE TYBO TURNOFF ARE EXCELLENT OILED MAIN HIGHWAY BETWEEN TONOPAH AND ELY. FROM THE TYBO TURNOFF IS SOME EIGHT MILES OF WELL GRADED GRAVEL ROAD WITH A GENTLE GRADE FROM THE HOT CREEK VALLEY FLOOR TO THE CAMP.

THE TWO NEAREST RAILHEADS TO TYBO MINE ARE : CALIENTE, NEVADA ON THE UNION PACIFIC RAILROAD AND MINA, NEVADA ON THE SOUTHERN PACIFIC RAILROAD, EACH IS APPROXIMATELY 140 MILES FROM THE PROPERTY.

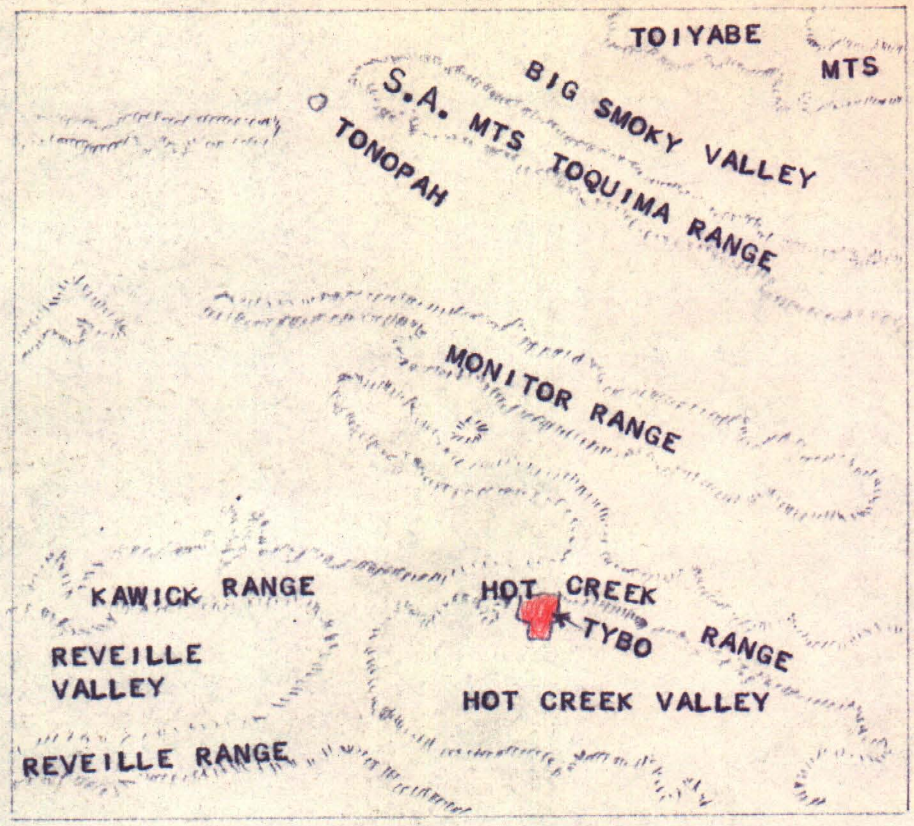
WHILE THE ELEVATION OF THE MINE IS OVER 6,000 FEET ABOVE SEA LEVEL, THE AREA IS NOT KNOWN AS A SNOW BELT. NORMALLY,OPEN WINTERS WITH VERY LITTLE SNOW ARE EXPECTABLE. THE WRITER WAS ON THE PROPERTY IN JANUARY, FEBRUARY AND MARCH OF 1960 AND SIX INCHES OF SNOW WAS THE MAXIMUM DEPTH THAT WINTER.

ADEQUATE CAMP AND DRILLING WATER IS AVAILABLE FROM SURFACE SPRINGS. UP TO 1,300 GALLONS PER MINUTE WATER SUPPLY FOR MILLING PURPOSES IS AVAILABLE FROM THE LOWER LEVELS OF THE HALES SHAFT. THE UPPER LEVELS WILL FURNISH SUFFICIENT WATER REQUIREMENT TO HANDLE ANY TREATMENT PLANT'S SCHEDULED CAPACITY FOR THE NEXT SEVERAL YEARS.

THE TYBO MINE POWER TRANSMISSION LINE FROM MILLERS NEAR TONOPAH HAS BEEN REMOVED. ELECTRICAL POWER CAN BE GENERATED WITH DIESEL ELECTRIC EQUIPMENT.

SOME CAMP BUILDINGS CAN BE SALVAGED WITH NOMINAL REHABILITATION COST. OTHER EMPLOYEE HOUSING CAN BE ACHIEVED BY RENTAL-PURCHASE OF FURNISHED TRAILER HOUSES. THEIR AMORTIZATION CAN BE ACCOMPLISHED BY EMPLOYEE RENTS.

AN ADEQUATE MECHANICAL AND MINE LABOR SUPPLY IS ALWAYS AVAILABLE AT ELY OR TONOPAH.



AREA OUTLINED ON STATE MAP

FIGURE NO. TWO

J. H. WREN & COMPANY
Consulting Mining Engineers
4297 D Street
Sacramento, California

MAP OF NEVADA SHOWING TYBO LOCATION

SCALE IN MILES

FIGURE NO. ONE

J. H. WREN & COMPANY
Consulting Mining Engineers
4297 D Street
Sacramento, California

OWNERSHIP, CONTINUATION :

LOTS 3,4,5,7,8,10 AND 12 TO 20 INC. BLOCK F

LOTS 2 TO 9 INC..................... BLOCK G

LOTS 1 TO 8 INCLUSIVE AND 10,13,14. BLOCK H

ALL OF .... BLOCK I

LOTS 1 AND 3....................... BLOCK J

ALL OF............................. BLOCK K

LOTS 1 TO 5 INCLUSIVE.............. BLOCK L

ALL OF .... BLOCK M

ALL OF............................. BLOCK N

54.357 ACRES OF PATENTED LAND, AND ANY AND ALL WATER RIGHTS AND EASEMENTS AND PROPERTY, INCLUDING REAL AND PERSONAL PROPERTY FORMERLY OWNED BY THE TREADWELL YUKON CO. , LTD., KNOWN AS THE TYBO MINE.

TYBO MILL TAILINGS APPARENTLY WERE STORED ON OPEN LAND. THEY WERE SAFE-GUARDED FROM BEING CARRIED AWAY BY WATERS WITH USE OF TAILINGS STORAGE CHECKS. UNDER LAWS EXISTING TO AND INCLUDING DECEMBER 31, 1957, TAILINGS IN THE STATE OF NEVADA ON OPEN LAND WERE THE PROPERTY OF THE MINE FROM WHICH THEY WERE PRODUCED AS LONG AS THAT MINE HAD NOT BEEN ABANDONED, ACCORDING TO RECENTLY OBTAINED LEGAL ADVICE. A LAW WAS PASSED IN 1957 BECOMING EFFECTIVE JANUARY 1, 1958 WHICH COVERED TAILINGS STORED ON OPEN GROUND AS BEING CONSIDERED AS ABANDONED IF LEFT WITHOUT WORKING FOR A PERIOD OF TEN YEARS. LEGAL ADVICE TO THE COMPANY IS THAT THIS LAW WILL APPLY IN 1958 AS THE TAILINGS WERE CLAIMED TO AND INCLUDING 1957 AND THE TYBO MINE HAD NEVER BEEN ABANDONED. A PLACER CLAIM WAS PUT ON THE TAILINGS BY A FOREIGN PARTY WHICH OUR LEGAL ADVICE INDICATES AS INVALID. NOTICE OF INTENT TO HOLD HAS BEEN GIVEN THE LOCATOR. ACCORDING TO NEW U. S. BUREAU OF LAND MANAGEMENT RULINGS, IT IS UNLIKELY THAT A PLACER CLAIM LOCATION IN ANY EVENT WOULD NOT HOLD AS PLACER VALUES WOULD HAVE TO BE PROVEN.

ALL HEREIN DESCRIBED REAL PROPERTY AND PATENTED MINING CLAIMS WERE PURCHASED FOR CASH BY C. L. & D. C. THE PROPERTY WAS DELIVERED, A TITLE SEARCH WAS MADE AND TITLE INSURANCE GRANTED. THERE ARE NO PROPERTY OR CORPORATE OBLIGATIONS AS OF THIS DATE.

TYBO MINE REPORT, NOV. 4, 1960

OWNERSHIP :

THE TYBO MINE AND TOWNSHIP LOTS ARE OWNED BY THE CARSON LAND & DEVELOPMENT CORP., A STATE OF NEVADA CORPORATION. CL&DC OWNERSHIP IS NOT OPEN FOR PUBLIC PARTICIPATION AND HAS LESS THAN ELEVEN MEMBERS.

THE CARGOLD MINING & DEVELOPMENT CORP. , A STATE OF NEVADA CORPORATION HOLDS A 20 YEAR MINING LEASE GRANTED BY THE CARSON LAND & DEVELOPMENT CORP. WITH A RENEWAL OPTION OF AN ADDITIONAL 20 YEARS. C.L.& D. C. RECEIVES A 6% OF THE GROSS INCOME FROM C.M.& D. C. UNDER THE TERMS OF THE MINING LEASE.

THE PROPERTY CONSISTS OF THE FOLLOWING PATENTED MINING CLAIMS AND REAL PROPERTY TOWNSITE LOTS :

TWO G LODE............ U. S. M. S. NO. 1300-37

CROSBY LODE........... U. S. M. S. NO. 1301-38

2ND EXTENSION TWO G LODE.................. U. S. M. S. NO. 1302-37 ALSO REFERRED TO AS 1302-38-44

NECKAR LODE........... U. S. M. S. NO. 1303-39

HEIDELBERG LODE....... U. S. M. S. NO. 1304-38

LAFAYETTE LODE........ U. S. M. S. NO. 1305-39

CASKET LODE........... U. S. M. S. NO. 1306-40

MILLSITE.............. U. S. M. S. NO. 1307-41 ALSO REFERRED TO AS 1307-5

MILLSITE.............. U. S. M. S. NO. 1308-42

BUNKER HILL LODE...... U. S. M. S. NO. 1309-43

G. F. MINE............ U. S. M. S. NO. 2123 ALSO REFERRED TO AS 2132

GARRET LODE........... U. S. M. S. NO. 3948

LOT 6......... BLOCK 4

ALL OF........ BLOCK A

LOTS 1 TO 8 INC. BLOCK B

LOT 1 ....BLOCK C

LOTS 1 TO 19 INC. BLOCK E

ALL OF......... BLOCK D

HISTORY :

The Tybo Mining District is one of the older State of Nevada mining areas. Like others of its type it was first worked for its surface ores, which carried high amounts of silver.

The earliest discovery of ore in the Tybo Mining District was made in 1869 according to reliable historical information. The 2-G Lode was discovered in 1871, and the Tybo Consolidated Mining Company erected a smelter in 1872. Charcoal burned from nearby native timber was used as smelting fuel. During the period from 1872 to 1879 total reported tons of ore from the Tybo Mine were,61,439,and only 156 tons from other properties were smelted. Yield out ofthe produced tonnage of crude ore was: 7,100 tons of lead bullion, which contained 1,743,000 ounces of silver and 15,330 ounces of gold. Average recovery was: 11 percent lead, 27.5 ounces of silver and 0.24 ounce of gold. The earliest smelter slag was resmelted, indicating a high original loss. The present slag pile at Tybo, holds values from $12 to $21 per ton.

Mining continued at the Tybo Mine until 1888 under different owners after 1879. A 20-stamp mill was in operation, and the silver content only of the oxidized ores was treated by the "Reese River" process, pan amalgamation followed by chloridizing roast. By that method about 80 percent of the silver value was reported to have been recovered. The reported production for the period, 1879 to 1888, all from the Tybo Mine was : 834,000 ounces of silver and 5,030 ounces of gold from 42,000 tons of ore.

Minor attempts were made to reopen the mine in 1901, 1906 and 1917. This latter attempt erected a straight flotation plant and lead smelter but was unsuccessful as there was no means of separating the lead sulphide from the zinc sulphide at the time. The plant closed in 1920.

The various properties included in the entire Western part of the district and along the 2-G fault line as far as the point where it crosses the ridge South of Tybo Canyon as well as some ground along the Eastern front of the range, were acquired in 1925 by the Treadwell Yukon Co. Ltd. After extensive exploration, construction of a 300-400 differential flotation plant was commenced in November of 1928 and started treating Tybo Mine ore on May 13, 1929. This company produced over 500,000 tons of ore to September 30, 1937 which had a gross value at depression prices of over $7,000,000. The total Tybo Mine production figure is well over $10,000,000. Selective flotation was a new process when the mill first started and many improvements have been made in lead-zinc selective flotation metallurgy since suspension of milling treatment at Tybo in 1937. Underground mining methods and equipment have become more efficient since the last operation. The economic cut-off point at 5½ ¢ lead, 5¢ zinc and 41¢ silver , no doubt, had much to do with the suspension of the Tybo Mine activities in 1937.

TYBO MINE REPORT, NOV. 4, 1960

HISTORY, CONTINUATION :

THE TREADWELL YUKON CORPORATION, LTD. SUNK THE HALES SHAFT 1,546 FEET DEEP, DROVE MANY THOUSANDS OF DEVELOPMENT FEET AND SEVERAL THOUSAND FEET OF DIAMOND DRILL EXPLORATION DURING ITS INTERIM AT THE PROPERTY.

THE FOLLOWING IS A COPY OF A PRODUCTION ENTRY DATED MAY 16, 1942 OF A LETTER FROM MR. D. L. FEATHERS, SECRETARY TREADWELL YUKON CORPORATION LTD. , CROCKER BUILDING, SAN FRANCISCO, CALIFORNIA WITH REGARD TO THE COMPANY'S TOTAL TONNAGE AND GRADE OUTPUT.

YEAR	DRY TONS	GOLD OZ.	SILVER OZS.	LEAD %	ZINC %
1929	54,065	.02	8.45	5.15	5.51
1930	74,159	.025	10.6	6.6	4.6
1931	72,138	.027	11.75	7.09	5.27
1932	NONE				
1933	NONE				
1934	73,266	.025	12.35	7.08	5.27
1935	106,086	.027	11.51	6.69	5.04
1936	73,317	.019	10.93	6.43	4.93
1937	50,100	.025	10.99	6.15	3.41
	503,131 TOTAL TONS				

DIRECT CRUDE
LESSEE ORE

FOLLOWING WAS PRODUCED BY MINOR LESSEES OF THE COMPANY.

1938	685	.23	39.0	13.5	NO PAY ZINC
1939	322	.12	20.69		AT SMELTER
1940	1,128	.12	19.4		FOR CRUDE.
1941	373	.17	28.8	10.9	6.00

BETWEEN 1943 AND PART OF 1944, THE HALL BROS. COMPANY, A TRUCKING FIRM OF ELY , NEVADA LEASED THE TYBO MINE FROM TREADWELL YUKON CORPORATION, LTD. DURING THAT INTERIM THEY SHIPPED SOME 3,000 TONS OUT OF THE REMAINING SLAG PILE AS DIRECT SMELTING ORE. THEIR PAY PRODUCTS WERE AVERAGED AT: .02 OZ. GOLD, 5.0 OZS. SILVER AND 3.75% TO 4% LEAD. THEY ALSO TRIED TO SHIP SOME OF THE MILL TAILS BUT THE GRADE WAS TOO LOW TO STAND SHIPMENT COST WITHOUT BENEFICIATION. THE HALL BROS. COMPANY LENGTHENED THE 300 LEVEL EASTERLY DRIFT SOME 300 FEET. MR. HALL PERSONALLY VOUCHED FOR THE FACT THAT HIS NEW DEVELOPMENT WAS ALL IN ORE AND THAT THEY DID NO STOPING ABOVE THE LEVEL, SHIPPING THE DRIFT BREAKAGE OVER THE FULL WIDTH AS DIRECT SMELTING CRUDE ORE. HE FURTHER STATED THAT BY SELECTIVELY MINING THE GR OUND THEY OPENED WOULD FURNISH A GRADE OF .07 GOLD, 12 OUNCES SILVER, 10 % LEAD AND 6% ZINC IN THE SULPHIDES WHICH OCCUR CLEAN AT VARIOUS LOCATIONS. THERE WILL, OF COURSE, BE SILVER ENRICHED OXIDE ZONES AT THIS ELEVATION WHICH WILL NOT BE AMANDABLE FOR DIFFERENTIAL FLOTATION AND REQUIRE MARKETING AS CRUDE ORE DIRECT TO A LEAD SMELTER. THERE ARE OVER 600 FEET OF BACKS ACCORDING TO THE CONTOUR MAP ABOVE THE 300 LEVEL AT POINT WHERE THE HALLS LENGTHENED THE DRIFT INTO NEW GROUND.

HISTORY, CONTINUATION :

THE HALL BROS. COMPANY SHIPPED SOME 25,000 TONS OF CRUDE ORE TO MARKET. THEY PAID AS HIGH AS 20% GROSS ROYALTY TO THE OWNING FIRM.

RANDOM SELECTION OF HALL BROS. COMPANY SETTLEMENT SHEETS FROM UNITED STATES SMELTING, REFINING & MINING CO., NEWHOUSE BLDG., SALT LAKE CITY, UTAH GAVE THE FOLLOWING RESULTS FOR A TOTAL OF 1,212.9 DRY TONS.

DATE	DRY LBS.	OZ. GOLD	OZS. SILVER	% COPPER	% LEAD	% INSOL.	% IRON	% ZINC	% SUL'R	% LIME
6/14/43	95,938	.10	23.0	.10	12.15	18.8	22.2	11.35	27.2	.4
4/19/44	97,320	.0675	7.08	.Tr.	3.7	54.3	12.5	4.15	11.6	2.5
3/10/44	104,898	.12	18.38	.05	8.25	44.1	15.6	7.12	17.2	.7
4/5/44	99,566	.14	12.25	.10	6.2	49.2	13.9	5.8	12.5	1.2
3/20/44	95,256	.145	17.65	.10	7.95	43.0	14.8	7.75	16.5	1.2
5/5/44	98,930	.09.	8.08	.05	4.25	52.7	14.2	4.15	14.4	.8
4/5/44	96,964	.09	9.85	.10	5.4	52.9	13.4	5.3	12.4	1.0
4/15/44	95,922	.0575	6.45	.05	3.4	56.8	11.6	4.25	10.3	1.8
4/27/44	101,978	.11	12.4	.05	6.0	48.2	14.6	5.45	16.3	.9
4/20/44	92,794	.07	6.88	.05	3.55	54.5	12.1	3.8	11.5	2.3
4/21/44	92,852	.0825	9.13	.05	4.6	52.0	13.6	4.75	13.6	2.2
4/25/44	94,106	.1275	10.48	.10	5.25	49.2	14.6	5.15	14.3	1.2
5/4/44	98,436	.12	9.36	.10	5.0	50.4	14.1	4.55	15.6	.7
4/7/44	102,286	.085	9.83	.10	5.1	50.5	14.4	5.13	13.8	1.2
6/26/44	106,740	.0275	18.0	.10	10.2	22.3	22.0	10.8	25.5	.6
9/5/44	102,710	.10	12.95	.15	6.15	46.3	14.7	6.35	14.3	2.0
7/10/44	113,400	.0325	16.87	.10	9.55	21.3	23.3	10.8	25.4	.3
7/10/44	146,328	.035	17.95	.10	10.4	20.6	23.3	10.82	26.2	.6
6/26/44	106,740	.0275	18.0	.10	10.2	22.3	22.0	10.8	25.5	.6
5/11/44	100,774	.09	8.75	.10	4.1	52.3	14.4	4.2	14.6	1.0
5/6/44	99,810	.114	8.85	.10	4.2	54.0	14.6	4.15	15.5	1.0
4/5/44	96,964	.09	9.85	.10	5.4	52.9	13.4	5.3	12.4	1.0
3/25/44	88,688	.0625	9.0	.10	4.45	55.0	12.4	4.55	11.6	1.0
2/28/44	96,412	.175	22.48	.05	10.53	39.8	15.4	8.1	17.1	.5
AVERAGE	101,075 TNS.	.09	12.65	.08	6.50	44.3	15.7	6.44	16.5	1.1

HALL BROS. COMPANY OF ELY, NEVADA WILL SEND A REPRESENTATIVE TO POINT OUT THEIR 300 WORK WHEN THAT LEVEL HAS BEEN REHABILITATED. THEIR WORK ON THE NEW DEVELOPMENT OF THE 300 EAST LEVEL WAS NOT MAPPED.

DURING THIS INTERIM OF TYBO MINE LESSEE ACTIVITY GRADE CONTROL WAS VERY POOR. BETTER SELECTIVITY AND LESS DILUTION IN THE CRUDE ORE PRODUCTION WOULD HAVE RAISED SHIPMENT VALUES. THE TREADWELL OPERATION ALSO HAD ITS GRADE CONTROL PROBLEMS TRYING TO KEEP MILL CAPACITY TONNAGE OUTPUT DAILY WHILE DOING EXPLORATION, LEVEL DEVELOPMENT AND THE MAIN THREE COMPARTMENT SHAFT GOING DOWN. FROM THE 1,310 FOOT LEVEL TO THE 1,546 FOOT ELEVATION NO ORE DEPLETION WAS MADE. THE 1,310 FOOT LEVEL WAS PREPARED FOR ORE PRODUCTION WITH SKIP POCKETS, GATES, ETC. BUT LITTLE TONNAGE WAS REMOVED OFF OF THAT LEVEL.

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GEOLOGY:

This section will cover the geology of the Tybo Mining District, Nye County, Nevada in general and in particular, the geologic details of the Tybo Mine.

Detailed geological information herein is the result of studies by Dr. Henry G. Ferguson, Dr. Edwin Kirk and Dr. Francis Church Lincoln. Particular reports' data were: "Geology of the Tybo District, Nevada" by Henry G. Ferguson, 1933 and "Mining Districts and Mineral Resources of Nevada" by Francis Church Lincoln, 1923.

Geologic maps herewith: Plate 1, Plate 1-A, Plate 2, Plate 3 and Plate 4.

The rocks include marine sediments of Cambrian, Ordovician, and Silurian age, two nonmarine formations of probable Tertiary age, and dikes and lava flows also regarded as Tertiary.

The Cambrian sediments have been mapped as three units. To these units new formation names (Swarbrick, Tybo and Hales) have been given. The oldest, the Swarbrick formation consists principally of chert and thin-bedded limestone and has an exposed thickness of 2,500 or 3,000 feet. Succeeding the Swarbrick is the Tybo shale, consisting dominantly of shale with a thickness of about 1,600 feet.

The uppermost Cambrian unit, the Hales limestone, consists almost wholly of limestone. Its upper contact is not exposed, but a probable thickness of 3,000 feet is present.

The Ordovician and Silurian formations are lithologically similar to those of the Eureka district, and the same nomenclature is therefore employed.

The Pogonip is dominantly limestone, but near the top contains slate and quartzite members. Both lower Pogonip (Beekman-town) and upper Pogonip (Chazyan) are present. No complete section was found, but it is estimated that no less than 500 feet of the lower Pogonip and 3,000 feet of the upper Pogonip are present.

The Eureka quartzite overlies the Pogonip limestone, but is lacking in places. Its maximum thickness does not exceed 150 feet.

The Ordovician limestone, which at Eureka overlies the Eureka quartzite, is lacking at Tybo and the quartzite itself suffered erosion before the deposition of the Silurian. The Silurian consists of several hundred feet of massive dolomite with a little limestone near the base. The formation is lithogically similar to the Lone Mountain limestone of Eureka.

The Gilmore Gulch formation consists of sandstone, shale, and siliceous tuff. On lithologic evidence it is thought to be of Tertiary age.

The Gilmore Gulch and older formations are cut by numerous dikes of quartz latite porphyry, and at least 500 feet of similar quartz latite, probably a flow, overlies the Gilmore Gulch formation.

After weathering and erosion of the rhyolite about 150 feet of dominantly tuffaceous sediments were laid down. These sediments are similar in character to those of the Esmeralda formation of upper Miocene age, and are herein designated Esmeralda (?) formation.

Overlying the Esmeralda (?) formation are flows of andesite, dacite, and rhyolite.

The structure of the district is comples. The Paleozoic rocks in the central part of the area have been strongly folded, the principal axis of folding trending a little north of west. The major anticline is overturned to the south and southwest and is broken by a large reverse fault. The rocks to the south of this fault are relatively undistrubed. The folding apparently did not involve the Gilmore Gulch formation, and it is assumed that it took place within Mesozoic or early Tertiary time.

Several stages of faulting are shown by relations of the faults to each other, to the dikes of quartz latite porphyry, and to the later lavas. The oldest major fault, the 2 G-Dimick fault, cuts the southern limb of the overturned anticline and is considered to have been formed at the time of folding. The displacement is in the reverse direction and may exceed 6,000 feet. Thrusting may have taken place along low angle faults in the eastern part of the district during the same period of compression.

The first period of normal faulting was prior to the intrusion of the quartz latite porphyry dikes. The principal fault formed at this time cut and displaced the earlier reverse fault, but there was also motion along the reverse fault. There was also movement later than the quartz latite intrusion along both faults. Normal faults along the range front are later than the lavas that overlie the Esmeralda (?) formation.

Although the faults along the range front are comparatively recent, the present relief of the range is probably not directly due to faulting, but to erosion of the less durable formations to the west.

ROCK FORMATIONS

Summary

The rocks of the Tybo district include sediments of early Paleozoic age, from Cambrian to Silurian, a sedimentary formation of unknown age, possibly Tertiary, and dikes, lava flows, and sediments of probable Tertiary age. The Paleozoic formations have been closely folded and extensively faulted, but the younger formations though tilted and faulted, are not folded.

Cambrian

The Cambrian of the Tybo district was divided on a lithologic basis into three units, to which, as they were not closely comparable with the nearest known section, that of the Eureka district, local names have been given.

Swarbrick formation -- The Swarbrick formation derives its name from the Swarbrick prospect, in the eastern part of the district, where it forms the hanging wall of the ore-bearing fissure. The formation crops out only in the eastern part of the district, where an anticline gives an elliptical area of outcrop about 3,000 feet wide along the creek, truncated on the south by the 2 G fault and extending northward from the 2 G fault for about a mile. The base of the formation is not present, and in the area exposed there is much minor folding and crumpling, which makes impossible any close estimate of thickness. However, about 2,500 or 3,000 feet is probably exposed.

The formation consists in large part of gray chert. The individual bands do not exceed a few inches in thickness. Interbedded with the chert is a varying amount of bluish-gray limestone, also in thin bands. The limestone appears to increase in amount below the top of the formation, and at the Swarbrick upper tunnel near the crest of the anticline the limestone exceeds the chert in volume. Near the top of the formation, shale is interbedded with the chert, and the contact with the overlying Tybo shale is gradational. The uppermost chert beds were included in the Swarbrick formation, and thus, as mapped, the uppermost 200 or 300 feet is in places dominantly shale, containing more or less chert.

The formation is prevailingly thin-bedded, and the topography in the area in which it crops out is consequently less rugged and lacks the prominent cliffs that mark the higher Cambrian and Ordovician limestones. On the other hand, it is much more resistant than the shales of the Tybo formation, which immediately overlie it; consequently there is a marked steepening of the canyon walls within the area occupied by this formation.

Tybo shale -- The Tybo shale, named for its exposures in Tybo Canyon near the camp of Tybo, consists dominantly of fissile olive-gray to dark shale. The lithologic differences between the basal part of the Tybo formation and the underlying Swarbrick formation are not sharp. For purposes of mapping, the base is taken as the top of the highest chert bed of the Swarbrick formation. Thin beds of limestone and calcerous shale with concretions of dense gray limestone appear near the top of the formation, and the transition between shale and the overlying thin-bedded limestone of the Hales formation is gradual, though sharper than the transition at the base of the formation.

The exposures are not as good as those of the other formations, and as the shales are much crimpled no close estimate of the thickness is possible. As measured across the strike of the formation on the basis of average dips observed and the dips of the underlying and overlying formations it appears probable that the total thickness is about 1,600 feet.

The principal area in which the formation is exposed is a belt between 1,000 and 3,000 feet wide bordering the Swarbrick formation north of the 2G fault, principally north of the canyon. In the eastern part, near the mouth of the canyon, the apparent thickness is probably increased through partial repetition by faulting along the extension of the northerly fault that borders the hills of the canyon.

The same formation also crops out south of the canyon in the lowland bordering the range between the range front and the valley fill.

As the Tybo shale is less resistant than the overlying limestone and underlying chert, it tends to form lowland areas. On the north side of the canyon it crops out in an area of gentle slope, largely covered by talus of limestone. South of the canyon the formation is repeated by faulting. The northward-trending canyon that enters Tybo Canyon near its mouth is cut along one belt, and the other occupies the pediment bordering the upland area.

Hales limestone -- The uppermost Cambrian formation is here named Hales limestone from the Hales shaft of the Tybo mine, which is almost entirely within this formation. The formation consists almost entirely of limestone. At the base there is about 50 feet of brown shaly limestone transitional from the underlying calcareous shale of the upper part of the Tybo formation. In places, however, as in the areas near the east front of the range, these transitional beds are missing, and the fissile shale of the Tybo lies directly below the limestone. It may be, however, that the absence of the transitional beds is due to faulting.

The formation consists chiefly of bluish-gray limestone, for the most part thin bedded but containing a few massive members. Lenses and nodules of dark chert are abundant near the base but are absent from the upper part of the formation.

The upper part of the formation, as mapped, contains one or more beds of quartzite. On the north slope of the ridge north of the canyon about 2,500 feet above the base of the formation, a bed about 200 feet thick is present. Three quartzite beds, each about 50 feet thick, were found in the block adjoining the Uncle Sam fault in the northern part of the district, but here the interpretation of the structure is uncertain and it may be that a single bed is repeated by folding or faulting. As the quartzite occurs above the horizon at which Cambrian fossils are present it may possibly belong to the overlying Pogonip limestone, perhaps marking the base. However, as its relation to the undoubted Pogonip is unknown and the lithology of the limestone is the same above and below, it is included on the map with the Hales limestone.

As the Hales is lithologically similar to the overlying Pogonip limestone, and as no single block of the fault-block mosaic of the district contains both Cambrian and Ordovician fossils, the position of the upper boundary could not be determined. As mapped, the entire thickness of thin-bedded gray limestone in the fault block north of the 2 G fault and east of the Uncle Sam fault is assumed to belong to the Hales formation, giving a probable thickness of about 3,000 feet. The thickness from the base to the highest bed in which Cambrian fossils were found is about 1,300 feet.

The principal area of outcrop of the Hales limestone is north of the 2 G fault, bordering the area of the Tybo shale. As it is more resistant it forms an upland around the more easily eroded shale. On the west, where the dips are generally steep, the formation crops out in a ridge between the Tybo formation and the Uncle Sam fault. On the north the gently dipping limestones form the prominent cliff-walled ridge that forms the north wall of the Tybo Canyon. The formation is not continuous on the eastern limb of the anticline, as it is broken by the faults that parallel the front of the range, but it forms the crest and eastern slope of the ridge facing the valley south of the canyon and is also present on the corresponding ridge north of the canyon.

Dr. Charles E. Resser reported as follows on the fossils collected from the Hales formation:

> Lot 30.73 contains a new species of Pterocephalia, which together with some smaller trilobites indicates the same formation as the one that occurs in the Eureka district, but unfortunately this formation is not placeable in any determined section. At present we consider this bed as situated either in the upper part of the Secret Canyon shale or a little higher in the section. Lot 30.72, which you say is just below 73, contains trilobites that are altogether new. The remainder of the material appears to be approximately the same, but the type of brachiopod that is present is not confined to any particular zone but ranges widely throughout the Upper Cambrian. However, such trilobites as I have been able to uncover would place this material also at about

the same horizon as the preceding lot, making all of it Upper Cambrian.

ORDOVICIAN

Two formations of the Ordovician section of the Eureka district, the Pogonip limestone and the Eureka quartzite, are present in the Tybo district, but no Ordovician formation higher than the Eureka quartzite is present, and the Eureka quartzite and to a minor extent the underlying Pogonip limestone appears to have been eroded before the deposition of the next higher formation, the Lone Mountain dolomite, of Silurian age.

Pogonip limestone -- As fossils characteristic of the Pogonip formation, which is widespread over eastern Nevada, were found at many different horizons below the Eureka quartzite, the accepted name is used in the description of this formation.

Both the lower Pogonip (of Beekmantown age) and the upper Pogonip (of Chazyan age) are present in the district, but as no certain dividing line could be established they are not separated on the geologic map.

The rock occupying the wedge between the two eastern branches of the 2 G fault contains fossils of lower Pogonip age. Here the rock consists almost entirely of blue-gray limestone with well-marked bedding planes from 6 inches to 5 feet apart. A thin bed of quartzite, apparently not continuous, crops out near the northern branch of the fault in about the middle of the exposed section. The thickness of the formation, as exposed between the two branches of the 2 G fault, is at least 500 feet. Fossils from this locality were identified by Dr. Edwin Kirk as Orthis sp. and Lingulella sp.

Fossils oflower Pogonip age were also collected at the south end of the ridge just north of the mouth of the canyon. Here the relations with the neighboring rocks are uncertain. The gray limestone containing the Ordovician fossils is in fault contact with shaly limestone similar to that which crops out elsewhere at the base of the Hales formation and which carries Cambrian fossils. The north end of the ridge is capped by quartzite lithologically similar to the Eureka, but the ridge is crossed by one or more faults.

Dr. Kirk identified the following fossils from this locality:

29-99 Base of limestone at mouth of Tybo Gulch, north of gulch.
Lingulella cf. L. pogonipensis (Walcott).
Orthis sp.
Cystid plates
Fragments of asaphoid trilobite
Annelid trails.

Fossils of upper Pogonip age were found within a much larger territory, but it is possible that in these areas there may also be lower Pogonip beds, or there may be a gap of unknown extent between the recognized upper and lower Pogonip exposures.

The thickest section exposed is in the area north of the Dimick fault and west of the 2 G fault. Here the lower portion, exposed on Air Shaft Ridge and in the lower part of Bunker Hill Canyon, consists of about 1,000 feet of medium to thin bedded blue-gray limestone that weathers to smooth surfaces of light gray. Above this is a bed of impure quartzite, conglomeratic in places, which is nowhere over 50 feet thick. This bed can be traced from the south side of Air Shaft Ridge to a point a short distance south of the Bunker Hill fault, but is not found farther north. About 700 feet of thin-bedded limestone overlies the quartzite.

Above this limestone is a persistent zone of shale 400 feet in thickness. The shale is in part brown and calcareous, but particularly at the north, near the head of Bunker Hill Canyon, it is in part micaceous, with red iron oxide staining on the partings. The 900 to 1,000 feet of limestone that overlies the shale is more massively bedded than the lower limestone members. In the area south of the 2 G fault the limestone at this horizon forms prominent cliffs above the bench cut on the shale, but north of the Dimick fault, where the dips are generally steep, the more massive members tend to form sharp ridges. At this horizon there appears to be at least one bed of dolomite, apparently continuous and independent of the sporadic dolmitization found in places along the faults. Just beneath the Eureka quartzite a little splintery black shale was seen in places. This bed is probably not over 20 feet thick and is rarely observable owing to the heavy talus from the overlying quartzite. The total thickness of the Pogonip beds exposed in the area north of the Dimick fault is about 3,000 feet. The ridge south of the 2 G fault and east of the Uncle Sam fault shows the same general lithologic sequence, though, perhaps through errors in location on the topographic map, the apparent thickness of the different members is not quite the same. From the 860-foot level of the Tybo mine to the crest of the ridge the total thickness of the beds exposed is about 2,200 feet.

The principal fossil collections from the upper part of the Potonip came from the ridge south of the 2 G fault. Dr. Kirk identified the following fossils from collections made on the ridge southeast of the Tybo mine. Of these the first two lots were collected from the limestone below the shale and the last immediately above it.

29-18	Orthis sp.
	Orthis type of O. tricenaria Conrad.
	Rafinesquina sp.
	Maclurites sp.
	Cameroceras sp.
29-19	About 100 feet above 29-18
	Receptaculites mammiliaris Newberry
	Maclurites sp.
	Illaenus sp.
	Small subspherical algae (?)
29-20	Overlying slate
	Indeterminable bryozoan.
	Orthis ef. O. lonensis Walcott.
	Orthis type of O. tricenaria Conrad.
	Calcareous algae (?)

Collections made south of the 2 G fault on the east front of the range yielded the following:

29-103.	
	Interminable bryozoan.
	Valcourea (?) sp.
	Liospira sp.
	Trochonema sp.
	Leperditia bivia White
30-101	
	Undescribed bryozoan.
	Orthis sp.
	Eotomaria sp.
	Maclurea sp.
	Leperditia bivia White.

Dr. Kirk comments as follows on the upper Pogonip collections:

The foregoing lots may be correlated with the Chazyan of the East. The horizon is not known in Colorado or Texas, but an approximately equivalent horizon is found in the Swan Peak of northern Utah.

Fossils of upper Pogonip age were also found on Air Shaft Ridge and the hill to the north, but in this area they are poorly preserved.

E u r e k a   q u a r t z i t e -- The Eureka quartzite, characteristically a dense white quartzite, overlies the Pogonip limestone. In a few places where cementation is not complete, generally near the base, it is grayish in color, and faint bedding and rarely cross-bedding can be distinguished. It differs from the thin quartzite beds within the Pogonip formation in being purer and more massive.

As no fossils were found in the formation, the correlation with the standard Eureka section is based on its lithologic character and stratigraphic position. Where it lies between the Pogonip limestone and Lone Mountain dolomite, as in the hills west of the Bunker Hill fault, its position together with its lithologic character serve to distinguish it with certainty. In the eastern part of the district the overlying Lone Mountain dolomite is eroded, and the quartzite occurs as isolated masses capping ridges of Pogonip limestone. Its nearly pure-white color, greater degree of cementation, and greater thickness serve to distinguish it from the quartzite within the Pogonip limestone. Two small wedgelike masses of what is believed on lithologic evidence to be the Eureka quartzute occur along the Bunker Hill fault north and south of Tybo Canyon.

The maximum thickness as exposed in the Tybo district is only about 150 feet. On the hills north of the Cunningham project the Eureka is present as a series of discontinuous lenses, of unequal thickness, the result of erosion prior to the deposition of the overlying Lone Mountain dolomite.

SILURIAN

Lone Mountain dolomite -- Above the Eureka quartzite in the western part of the district is a thick formation consisting of several hundred feet of massive dolomite with some limestone near the base, which is correlated with that part of the Lone Mountain limestone of the Eureka district which is of Silurian rather than of Ordovician age.

The formation is readily distinguishable from the underlying Pogonip limestone by its more massive appearance and characteristically rough surface. Well-defined bedding planes are rare, especially in the dolomitic portion. Dolomite forms the bulk of the formation, in contrast to the dominant limestone of the underlying Pogonip limestone. There is, however, a small amount of dark likestone near the base and, as noted above, there is in places a little dolomite, apparently unconnected with faulting, in the upper part of the Pogonip limestone.

The western part of the hill north of Tybo Canyon and west of the Bunker Hill fault contains the principal exposure of this formation. Here it rests for the most part on the eroded and channeled surface of the Eureka quartzite and, where this is missing, directly on the Pogonip limestone. At the base is dark limestone of variable thickness, generally not over 100 feet, much more massive than the underlying Pogonip limestone and with a rougher surface, and above this is massive dolomite, lighter in color and characteristically weathering to a rough irregular surface. In places the dolomite contains white chert.

Massive dolomite, which is considered to be a part of this formation, although the underlying Eureka quartzite is not exposed, crops out in the triangular area bounded by the Dimick, Gilmore, and Uncle Sam faults.

The only determinable fossils from this formation were obtained from the dark limestone near the base of the formation a short distance north of the Cunningham prospect. Dr. Edwin Kirk reports on them as follows:

This lot is of middle Silurian age.
Conchidium sp.
Plectatrypa ? sp.
Coenites sp.
Pachypora sp.
Striatopora sp.

In the Eureka district the limestone directly overlying the Eureka quartzite is of Ordovician age. This limestone is absent in the Tybo district. As the Eureka quartzite was eroded prior to the deposition of the Silurian limestone, it may be that post-Eureka Ordovician limestone, if deposited in this area, was removed during this period of erosion.

TERTIARY (?)

Gilmore Gulch formation -- The Gilmore Gulch formation, named from its exposures in Gilmore Gulch, consists of sandstone, dark shale, and siliceous tuff. It occupies a low-lying area in the southern part of the district. The rocks are less resistant than others of the region, and the area in which they crop out is largely covered by talus from the quartz latite hill on the west and the cliffs of Pogonip limestone on the east; consequently exposures are poor.

The base of the formation is not exposed; the probable thickness of the exposed portion between the Uncle Sam fault and the rhyolite to the west is 400 to 500 feet.

The area in which the Gilmore Gulch formation is exposed is separated from the older formations on the north and east by faults. On the west the formation is overlain by a thick flow of quartz latite. No indication of its age is therefore evident from the areal geology other than the fact that the structural relations indicate that it is younger than the Lone

Mountain dolomite and older than the thick series of dominantly volcanic rocks that overlie it.

In the neighborhood of the Eureka district, particularly in the area shown on the Roberts Mountain topographic map, west and northwest of Eureka, there is an undescribed formation of probable Carboniferous age consisting dominantly of dark shale and sandstone and containing at least one flow of a basic amygdaloidal lava. It was at first supposed that the Gilmore Gulch formation of the Tybo district was the equivalent of this formation, and specimens of the shales contain possible fragmentary plant remains that suggest fragments of Stigmaria.

Field work in 1930 threw doubt on the probability of Carboniferous age. Except near the Uncle Sam fault the rocks are less dense and compact than the Paleozoic formations elsewhere. As additional outcrops were studied it was seen that bedded tuffs, derived from siliceous igneous rocks, constitute a considerable part of the formation, and that these tuffs show a lack of alteration more consistent with a Tertiary than a Carboniferous age. The tuffs and lavas of Triassic and Jurassic age in the central part of the Tonopah quadrangle, 60 miles to the west, are highly altered. In the southern part of the Tybo district, just south of the area shown on the map, there was found a flow of quartz latite or dacite, similar in general appearance to the thick lava flow overlying the Gilmore Gulch formation. This flow is apparently interbedded with the sediments of the formation and is succeeded by a few feet of sandstone before the base of the large quartz latite flow is reached.

The ovservations obtainable on the attitude of the beds show that although dips are steep close to the Uncle Sam fault, owing to drag on the fault, there are apparently no folds within the formation, and the attitude of the higher beds is the same as that of the base of the overlying lava. However, the Pogonip limestone just east of the Uncle Sam fault likewise shows only gentle tilting.

The Tonopah formation of the Tonopah district consists of at least 1,000 feet of largely water-laid material and is older than the Esmeralda formation. Although it is more tuffaceous than the Gilmore Gulch formation, its presence in approximately the same stratigraphic position is perhaps additional though slight evidence for a possible Tertiary age of the Gilmore Gulch formation. The Tertiary deposits of the Elko region contain, according to Chaney, a flora indicating a middle Miocene age. It is therefore thought that, notwithstanding the absence of definite fossil evidence in the Tybo district an early Tertiary age (older than upper Miocene) is not unlikely.

TERTIARY

Rocks to which a Tertiary age can be rather definitely assigned, although no fossils were found in them, occur in the western part of the district and cover the western slope of the range. These rocks are dominantly volcanic flows but also include sediments, and rocks of identical lithologic character occur in places along the eastern front of the range, east of the faults that parallel the range front. Porphyritic dikes similar in composition to the oldest of the flows are intrusive into the older sediments, particularly along the faults. Although there is no essential difference in composition between these dikes and the quartz latite flow, it is convenient to emphasize the difference in geologic occurrence by retaining the local distinction implied by the term "porphyry" and referring to the dikes as quartz latite porphyry and the effusive rock as quartz latite

Quartz latite prophyry -- A large number of small masses of porphyry occur throughout the area covered by the older formations. For the most part these masses have been intruded along preexisting fault planes, but in the relatively weak and thin-bedded shale of the Tybo formation there are numerous small sills parallel to the bedding. Small dikes that are not related to known faults are also found in the Pogonip limestone, particularly in areas where it has been strongly folded. The more massive Lone Mountain dolomite is free from porphyry, except along the faults at its boundaries.

The greater number of the dikes are alike in texture and composition, and nearly all show more or less hydrothermal alteration. The rock is white and fine grained and carries abundant small quartz phenocrysts. In a few places, as in one of the dikes north of the Bunker Hill shaft and on the 800-foot level of the Tybo mine, there is a well-marked banding parallel to the walls.

In most of the dikes the only readily recognizable mineral is quartz, which occurs in phenocrysts as much as 3 millimeters in diameter, for the most part deeply embayed by the matrix. Close inspection usually reveals also feldspar and a little bleached biotite. Study under the microscope shows that oligoclase, about Ab_{so} in composition, generally in part replaced by calcite and sericite, forms most of the small phenocrusts and much of the feldspar in the groundmass. Phenocrysts of orthoclase, similarly altered, and also present, and in some specimens the amount of orthoclase exceeds that of the oligoclase. Biotite is sparingly present and is inconspicuous. It is commonly altered to chlorite or sericite or a mixture of both minerals. The groundmass consists of a very fine grained aggregate of quartz and feldspar, the individual grains ranging from 0.02 to 0.05 millimeter. In one or two of the thin sections examined the groundmass shows a poorly developed spherulitic texture.

A few dikes similar in general composition are characterized by large feldspar phenocrysts. Some show oligoclase phenocrysts as much as two centimeters in length, sparsely scattered through the rock. Others show more abundant smaller phenocrysts of feldspar three millimeters or less in length and somewhat parger phenocrysts of quartz. The smaller feldspars are mostly untwinned. Biotite, largely altered to chlorite and sericite, is present in rather rare small phenocrysts. Dikes of this variety of porphyry were noted in the Tybo mine near the 2 G shaft and on the surface near the Bunker Hill shaft. The relative age of the two varieties was not determined.

There is no perceptible metamorphism of the sedimentary rocks adjacent to the dikes other than a slight induration of the soft shale of the Gilmore Gulch formation, but near the Rescue prospect, on the east front of the range, sough of the 2 G fault, there is a small area in which the gently tilted limestone of the upper Pogonip has been altered to finely crystalline white marble. No igneous rocks crop out in the immediate vicinity, but the marbleized area may be the result of contact metamorphism by an underlying intrusive.

Quartz latite -- A large mass of quartz latite forms the high peak west of the Uncle Sam fault and south of the Dimick fault and crops out over a considerable area west, south, and north of this peak. Similar quartz latite is also found along the east front of the range, south of Tybo Canyon and east of the range-front fault. In the principal area the lava shows flow banding at the base. This flow banding has approximately the same dip and strike as the underlying Gilmore Gulch formation. Near the top of the peak there is marked columnar jointing.

The upper part directly below the overlying sediments is deeply weathered, as if it had been long exposed prior to the deposition of the later (Esmeralda ?) sediments. In this upper deeply weathered part the iron of the biotite is largely oxidized. This, together with oxidation of probable pyrite, gives brown and reddish outcrops.

The total thickness of the quartz latite exceeds 500 feet.

The flow banding at the base and the presence of similar quartz latite in two widely separated parts of the district suggest that the rock is a flow, but it might also be interpreted as a large intrusive mass from which the cover was removed by erosion prior to the deposition of the later sediments.

The quartz latite does not differ essentially from the porphyry dikes just described. The grain is finer, and the phenocrysts are generally smaller and less prominent, though in places they form a greater proportion of the rock than in the dikes. Biotite appears to be much more abundant in the rhyolite than in the dikes. This abundance is in part due to its generally less complete alteration. Quartz is present in small embayed phenocrysts not exceeding two millimeters in diameter and generally less than one millimeter. Feldspar phenocrysts are of the same size and equal abundance. As in the dikes, oligoclase and orthoclase are both present; their relative abundance is undertain, but oligoclase is apparently more abundant than orthoclase.

In general the groundmass is more minutely crystalline than that of the dikes, spherulitic texture is much more common, and glass is present in specimens collected near the base of the flow.

The close petrologic similarity of the flow to the porphyry dikes suggests that they are essentially contemporaneous and that the dikes may represent conduits through which the lava passed to the surface. The apparent difference between the two rocks is largely due to the greater abundance of biotite in the quartz latite and its comparative lack of alteration.

Esmeralda (?) formation -- Resting on the quartz latite mass just described is a series of light-colored water-laid sediments, dominantly tuffaceous. At the base is a conglomerate containing pebbles of rhyolite. Nothing was found to indicate the age of these sediments, but they resemble the Esmeralda formation, of upper Miocene age, which is present in the Manhattan district, 50 miles to the west, and at Tonopah, 65 miles to the southwest, and as this formation is widespread over central and western Nevada, it is thought that the correlation is justified, although confirmatory fossil evidence is lacking. Similar sediments also overlie the quartz latite on the east front of the range, south of Tybo Canyon. As they are younger than the quartz latite, they are believed to be also younger than the mineralization. The faults in the western part of the district do not cut these sediments or the overlying lavas, but they are cut by the faults that parallel the east front of the range.

The maximum thickness in the western area is about 150 feet, but the formation appears to thin out to the south, as if deposited on an uneven surface of the quartz latite, so that on the high ridge a mile south of the mapped area and in the hills north of the area andesite appears to rest directly on the quartz latite.

Andesite and dacite -- Above the youngest sediments (Esmeralda formation?) lies a series of andesite and dacite flows, several hundred feet in thickness. These flows differ somewhat in texture and composition in different places and were not studied in detail. At one point, close to the power-line road, the succession of lava flows is broken by a bed of white tuff. A single outcrop of similar tuff, showing a steep dip, was found in the extreme southeast corner of the area mapped, near the fault that marks the eastern front of the range. The dip of the andesite flows in the western part of the district is less than that of the underlying Esmeralda (?) formation, indicating an unconformity.

Rhyolite -- On the west edge of the district the crest of the range is formed by a thick flow of rhyolite. This rock is platy and shows flow structure at the base and columnar jointing in the upper part. As far as could be seen from the road at the summit, this rhyolite forms the west slope of the range.

STRUCTURE

Summary

The structure of the Tybo district is comples, and the writer is by no means satisfied that in the short time available for the work he has been able to make an adequate explanation of all the facts observed. The most significant dips of the beds in the portion studied in detail are shown on the geologic map (Plate 1), but no attempt was made to work out minor details of the structure. From the available data, however, it is believed that the best interpretation of the structural history of the region is as follows:

In the area surrounding the district the Paleozoic rocks are relatively undistrubed, but within the district they are sharply folded in a narrow zone having a general northwesterly trend. In places the principal fold was overturned to the southwest. The first faulting took place within and consequent upon this overturned fold and was presumably the result of regional compression. The steeply dipping reverse fault was thus formed. Minor thrust faulting within the area of folding may have occurred at this time also. Later normal faulting took place at several different periods. The old fault was cut and displaced by one of these younger faults, but there was also later movement along this older fault in the reverse direction.

FOLDING

As far as known the Paleozoic rocks elsewhere in the Hot Creek Range, though faulted and tilted, are not highly folded. The sharp fold of the Tybo district appears to be a local feature. Even within the district pronounced folding is confined to that portion north of the 2 G and Dimick faults and south of the high ridge that lies north of Tybo Canyon. This folding has produced an irregular anticline.

As outlined along the upper boundary of the lowest Cambrian formation, the Swarbrick, the axis of the central part of the anticline trends north and south. The beds present steep dips and in places both limbs in the southern portion are overturned. Within the area of the Swarbrick formation the rock s are locally much contorted and show sharp subordinate folds. As outlined by the upper boundary of the next higher unit, the Tybo shale, the anticlinial area shows two distinct anticlinal axes which trend northwest. The northern of these axes is just south of the cliff that forms the top of the canyon rim. To the north and northeast the dips are gentle, but on the south and west they are steep and in part overturned. The crest of the southern anticline is just north of the 2 G fault. Here also the overturn is to the south, so that al though the Tybo shale is cut by the 2 G fault on the surface south of the Hales shaft, the mine workings directly below to a depth of nearly 900 feet show the stratigraphically higher Hales limestone against the fault.

The area west of the Uncle Sam fault and north of the Dimick fault presents a similar structure. The belt of dark shale within the Pogonip limestone outlines an anticline whose axis trends northwest. On the crest and northern limb the dips are moderate, but on the southern limb, in the portion north of Tybo Canyon, nearly vertical dips prevail. Overturned beds are found south of the canyon, close to the Dimick fault. Similarly the Eureka quartzite has vertical and overturned dips against the Dimick fault on the west end of Air Shaft Ridge, but progressively more moderate northward dips beneath the Lone Mountain dolomite north of the valley.

Outside this narrow belt of sharp folding there are only gentle flexures.

In the triangular area about 3,000 feet long that lies between the 2 G fault and the Uncle Sam fault the beds of Pogonip limestone dip gently to the north and northwest, but farther south, close to the Uncle Sam fault, on the ridge south of Fairbanks Canyon, southerly dips prevail. Eastward, near the Swarbrick prospect, the dips are steeper and dominantly to the northwest. The steeper dips (over 40°) are nearly everywhere close to faults and suggest drag, but the general attitude of the beds as outlined above suggests that south of the 2 G fault there may be a parallel but less pronounced anticline.

On the high ridge north of Tybo Canyon the sediments, though broken by faults, show prevailing rather gentle dips, apparently becoming less steep to the north. However, west of the crest, close to the area of porphyry that has been intruded along the Uncle Sam fault, steeper westerly to northwesterly dips prevail.

The folding involved the Lone Mountain dolomite, but although the relation of the Gilmore Gulch formation to the folds is uncertain, it is thought likely that the folding was completed before the Gilmore Gulch formation was deposited, for the dips of this formation correspond to the flow banding of the overlying flow. The younger lavas are likewise tilted to the southwest but at a smaller angle. The only definite evidence as to the date of the folding, therefore, is that it is later than upper Silurian. It is, however, presumably post-Paleozoic and contemporaneous either with the revolution that affected the rocks of the Sierra Nevada and western part of the Basin and Range province in late Jurassic or post-Jurassic time or with that which had its maximum intensity in the Rocky Mountains in early Tertiary time and extended into the eastern part of the Basin and Range province.

FAULTING

General Features

Several stages of faulting are shown by the relation of the faults to one another and by the relation of the intrusive porphyry, the quartz latite flow, and the later lavas to the different faults. It is believed that during each of these episodes renewed movement took place along the earlier faults.

It is suggested that the oldest major fault of the district, of which the present 2 G, Dimick, and Gilmore faults are segments, was formed as a result of the folding described above, along the oversteepened southwest limb of the southern anticline. This origin is indicated by the position of the fault relative to the crest of the overturned anticline and by the fact that the movement on this fault is in the reverse direction.

A possible alternative explanation of the 2 G fault and its continuation in the Dimick and Gilmore faults is that it represents a transverse fault of similar character to those studied by Nolan in the Gold Hill district, Utah. On the assumption that rather localized pressure was exerted from the east, it might be supposed that the fault developed early in the period of regional compression and that the folding, accompanied by minor thrusting (as in the gently dipping fault separating the Swarbrick and Tybo formations on the eastern ridge south of the canyon) was localized to the north of the fault. The relatively unfolded area to the south may either have remained stable or moved westward without folding along an overthrust fault whose plane is below the depth reached by mining developments on the 2 G fault.

Study of an area larger than that included in the present investigation would be necessary to determine which of these hypotheses to adopt, but the northerly dip of the fault and its position on the overturned limb of the fold incline the writer to prefer the first one.

It is possible that two other faults were formed at the same time. The fault along the ridge north of the canyon in the eastern part of the area mapped dips 30° - 45° and does not involve the Tertiary volcanics. The relations shown in section E E', plate 1, might be interpreted as the result either of normal faulting or of thrusting. The fault that crops out just west of the crest of the eastern ridge south of the canyon (Section A A', plate 1), does not continue south of the 2 G fault nor north of the fault that follows the east slope of the ridge and may be the result of thrusting from the east.

Probably at some time in the early Tertiary -- before the beginning of the upper Miocene, if the sediments above the rhyolite are correctly correlated with the Esmeralda formation, and probably before the deposition of the Gilmore Gulch formation -- there was widespread normal faulting throughout the region. To this period belong the Uncle Sam and Bunker Hill faults and other minor faults in the western and central parts of the district.

The Uncle Sam fault cuts the earlier 2 G fault, probably with approximately vertical downthrow to the west, so that the western segment of the original fault, the present Dimick fault, which, like the 2 G, dips steeply to the north, crops out south of the intersection of the Uncle Sam and 2 G fault.

There are porphyry dikes along the Uncle Sam, 2 G, Dimick, and Gilmore faults. The Dimick fault, however, cuts the quartz latite flow, and the quartz latite mass west of the Uncle Sam fault is depressed relative to the area on the east. Therefore additional faulting must havetaken place after the intrusion of the dikes along the faults and the outflow of the quartz latite, to which they may have been conduits.

This faulting must have been earlier than the final period of faulting, for the quartz latite flow and the overlying Esmeralda (?) formation are tilted toward the northwest to a greater degree than the later lavas.

The final stage of faulting developed new faults along the eastern front of the range and presumably blocked out the range in its present form. Lavas similar in composition to those of the higher western part of the range are present on the pediment along the eastern front.

These eastern faults appear to be a series of echelon faults rather than a single fault, and although the amount of displacement as indicated by the juxtaposition of the Tertiary lavas and Cambrian sediments is of the magnitude of several thousand feet, the individual faults cannot be traced for long distances and are lost where they pass into the area covered by the outcrop of weak Cambrian shales.

The eastern faults may have been as late as early Pleistocene, and they have determined the present outline of the range, but the present relief is probably in part the result of erosion of the down-faulted and on the whole less resistant formations east of this zone of faulting, and the worn-back scarp parallel to the range front is very likely a fault-line scarp rather than an original fault scarp.

There is evidence of movement later than the mineralization, which is itself later than the quartz latite, along the faults of the western part of the area, but it is not certain whether this can be correlated with the development of the range-front faults. Evidence of later movement on the 2 G fault is seen in the presence of post-mineral gouge in the workings of the Tybo mine. Apparently the amount of gouge increases to the west, which suggests that such late movement as took place along this fault was a consequence of renewed movement on the Uncle Sam fault. Along the Uncle Sam fault there has also been movement later than the porphyry dikes that follow the fault plane. The Gilmore Gulch formation dips away from the Uncle Sam fault, steeply close to the fault and more gently farther west, and the quartz latite and the overlying Esmeralda (?) formation have the same inclination as the western part of the Gilmore Gulch formation. The lavas above the Esmeralda (?) sediments, however, dip at lower angles. This fact seems to indicate that the renewal of movement along the Uncle Sam and probably the Dimick fault also took place in two stages, for the presence of an old topography on the crest of the range renders it unlikely that the northwestward dip of the younger lavas is a regional tilt consequent upon the faulting along the range front.

The net result of these different periods of faulting was to leave the central part of the district as a horst of older formations bounded on the east and west by relatively depressed younger rocks. On the east the bounding faults were newly developed and dip to the east, with the younger rocks on the hanging-wall side, but on the west the planes of the older faults were followed by the renewed movement, thus bringing the younger rocks in places below the older.

The degree to which movement later than mineralization affected the area west of the Uncle Sam fault naturally has an important bearing on the future mining development in this area, for it may be that along the Dimick fault the zone of productive mineralization has been depressed below that of the Tybo mine on the east. Data are lacking, however, for any estimate of the magnitude of such movement.

<u>Individual Faults</u>

2 G fault -- The 2 G fault is a reverse fault formed along the

overturned southern limb of the southern of the two anticlines outlined by the Tybo shale. The position of this fault and its displaced segment, the Dimick fault, relative to the overturned southern limb of this anticline suggests that it was formed as a result of the oversteepening of this fold. An alternative explanation is that it is a transverse fault along which movement was largely horizontal -- to the west north of the fault -- and that the folding and minor thrusting to the north, as contrasted with the slight deformation of the sediments to the south, was confined to the westward-moving northern block, whereas the southern block either remained stationary or moved westward without folding.

The fault is certainly traceable for 8,000 feet, from the Uncle Sam fault eastward to the Swarbrick prospects on the east side of the ridge overlooking Hot Creek Valley. It carries the ore bodies of the Tybo mine and has been developed underground in that mine for a horizontal distance of about 2,400 feet and a depth of nearly 900 feet below the collar of the 2 G shaft. The average strike is about N. 68° W. and the dip is 70° - 80° N. On the south the Pogonip limestone, with relatively gentle dips, forms the foot-wall for the entire distance. The northern or hanging wall consists of Cambrian strata. The limestone of the Hales formation forms the hanging wall at the eastern and western ends, with the lower formations, the Tybo and Swarbrick, in the middle part. Below the 300-foot level in the Tybo mine the overturned dips north of the fault cause the Hales limestone to be the hanging-wall rock of the mine workings, although shale of the underlying Tybo formation forms the hanging wall at the surface.

Porphyry is present in places along the fault plane itself, and cross cuts in the Tybo mine show that dikes also occupy parallel fissures close to the main fault. The largest mass is near the intersection of the two branches that diverge eastward.

At the western end there are two distinct branches with Pogonip limestone between them. These branches apparently unite on the surface near the 2 G shaft and are about 200 feet apart close to the Uncle Sam fault. What are apparently the same faults have also been developed on the 300-foot level of the mine. But the intersection, which pitches to the west, is presumably above the point where the 710-foot level intersects the Uncle Sam fault. Another branch from the 2 G fault diverges in the opposite direction from a point about 2,000 feet east of the intersection of the 2 G and Uncle Sam faults and where it crosses the ridge is about 1,000 feet from the 2 G fault.

Fossils of lower Pogonip (Beekmantown) age were collected from the wedge that lies between the main fault and the branch that diverges to the southeast; the presence of lower Pogonip indicates that the displacement is divided between these two branches, with the greater amount on the northern branch.

As no complete stratigraphic section could be worked out in the district the apparent vertical displacement on this fault is not measurable, but it may exceed 6,000 feet. On the north side the lowest stratigraphic unit in contact with the fault, the Swarbrick formation, which has a thickness of at least 2,000 feet above the lowest point at the fault contact, is succeeded by 1,600 feet of the Tybo shale and this by at least 1,300 feet of the Hales limestone. To the south fossils identified by Kirk as belonging to the upper (Chazyan) part of the Pogonip were collected close to the fault, and in all considerably more than 1,000 feet of the upper and lower parts of the Pogonip must be present on the south side.

Dimick and Gilmore faults -- The Dimick and Gilmore faults are regarded by the writer as the continuation of the two western branches of the 2 G fault displaced by the Uncle Sam fault. Their intersections with the Uncle Sam Fault are south of those of the two western branches of the 2 G fault with the Uncle Sam fault, and they are much farther apart than the two branches of the 2 G fault. This would be the expected situation of two faults with northerly converging dips displaced approximately vertically by a fault nearly at right angles to their strikes.

The Dimick fault for about 2,000 feet westward from the Uncle Sam fault strikes about west and dips steeply to the north, probably about 80°. Along this portion it has Pogonip limestone, which dips moderately toward the southwest, on the north, and massive dolomite, presumably of Silurian age, whose attitude could not be determined, on the south. Porphyry is present in places along the fault plane. Beyond this point, which probably about coincides with the junction of the Dimick and Gilmore faults, the strike is about N. 60° W. and the dips average 55° to 60° NE. Across the western end of Air Shaft Ridge the Eureka quartzite and for a short distance Silurian (Lone Mountain) dolomite, both with overturned steep northeasterly dips, occur on the hanging-wall side against quartz latite on the footwall. It is probable that there is a branch fault on Air Shaft Ridge north of the Eureka quartzite, for the apparent thickness of the upper part of the Pogonip, as measured from the band of impure quartzite that extends from the central part of the ridge northward to the

Bunker Hill fault, is less than 1,000 feet, as contrasted with about 1,900 feet on the north side of the valley. The Dimick fault can be followed for about 1,000 feet north of the valley until it is lost under the wash. In this section it truncates the strike of the upper part of the Pogonip limestone, the Eureka quartzite, and the lower part of the Lone Mountain dolomite on the hanging-wall side. Quartz latite continues along the foot-wall. At the northern border of the area covered by the geologic map a fault contact between quartz latite and Silurian (Lone Mountain) dolomite shows parallel strike and dip. If this is the same fault as the Dimick it must have been displaced to the northeast by another fault, for the projection of its strike to the southeast brings it against the Silurian dolomite.

The Gilmore fault can be followed with certainty westward from the Uncle Sam fault for a distance of about 2,000 feet. Farther west surface exposures are obscure, but it probably joins the Dimick fault near the west end of Air Shaft Ridge. As the fault crosses the steep hill west of the Uncle Sam fault the trace on the surface is curved, but the strike is about west and the dip averages about 65° N. On the hanging-wall side occurs massive Silurian dolomite, and on the footwall are the sandstone and shale of the Gilmore Gulch formation, showing steep dips close to the fault plane but gentle southwesterly dips a short distance away.

The combined displacement on the Dimick and Gilmore faults cannot be even as roughly estimated as that on the 2 G fault, because the total thickness of the Gilmore Gulch and Lone Mountain formations is unknown, and there is no clue to the thickness of strata that may intervene between the Lone Mountain dolomite and the Gilmore Gulch formation. In view of the vastly different ages of the formations involved it is a reasonable assumption that the displacement of the two faults is of the same order of magnitude as that of the 2 G fault. It is certain that the apparent throw on the Dimick fault alone, where the Lone Mountain dolomite is in contact with the Pogonip limestone, represents a stratigraphic displacement of at least 2,000 feet. To this amount must be added whatever displacement may be indicated by the juxtaposition of the Gilmore Gulch and Lone Mountain formations along the Gilmore fault.

Uncle Sam fault -- The Uncle Sam fault sectios A A', B B' and C C', Plate 1) crosses the entire district, and as far as could be seen from the ridges on the north and south continues in both directions for a considerable distance. South of the Gilmore fault the upper part of the Pogonip limestone on the east is in contact with the Gilmore Gulch formation on the west. Between the Gilmore and Dimick faults the Lone Mountain dolomite is in fault contact with the Pogonip limestone. North of the Dimick and 2 G faults Cambrian limestone occurs on the west and the upper part of the Pogonip limestone on the east. The strik e is north from a point a mile or more south of the southern border of the mapped area in Tybo Canyon; on the north side of the canyon it is about N 30° W. Surface observations on the hill south of Tybo Canyon indicate an eastward dip of 75° to nearly vertical. What is apparently the same fault on the 300-foot level of the Tybo mine dips 80° W., and the position of the outcrop relative to the fault on this level likewise indicates a steep westerly dip. If the assumption is correct that the fault near the west end of the 710-foot level is also the Uncle Sam fault, there must be a reversal in the direction of the dip between these levels, for the dip in that place is 85° NE. and the position of the fault about 100 feet to the northeast of its position on the 300-foot level.

If, as seems likely, the regional northwesterly dip of 10° to 15°, shown by the lavas younger than the Esmeralda (?) formation, is a result of tilting of the whole area consequent upon the late faulting along the range front, the original dip of the Uncle Sam fault may have been steep to the west. The Uncle Sam fault is therefore regarded as a normal fault later than the 2 G fault, which it displaces.

The displacement is large, but the lack of a complete stratigraphic section prevents accurate measurement. It is possibly of the order of magnitude of 2,000 feet.

Porphyry has been intruded in places along the fault plane. In the southern segment the dikes are narrow, but larger masses, with a maximum width of 1,000 feet, are present along the northern segment.

A branch of the Uncle Sam fault extends northwestward with nearly parallel strike across the east end of the high ridge north of Tybo. Limestone regarded as belonging to the Hales formation borders the fault on both sides, but on the southwest side it contains narrow bands of impure quartzite or perhaps a single bed repeated by minor faults. As the Hales and Pogonip formations are lithologically similar, it is possible that this limestone belongs to the Pogonip limestone. No fossils were found in the segment between the two faults.

A peculiar feature of the Uncle Sam fault is the presence of two narrow slivers of quartzite, each less than 100 feet in width, in the plane of the fault, one south and one north of Tybo Canyon. (See map and section C C', Plate 1.) This quartzite is of the same dense white variety as the Eureka quartzite and has been mapped as Eureka, but on lithologic evidence alone. The southern mass, which forms a narrow wedge between the upper part of the Pogonip limestone and the Gilmore Gulch formation, can be interpreted as the result of distribution of displacement between two branches of the fault, for its position implies a drop of 600 or 700 feet below the projected position of the Eureka quartzite in the area east of the fault, and it is at a considerable but unknown distance above the horizon at which the quartzite should be present in the area west of the fault. The northern mass of quartzite, however, lies stratigraphically below the projected position of the Eureka quartzite on both sides of the fault -- several hundred feet below west of the fault and much farther below east of it. Therefore, if it is indeed the Eureka quartzite it must be a keystonelike wedge dropped down to a greater extent than the amount of displacement on the fault itself.

An alternative explanation for the northern mass is that it represents not the Eureka quartzite but a quartzite bed within the Pogonip limestone which, because of secondary silification along the fault plane, now closely resembles the Eureka. Against such an explanation are the facts that silicification was nowhere else observed along other fault planes and that the other outcrops of quartzite within the Pogonip limestone do not bear any close resemblance to the Eureka quartzite.

Bunker Hill fault -- The Bunker Hill fault has a northwesterly strike and diverges from the Uncle Sam fault at a point near the old Bunker Hill shaft. It is a normal fault with relatively small vertical displacement, which, as measured by the offset of the shale in the Pogonip limestone, is not over 300 feet.

Range-front faults -- Insufficient time was devoted to the east front of the range to work out the structure in detail, and along the pediment that borders the range the exposures are not as good as elsewhere in the district. Along certain of the faults there has been comparatively recent movement, because rocks similar to the quartz latite, Esmeralda (?) formation, and andesite of the western part of the district are faulted down along the east front. Two of them, however, which do not involve the Tertiary rocks, may be older and may have formed during the period of folding and compression.

A fault with comparatively low dip to the northeast -- from less than 30° to not over 45° -- crops out just west of the crest of the ridge that borders the district north of the canyon. On the hanging-wall side is the upper part of the Pogonip limestone, with only a few feet intervening between the fault plane and the Eureka quartzite, which caps the hill. As the Paleozoic rocks are here folded, the structural relations (section E E' Plate 1) are explainable either on the assumption of a normal fault or a thrust, which has moved the crest of another fold southwestward.

A similar fault, for which the evidence of greater age is stronger, lies west of the crest of the eastern ridge south of the canyon. Slate of the Tybo formation lies to the west, and limestone that is assumed to belong to the Hales formation, though no fossils were found, to the east. The fault is approximately parallel to the strike of the beds on both sides, and its recognition was due to the thinning of the outcrop of the Tybo shale to the south and to minor discordance in structure here and there along its course. The dip is unknown, but the trace of the outcrop suggests that it is fairly gentle to the east. The fault is cut off on the north by the fault that follows the eastern face of the ridge. On the south it is traceable as far as a mass of porphyry along the 2 G fault. It does not cut this porphyry or the 2 G fault, but on the other hand no corresponding fault was observed south of the 2 G fault to the west. The structural relations (section A A', Plate 1) can be explained on the basis of either a normal or a thrust fault, as it cuts the limb of the anticline obliquely. If it is a normal fault it is presumably older than the porphyry. It does not cross the 2 G Fault, and this assumption therefore requires that the downthrow of the hanging-wall block must have been accompanied by movement on that part of the 2 G fault east of the intersection. If it is a thrust fault it is best explained by supposing that the 2 G fault is a transverse fault along which the north side moved to the west, and that this fault developed as a minor thrust in conjunction with this westward movement.

Near the extreme southeast corner of the area shown on the geologic map is a small outcrop of limestone from which Cambrian fossils were obtained. This limestone dips to the north below the shale of the Tybo formation, but it could not be determined whether this relation was due to an overturned fold or a thrust fault, or whether the limestone might be a bed within the Tybo formation not found elsewhere in the district.

The other faults along the eastern border of the range appear to be comparatively young normal faults, because they involve the Esmeralda (?) formation and younger lavas and no porphyry has been intruded along them. These faults have strikes between north and northwest, and the dips in the few localities where they could be determined showed a range of from 35° to 70° E. None of the faults could be traced far, and all were lost northwards in the shale of the Tybo formation, possibly dying out as flexures, although the magnitude of the displacement at their south ends, as shown by the downfaulting of the Tertiary lavas, makes this explanation doubtful.

The best-exposed fault of this group follows the eastern base of the ridge south of the mouth of the canyon. Along most of its course it separates the Cambrian Hales and Tybo formations. South of the point where it cuts off the 2 G fault Pogonip limestone lies on the footwall side, and still farther south dacite, similar to that which occurs above the Esmeralda (?) formation in the western part of the district, comes in on the footwall side along an eastward-trending fault.

The east-west fault, which dips steeply to the north, possibly marks the position of the 2 G fault as displaced by the fault just described. If so, it is to be supposed that the fault was at one time covered by the later flows and that when the faulting along the range front took place the old fault broke through this cover, and the block of andesite now exposed is the result of gravitative downfaulting along these two faults, normal with respect to the north-south fault but reverse to the steep dip of the rejuvenated east-west fault. The other faults that lie to the east seem to form a definite zone rather than a single fault and appear to be in echelon arrangement. The outcrops, however, are poor in this part of the area, and the distance from definite fixed points has rendered their exact position uncertain. In the few localities where the actual fault plane is exposed there is abundant gypsum in large crystals in the fault gouge. This mineral was not seen in connection with any of the western faults.

The position of the quartz latite relative to the dacite and andesite in the extreme southwest corner of the area mapped suggests thrust faulting along the range front, but the field relations are obscure. It appears from the contact of the quartz latite and dacite to the west of the fault that the surface of the quartz latite was irregular. Therefore, if there is some horizontal component the major direction of faulting may be normal. The dacite, as shown by the dip of the interbedded tuff, is strongly tilted, and other faults may be present. Certainly the relation of the quartz latite to the older rocks to the north indicates normal faulting.

GEOMORPHOLOGY

No geomorphic study of this portion of the Hot Creek Range was made, and the following notes are consequently of less value than if the conclusions had been checked by observations made over a wider area.

The high ridges north of Tybo Canyon show remnants of an older topography at altitudes slightly greater than 8,000 feet. The contrast is abrupt between the rolling upland and the steep walls of the present canyon. The southern ridge, though reaching nearly to the same altitude and showing a fairly even skyline, is narrower and no longer preserves the remains of the old topography. This mature surface is also preserved along the crest of the range. A little waterworn gravel was found on the divide west of Tybo, at the point where the road following the power line crosses the range, at the height of about 8,000 feet.

The western slope of the range coincides with the dip of the rhyolite flows, but as this old topographic surface cuts across the rhyolite as well as the older rocks, this slope cannot be directly the result of the tilting of the range consequent upon faulting toward the east, but must be a dip slope revealed by the erosion of less resistant overlying material. For the same reason no major movement can have taken place on the Uncle Sam fault or other faults in the central part of the district since the development of this surface.

Similar old topographic surfaces are found on other ranges in Nevada and probably represent remnants of widespread early Pleistocene or late Pliocene surfaces of low relief. On the Toquima Range, about 30 miles to the northwest, an old erosion surface is preserved at a general altitude of about 10,000 feet. This surface was broken up by renewed faulting during the Pleistocene epoch, but it is uncertain whether the ranges that resulted from this recent faulting were formed as independently uplifted blocks in an area of low relief, or whether, as is more commonly assumed, there was first a regional uplife followed by graben faulting, which outlined the present valleys. The presence of postmature surfaces on nearly all the basin ranges at greatly different altitudes is suggestive of the first hypothesis, but on the other hand the old surface is not a peneplain, so considerable original differences in altitude are possible, and if the region were one of interior drainage the old topography might have been dependent on base-levels at different altitudes.

Blackwelder has emphasized the difference between the ranges of the Great Basin which follow faultline scarps and those which have a relief that is directly due to faulting and which are bordered by fault scarps, more or less worn back according to the resistance of the rock, and the interval since the activity of the fault. It seems probable that the eastern front of the Hot Creek Range is a faultline scarp rather than a primary fault scarp and that the present relief of the range is due to erosion of material east of the range-front faults rather than directly to faulting.

As far as can be seen from the road along the valley the range is bordered by Tertiary lavas for some distance south of the Tybo district. Spurr crossed the range at Hot Creek about 10 miles north of Tybo, and his section shows lavas along the eastern front at that point. Between Tybo Canyon and Hot Creek, however, Paleozoic rocks form the range front. These rocks, as shown by the exposures in the pediment south of the canyon, are faulted and are in fault contact with the Tertiary formations.

The Esmeralda (?) formation, overlying the quartz latite, and the quartz latite itself, where weathered and fissured, are more susceptible to erosion than the later lavas. Where the Esmeralda (?) formation, of which traces yet remain in the pediment along the range front, was originally present in considerable thickness, as at the mouth of Tybo Canyon, the Tertiary formations east of the present range may have been removed by erosion, giving the present faultline scarp. Farther south, where the more durable later lavas rested directly on the rhyolite, these lavas form the front of the range, possibly bounded by other faults.

There were two distinct stages in the sculpture of the range. At the close of the first stage a rather wide valley was formed in the present Tybo Canyon; later erosion carried away the valley fill, deposited during the earlier stage, thus revealing the pediment that fronts the range, and cut the canyon to a greater depth. Traces of the older valley remain in gravel-covered spurs at heights of several hundred feet above the present canyon floor. The wide bench of altered quartz latite southwest of the Dimick fault was probably developed in this stage, aided by the stripping of its cover of weak tuffaceous sediments of the Esmeralda (?) formation. A remnant of the valley fill of the early stage is preserved in the huge gravel ridges that project into the valley a short distance north of the mouth of the canyon.

The cause of this lowering of base-level was not determined, but on looking southeast from the hills fronting the range a marked gap appears in the hills at the south end of Hot Creek Valley. Perhaps there has been a capture of drainage from Hot Creek Valley by Reveille Valley, which lowered the base-level and laid bare the pediment of Tertiary rocks that fronts the range east of the Tybo district.

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JOHN B. FARISH, REPORT DATED, OCTOBER 1910

W. H. BLACKBURN, GEN'L. SUPT., TYBO MINE, 1928-1937

MINERALOGY

THE PRIMARY SULPHIDE MINERALS ARE PYRITE, SPHALERITE, GALENA, CHALCOPYRITE, PYRRHOTITE, AND ARSENOPYRITE. IN THE TYBO ORES WHICH ARE AMENDABLE TO DIFFERENTIAL FLOTATION, GALENA AND SPHALERITE ARE THE MAJOR PAY MINERALS. VARYING AMOUNTS OF SULPHIDE NON-PAY MINERALS ARE PRESENT, PYRITE PREDOMINATING. MINERALIZED ZONES,DURING THE 1929-1937, INC. PRODUCTIVE PERIOD WHICH WERE BELOW THE THEN EXISTING ECONOMIC CUT-OFF POINT WERE FOUND TO HAVE GREATER PYRITE PERCENTAGE AND LESSER AMOUNTS OF GALENA AND SPHALERITE. OF THE TWO MINERALS, GALENA AND SPHALERITE, GALENA RATIO IS SLIGHTLY HIGHER. A TYPICAL RATIO EXAMPLE IS: 7.38% LEAD TO 5.55% ZINC IN THE ORES. THE GALENA CARRIES THE GREATER AMOUNT OF SILVER. ASSAYS OF PURE MINERAL GAVE A CONTENT OF 110 TO 130 OUNCES OF SILVER WITH THE GALENA TO THE TON, AS AGAINST A MAXIMUM OF 20 OUNCES FOR SPHALERITE AND 11 OUNCES FOR THE PYRITE. A TYPICAL MONTH MILL RUN SHOWED A TOTAL SAVING OF 74.9% OF THE ASSAY OF SILVER WITH 65.4% BEING IN THE LEAD CONCENTRATES AND ONLY 9.5% IN THE ZINC CONCENTRATES. A GOOD PORTION OF THE SILVER IN THE TYBO MINE TAILINGS IS CONTAINED IN THE IRON PYRITE, INCLUDING PYRRHOTITE AND MARCASITE.

THE SPHALERITE IS DARK BROWN TO ALMOST BLACK. ANALYSES OF SPECIMENS SHOW 10-15% OF IRON BUT ACCORDING TO THE STUDIES OF M. N. SHORT, U. S. GEOLOGICAL SURVEY, POLISHED SECTIONS INCLUDED SPECKS OF CHALCOPYRITE AND ARSENOPYRITE. A PART OF THE IRON MAY BE DUE TO THOSE INCLUSIONS. THE SPHALERITE IS MORE COARSELY CRYSTALLINE THAN THE GALENA AND,THOUGH MOSTLY IS INTIMATELY MIXED WITH THE GALENA, HAS BEEN PROVEN TO OCCUR IN NEARLY PURE COARSELY CRYSTALLINE MASSES SEVERAL FEET IN DIAMETER.

PYRITE IS THE MOST ABUNDANT OF THE SULPHIDE MINERALS. THE PORPHYRY IN THE DISTRICT IS IMPREGNATED WITH PYRITE TO A GREATER OR LESSER EXTENT. IN PLACES WHERE THE ORE MINERALS HAVE REPLACED LIMESTONE INSTEAD OF PORPHYRY, PYRITE OCCURS IN POORLY DEFINED LAYERS, SEPARATED BY SIMILAR LAYERS OF GALENA, SPHALERITE AND GANGUE. THIS OCCURRENCE IS RATHER RARE AND MIGHT REPRESENT OUTLINES OF THE ORIGINAL BEDDING PLANES OF THE LIMESTONE BUT COULD ALSO BE RHYTHMIC BANDING. THE WRITER SAW EVIDENCE AT THE TYBO MINE INDICATING THAT THE PYRITE IS A ZONE INFLUENCE MINERAL WITH THE GREATER PERCENTAGE RATIO AGAINST THE PAY MINERALS ON THE BOUNDARY LINES OF THE ORE BODIES.

ARSENOPYRITE IS WIDESPREAD BUT IN MINOR AMOUNTS. ASSAYED ORE SPECIMENS HAVE SHOWN A CONTENT OF 0.59%.

CHALCOPYRITE IS OF VERY MINOR PERCENTAGE AND ASSOCIATED WITH THE SPHALERITE. SPECIMENS HAVE SHOWN A CONTENT OF BUT 0.02%.

PYRROTITE IS SPORADIC IN OCCURRENCE, LIMITED IN ABUNDANCE AND IS PROBABLY QUANTITATIVELY UNIMPORTANT.

MINERALOGY, CONTINUATION :

BELOW THE OXIDE-SULPHIDE LINE OF DEMARCATION BETWEEN DIFFERENTIAL FLOTATION PRODUCTS AND THE UPPER DIRECT SMELTING CRUDE ORE, THE ORE BODIES CONSIST OF LARGELY SULPHIDES. PLEASE NOTE, FIGURE NO. 3", A VERTICAL SECTION OF 2-G VEIN MINERAL GRADATION. NO DOUBT, IMPROVEMENT IN THE SELECTIVE FLOTATION PROCESS DURING THE PAST 23 YEARS WILL ALLOW BETTER OVERALL RECOVERY AND MORE ACCEPTANCE OF PARTLY OXIDIZED LEAD MINERAL AREAS INTO THE DAILY TREATMENT TONNAGE THAN WAS POSSIBLE WHEN THE PIONEERING CONCENTRATOR WAS IN MOVEMENT, 1929 TO 1937. THIS PROBABLY WILL RELEASE TONNAGE THAT IS DEVELOPED BUT EARLY OPERATORS COULD NOT TAKE ON ACCOUNT OF COMBINED SULPHIDES WITH THE OXIDES AND TREADWELL COULD NOT BALANCE IT ON ACCOUNT OF THE OXIDES.

ORE SPECIMENS HAVE ASSAYED 32.05% SILICA BUT QUARTZ PROBABLY CONSTITUTES ONLY A SMALL PART OF THE PERCENTAGE. THE GREATER PART OF THE SILICA CONTENT BEING CONTAINED IN THE SERICITE AND OTHER SILICATES OF THE ALTERED PORPHYRY.

COARSELY CRYSTALLINE CALCITE IS A COMMON GANGUE MINERAL.

ROCK ALTERATION ALONG THE VEIN IS MOSTLY CONFINED TO THE PORPHYRY. IN PLACES THE LIMESTONE ALONG THE VEIN IS SILICIFIED TO A SLIGHT EXTENT. THE PORPHYRY ALTERATION, HOWEVER, IS WIDESPREAD. NEAR THE ORE THE PORPHYRY IS SO ALTERED THAT QUARTZ PHENOCYRSTS ARE THE ONLY REMAINING REMNANTS OF THE ORIGINAL MINERALS. CALCITE OCCURS MORE FREQUENTLY CLOSE TO THE ORE AND MINERALIZED AREAS. SPECIMENS TAKEN NEAR THE ORE BODIES SHOW THAT THE PORPHYRY HAS BEEN ALTERED TO A COMBINED MIXTURE OF CALCITE AND SERICITE.

THE ORE DEPOSITION ORIGIN IS DEFINITELY RELATED TO THE INTRUSIVE PORPHYRY, WHICH FOR THE MOST PART FOLLOWED PREEXISTING FAULTS.

THE OTHER PRINCIPAL FAULTS ALONG WHICH THERE HAVE BEEN INTRUSIONS OF PORPHYRY ARE THE GILMORE, DIMMICK AND UNCLE SAM. ALL THESE FAULTS HAVE BEEN PROSPECTED AND HAVE PRODUCED SOME ORE. ACCORDING TO AN OBSERVATION BY HENRY G. FERGUSON IN HIS "GEOLOGY OF THE TYBO DISTRICT, NEVADA", THE FOLLOWING OBSERVATION WAS MADE : " THERE WAS POST MINERAL MOVEMENT ALONG THE UNCLE SAM FAULT, AND IT IS THEREFORE POSSIBLE THAT ALONG THESE FAULTS THE ORE-BEARING ZONE HAS BEEN DEPRESSED BY THIS FAULTING AND WILL BE FOUND AT GREATER DEPTH AVERAGE THAN THAT DEVELOPED ALONG THE 2-G FAULT". IN ANOTHER SECTION OF THE REPORT MR. FERGUSON MENTIONED THAT EASTERLY EXPLORATION SOME DISTANCE FROM THE HALES SHAFT, ALONG THE 2-G FAULT LINE, WOULD BE VERY FAVORABLE RELATIVE TO THE DISCOVERY OF NEW ORE AS THE ZONE HOLDS THE MINERAL MAKING INFLUENCE OF A LARGE STOCKWORK OF PORPHYRY INTRUSIVE. THIS HAS ALREADY BEEN PARTLY VERIFIED BY THE PROVEN ORE OCCURRENCE DEVELOPED ON THE 300 LEVEL EASTERLY BY THE HALL BROS. COMPANY IN THE EARLY 1940S AFTER TREADWELL YUKON SUSPENDED OPERATIONS.

METALLURGY :

EARLY TYBO MINE METALLURGICAL HISTORY AS MENTIONED IN THE FIRST PAGES OF THIS REPORT, FIRST INCLUDED DIRECT SELECTIVE OXIDE ORE SMELTING ON THE PROPERTY WITH ACCOMPANYING HIGH LOSSES, SUBSEQUENTLY STAMP MILL GRINDING WITH PAN-AMALGAMATION OF THE SILVER AND GOLD FOLLOWED BY A LATER PERIOD WHEN SIMPLE FLOTATION WAS USED WITH THE CONCENTRATES BEING SMELTED ON THE PROPERTY.

THE TREADWELL YUKON CONSOLIDATED, LTD. COMMENCED MILLING ON MAY 13, 1929 IN ONE OF THE EARLY UNITED STATES DIFFERENTIAL FLOTATION PLANTS. THE PROCESS,DISCOVERED IN THE MIDDLE 1920S, MADE IT POSSIBLE TO SEPARATE LEAD SULPHIDES FROM ZINC SULPHIDE,PREPARED FOR LEAD SMELTING AND ZINC PLANT MARKETS. DURING THIS PERIOD ANY AMOUNT OF OXIDE ORE TREATED WITH THE SULPHIDE ORE RESULTED IN VERY POOR RECOVERY. AS A CONSEQUNCE THE LEAD-ZINC SULPHIDE ZONES MINED HAD TO MEET MINIMUM OXIDE CONTENT REQUIREMENT. THE IMPROVEMENT DURING THE PAST 23 YEARS IN DIFFERENTIAL FLOTATION PROCESS PROCEDURE WILL ALLOW SOME OF THE OPENED TONNAGE WHICH THE FORMER OPERATOR COULD NOT TREAT, TO BE SUCCESSFULLY HANDLED METALLURGICALLY AT THIS TIME. AN EXAMINATION OF "PLATE NO. 6 " HEREWITH, SHOWING A LONGITUDINAL SECTION OF THE MINE WORKINGS IN DETAIL TO THE 710 FOOT LEVEL INDICATES THAT MUCH TONNAGE JUST ABOVE THE 340' TO THE 360' ELEVATION WAS LEFT IN THE BACK OF STOPES. AS THIS LINE IS NEAR THE DEMARCATION POINT BETWEEN OXIDES AND SULPHIDES, IT IS SAFE TO ASSUME THAT METALLURGICAL COMPLICATIONS PREVENTED TOTAL PRODUCTION OF THESE PREPARED BLOCKS. SEVERAL LARGE SAMPLES WERE TAKEN OFF OF THE ACCESSIBLE AREAS OF THE 300' LEVEL ABOVE THESE BLOCKS OF REMAINING ORE. BOTH INTERNATIONAL SMELTING REFINING AND MINING CO. AND U. S. SMELTING, REFINING & MINING CO. INDICATED THAT THE ORE WAS ACCEPTABLE. U. S. S. R. & M. CO. WOULD RUN IT THROUGH THEIR SELECTIVE FLOTATION PLANT AT MIDVALE, UTAH. IT IS UNLIKELY, HOWEVER, THAT ANY OF THIS ORE WOULD BE SHIPPED FROM THE PROPERTY WITHOUT MILLING FIRST AS A MATTER OF ECONOMY.

DURING THE LAST MILLING OPERATION AT THE PROPERTY, SOME 320 TONS PER DAY WAS THE MILLING OBJECTIVE. ASIDE FROM BETTER METALLURGICAL PROCEDURE NOW POSSIBLE, A SMALLER PLANT TO HANDLE SOME 100 TONS PER DAY WOULD ALLOW SELECTIVITY OF THE MILL FEED WHILE REHABILITATING TOWARDS THE LOWER LEVELS WHICH COULD FURNISH ADDITIONAL DAILY TONNAGE FOR AN ADDED TREATMENT UNIT. UPPER LEVEL ORE SALVAGE FROM PILLARS, ENDS OF STOPES, AND TONNAGE THAT WAS JUST BELOW THE ECONOMIC CUT-OFF POINT PREVIOUSLY WOULD PROBABLY MAKE EASILY OBTAINABLE PRODUCTION AT REASONABLE MINING COST BY USE OF MODERN METHODS. ACCURATE GRADE ESTIMATES AND BLOCK AVERAGES ARE WELL SUBSTANTIATED BY THE ESTABLISHED GRADE OF VOLUME RUN OUT OF THE VARIOUS PRODUCTION LEVELS.

FOLLOWING ,ON REPORT PAGE NUMBER 54,IS THE COMMENCEMENT OF A PHOTOSTAT OF U. S. BUREAU OF MINES INFORMATION CIRCULAR NO. I. C. 6430, MARCH 1931, WHICH CARRIES DETAILED METALLURGICAL DATA CONCERNING THE TREADWELL YUKON CONSOLIDATED, LTD.'S TYBO MINE TREATMENT PLANT.

U. S. BUREAU OF MINES INFORMATION CIRCULAR # 6430 SHOWING VERTICAL SECTION OF THE TYBO VEIN'S APPROXIMATE DEGREES OF OXIDATION AND VARYING AMOUNTS OF AG, PB ASSOCIATED WITH FE S, ZN S

SURFACE

100 FT. — LEAD , ZINC ALMOST COMPLETELY OXIDIZED

200 FT.

ZONE OF PARTIAL OXIDATION AND SULPHIDE ENRICHMENT

LEAD, ZINC AND IRON FROM 30 TO 50 PERCENT OXIDIZED.

300 FT.

	SILVER OZS.	LEAD %
PYRITE..........	12 TO 15	3.5 TO 5.2
SPHALERITE......	18 TO 30	2.5 TO 4.0

LEAD, ZINC AND IRON FROM 15 TO 25 PERCENT OXIDIZED.

400 FT.

	SILVER OZS.	LEAD %
PYRITE..........	8 TO 12	1.5 TO 3.0
SPHALERITE......	14 TO 18	2.0 TO 3.0

500 FT.

LEAD, ZINC AND IRON FROM 5 TO 15 PERCENT OXIDIZED.

	SILVER OZS.	LEAD %
PYRITE..........	4 TO 8	0.5 TO 1.5
SPHALERITE......	6 TO 10	0.8 TO 2.0

600 FT.

LEAD, ZINC, IRON FROM 0 TO 10 PERCENT OXIDIZED.

	SILVER OZS.	LEAD %
PYRITE..........	3.0 TO 5.0	0.3 TO 0.5
SPHALERITE......	5.0 TO 8.0	0.7 TO 1.0

700 FT.

TYPICAL ASSAYS OF PURE MINERALS GIVE THE FOLLOWING RESULTS :

	SILVER OZS. PER TON
GALENA....................	110.0 TO 130.0
SPHALERITE(UPPER LEVELS).	12.0 TO 20.0
SPHALERITE(LOWER LEVELS).	7.0 TO 10.0
PYRITE (UPPER LEVELS)....	8.0 TO 11.0
PYRITE (LOWER LEVELS)....	3.0 TO 6.0

MINE ORE - 12" MAX.
STORAGE (300 T)
SCREEN
PRIMARY CRUSHER - 3"
SCREEN
SECONDARY CRUSHER - 3/4"
SCREEN
(+) (-)
STORAGE (300 T)
CONVEYOR AND WEIGHING
STORAGE (300 T)
PRIMARY GRIND MILL
CLASSIFIERS
(+) (-)
LEAD ROUGHER
CONC'TS. TAILS
2 STAGE PB CLEANING
PB SCAVENGERS
CONC'TS
1ST STG. MIDS
TAILS
CONC'TS.
THICKENER
HYDROCYCLONES
HYCY'NE
HYCY'NE'S
FILTER
FINES COARSE
COARSE FINES
COARSE FINES
STORAGE (50 T)
TRUCK TO SMELTER
ZN CONDITIONER
ZN ROUGHER
REGRIND M.
CONC'TS. TAILS
2ND STAGE ZN CL'N.
ZN SCAVENGER
CONC'TS.
1ST. MIDS
TAILS
CONC'TS.
THICKENER
POND
FILTER
STORAGE (50 T)
TRUCK TO ZN PLANT

NOTE : IF POSSIBLE CRUSHING CAPACITY SHOULD BE SET UP FOR 300 TONS AS SUBSEQUENTLY THE LEAD AND ZINC UNITS COULD HAVE THEIR CAPACITY INCREASED. 100 TONS PER DAY FOR SELECTIVE FLOTATION FEED WILL BE SUFFICIENT UNTIL THE LOWER LEVELS CAN BE REHABILITATED.

SUGGESTED SELECTIVE FLOTATION PLANT FLOW SHEET TO HANDLE THE TYBO MINE'S SULPHIDE LEAD-ZINC CRUDE ORES. IT WILL BE SOME TIME BEFORE THE ABOVE FLOW SHEET CAN BE INSTALLED BUT EVENTUALLY SUCH A CONCENTRATING PLANT WILL BE NEEDED. THE 300 TONS STORAGE CAPACITY ABOVE IS CALCULATED FOR BALANCE AND TO ALLOW THE MINE TO WORK ON A FIVE DAY BASIS WITH A STAGGERED MILL LABOR COMPLEMENT FOR A SEVEN DAY TREATMENT SCHEDULE WEEKLY. FIRST MOVEMENT WILL PROBABLY BE PRIMARY AND SECONDARY CRUSHING AND JIG BENEFICIATION WHILE BALANCE OF MILL IS BEING SET UP.

JUNE 14, 1961, JAMES H. WREN, 4297 - D - STREET, SACRAMENTO, CALIF.

METALLURGY, CONTINUATION :

A SIMILAR ORE CHARACTER AS EXISTS IN THE TYBO SULPHIDE ZONES IS BEING MINED AND MILLED BY THE RICO ARGENTINA COMPANY IN COLORADO. MR. SHERMAN HINKLEY, GEN'L. MGR. OF THE OPERATION, GAVE THE FOLLOWING INFORMATION TO A MEMBER OF CARGOLD MINING & DEVELOPMENT CORP. :

TREATMENT OF 200 TONS PER DAY.

MILL HEADS : 5% LEAD, 6% ZINC, 3 OUNCES SILVER

MILL COST : $2.50 PER TON.

MILL GRIND : MINUS 100 MESH.

RECOVERY : 90% LEAD, 85% ZINC.

LABORATORY ANALYSES SHOW THE RICO ARGENTINA ORES TO BE QUITE SIMILAR IN CHARACTER, HIGH PYRITE CONTENT AND THE LEAD-ZINC RATIO. TYBO HAS HIGHER LEADS THAN ZINC IN ABOUT THE SAME RATIO. TYBO ALSO HAS SOME GOLD PAY AS WELL AS MUCH HIGHER SILVER.

BASIC,DETAILED METALLURGY ON THE TYBO SULPHIDE ORES HAS BEEN USED AS A BASE LINE WITH WHICH TO ALIGN A COMPLETE MILL TEST OF THE AVAILABLE RESERVES' TONNAGE. SUCH A THOROUGH MILL TEST WILL BE BALANCED AGAINST THE UPPER LEVEL TONNAGE WITH SOME OXIDE CONTENT (375' ELEVATION TO ABOVE THE 300' WHERE SULPHIDE ORE ZONES RESISTED OXIDATION), ON THE BASIS OF CURRENTLY PROVEN METALLURGICAL PROCEDURE. NO MILLING COMPLICATIONS BELOW THE 400 FOOT LEVEL ARE ANTICIPATED.

A NORMAL LEAD-ZINC 100 TON CAPACITY SELECTIVE FLOTATION PLANT SHOULD BE THE TYPE OF UNIT FOR THE TREATMENT OF ORES AMENDABLE TO THAT PROCESS. IT IS SUGGESTED, HOWEVER, THAT CONSIDERATION BE GIVEN INSTALLATION OF A HIGHER CAPACITY CRUSHING UNIT TO ENABLE RAISING MILL CAPACITY BELOW THE CRUSHER LINE, WITHOUT ADDING CRUSHING EQUIPMENT.

WHILE THE LONG RANGE FUTURE OF THE TYBO MINE IS DEPENDENT UPON SULPHIDE ORE TREATMENT ON THE PROPERTY IN-ORDER-TO OBTAIN THE BETTER OVERALL NET INCOME, MARKETING ACCEPTANCE AND LEVERAGE, THREE OTHER TYPES OF PRODUCTS SHOUKD BE GIVEN CONSIDERATION. THEY ARE: OXIDE ORE SUITABLE FOR "BLOCK-LEASING" OUT TO MINING TEAMS THAT WILL SELECTIVELY MINE THIS ORE FOR DIRECT CRUDE SMELTING SHIPMENTS. 30,000 TO 40,000 TONS OF SLAG AND SOME 500,000 TONS OF MILL TAILINGS. FOLLOWING IS A BRIEF DESCRIPTION OF POSSIBLE HIGH VOLUME PER MANSHIFT WORKED WITH LOW COST BENEFICIATION.

METALLURGY, CONTINUATION :

TYBO MILL TAILINGS :

NOTE : SUPPLEMENTAL MILL TEST FIGURES WILL BE COMPILED AS SOON AS THE STUDY HAS BEEN MADE.

A). TAILINGS VOLUME.................. 500,000 TONS.

B). GRADE : TEST PITTING AND TRENCH SAMPLES TAKEN IN VOLUME INDICATE A PAY METAL CONTENT OF ; .015 AU, 2½ OZS. AG, 2.0% PB AND 2.0% ZN. GROSS MARKET VALUE : $12.25

C). PRELIMINARY HEAVY MEDIA TESTS SHOW THAT SOME 25% OF THE TOTAL TONNAGE IS PYRITE. WITH REFERENCE TO THE HEREWITH I. C. NO. 6430 CIRCULAR, IT WILL BE NOTED THAT THE SULPHIDE IRON CARRIES SILVER AND SOME OF THE OTHER PAY METALS, IN FORM OF GALENA AND SPHALERITE COMBINED WITH THE IRON. IT IS POSSIBLE THAT A REGRIND OF A BENEFICIATED PRODUCT FROM THE TOTAL TAILINGS MIGHT RELEASE THE VALUES IN SUCH FORM WHICH WILL BE RECOVERABLE.

D). FAST, HIGH VOLUME TAILINGS CONCENTRATION IS PROBABLE WITH USE OF A JIG PROCEDURE OR SPIRALS, WITH ALL SLIMES REJECTED.

E). ONE TRACTOR WITH A 15 CU. YD. SCRAPER WOULD MORE THAN ADEQUATELY DELIVER 1,000 TONS OF TAILINGS TO A TUNNEL STOCKPILE OVER A CONVEYOR TO THE GRAVITY CONCENTRATION UNIT. THE BENEFICIATED PRODUCT COULD BE TREATED AT THE TAILINGS SITE OR IN THE PROPOSED PLANT FOR THE TYBO MINE ORE.

F). IN VIEW OF THE 1/2 MILLION TONS OF AVAILABLE VOLUME, A SCALPING BENEFICIATION AND SUBSEQUENT SELECTIVE FLOTATION TREATMENT MIGHT BE ABLE TO STAND A 50% RECOVERY LOSS AND STILL BE HIGHLY ECONOMIC, IN VIEW OF THE GROSS VALUE REPRESENTED.

OLD SMELTER SLAG :

A). 3,000 TONS OF SLAG WAS SHIPPED OUT OF A 30,000 TO 40,000 TON PILE. THEIR ANALYSES ON PAY METALS AVERAGED 5 OR BETTER OUNCES OF SILVER 4% OR BETTER LEAD AND .02 GOLD. MORE SPECIFIC ASSAY DATA IS HEREIN LISTED UNDER "RESREVES". SUBSEQUENT SAMPLES TAKEN BY CM&DC GROSS PAY METAL VALUES AT $14.00.

B). VISUAL INSPECTION OF THE SLAG CHARACTER SHOWS UNDER MAGNIFYING GLASS THAT FINE TO COARSE METALLIC BEADS ARE DISSEMINATED THROUGH THE SLAG. EVIDENTLY THERE WERE MANY POOR MELTS AS "SNIPERS" HAVE STOCKPILED A FIRST GRADE OF HAND PICKED SLAG WHICH RUNS OVER $200 PER TON AND A SECOND PRODUCT THAT RUNS OVER $70 PER TON.

METALLURGY, CONTINUATION :

OLD SMELTER SLAG

c). A JIG TEST SAMPLE WILL BE TAKEN OUT OF THE SLAG PILE TOMORROW. RESULTS OF THE RUN WILL BE ADDED TO THIS SECTION AS SUPPLEMENT.

d). IN THE EVENT THAT A SCREEN ANALYSIS PROVES VALUES IN FRACTIONS OF A SIZE AMENDABLE TO JIG BENEFICIATION, LOW COST TREATMENT TO DELIVER A MARKETABLE PRODUCT CAN BE ACHIEVED. A PRIMARY CRUSHER WITH A SET OF ROLLS WHOSE DISCHARGE WILL GO OVER A CLOSED CIRCUIT SHAKING SCREEN WOULD PROBABLY DELIVER A JIG CONCENTRATION SIZED PRODUCT. A FRONT END LOADER, CRUSHER, ROLLS, CLASSFYING SCREEN, JIGS, DEWATERING UNIT AND TRUCK LOADING BIN BALANCED FOR 300 TONS OF HEAD PRODUCT PER DAY WOULD BE A SIMPLE BENEFICIATING FLOW SHEET, IF THE JIG TESTS PROVE THE ECONOMICS.

OXIDE ORES :

NO METALLURGY WILL BE NEEDED ON ANY OF THE STRAIGHT LEAD SMELTER PRODUCTS OTHER THAN SELECTIVE MINING TO KEEP BREAKAGE FREE OF DILUTION.

IT WAS NOTED THAT WHILE THE 300 FOOT LEVEL, ACCESSIBLE FOR INSPECTION THROUGH THE 2-G SHAFT, HOLDS COMBINED OXIDES-SULPHIDES CHIEFLY WITH SOME AREAS ENTIRELY OXIDIZED, LEVEL CLEANUP WILL RESULT IN BOTH DIRECT SMELTING TONNAGE AS WELL AS SOME SULPHIDE ORE SUFFICIENTLY CLEAN TO SEGREGATE FOR SUBSEQUENT SELECTIVE FLOTATION TREATMENT. THIS PRODUCTION WILL BE ACCEPTABLE BUT WILL BE LIMITED IN OVERALL RESERVES WITH THE POSSIBLE EXCEPTION OF THE EASTERLY DEVELOPMENT EXTENSION BY THE HALL BROS. COMPANY DURING THE EARLY 1940S.

PENDING METALLURGICAL TESTS :

A). FINAL CONCLUSION OF BENEFICIATION PROCEDURE FOR THE 500,000 TONS OF MILL TAILINGS.

B). SCREEN ANALYSIS OF THE SLAG PILE. ITS RESULTS WILL DICTATE BENEFICIATION METHOD AND ECONOMIC CONCLUSION ESTIMATE.

C). SELECTIVE FLOTATION TEST ON SULPHIDE ORE WITH AN OXIDE LEAD COMPLICATION.

D). SELECTIVE FLOTATION TEST ON THE STRAIGHT SULPHIDE ORES AFTER COMPLETE REHABILITATION TO THE AREAS OF SUBSTANTIAL LEVEL PILLAR, NARROW WIDTHS WHICH WERE LEFT BY THE FORMER OPERATION, BLOCKS JUST BELOW THE THEN EXISTING ECONOMIC CUT-OFF POINT. OBJECT WILL BE TO ARRIVE AT A UNIFORMED , BALANCED MILL HEAD SUITABLE FOR THE REAGENT AND CONCENTRATE CONTROL OF THE PROJECT.

TYBO MINE REPORT, NOV. 4, 1960

DEVELOPMENT, RESERVES, ECONOMICS, SUMMARY AND EXHIBITS WILL BE FOUND IN VOLUME TWO OF THE TYBO MINE REPORT.

2-G HEADFRAME ON GROUND
MAY 4, 1961 OVER 70 YEARS
AFTER ERECTION

8 MILES FROM OILED ROAD

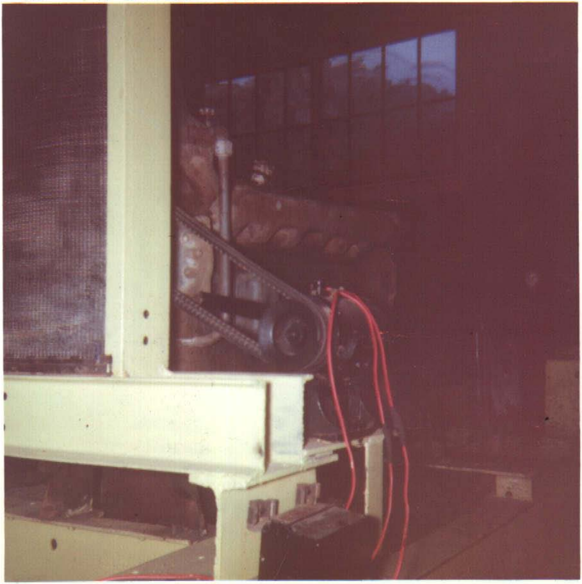
TO GILMORE MINE

2-G HOIST AND SPEED REDUCER

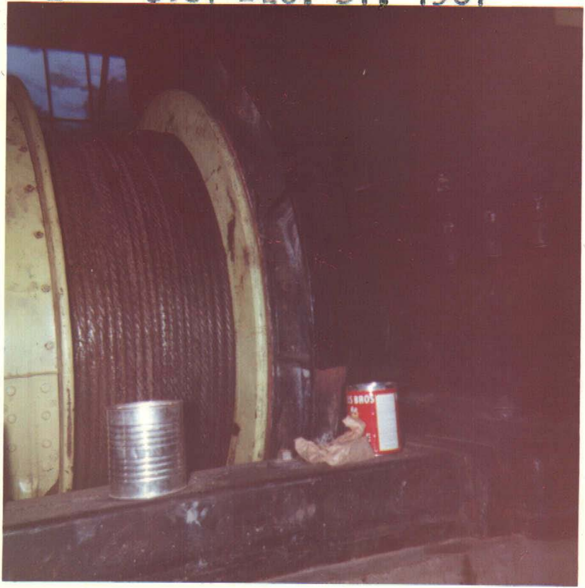
BUNKERHILL SHAFT

SEE GEOLOGIC MAP

2-G POWER UNIT



2-G HOIST DEC. 31, 1961



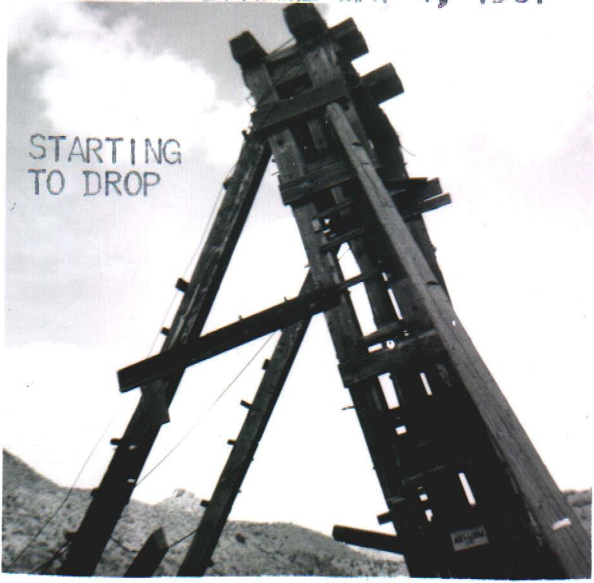

2-G SHAFT
APRIL 1961

COMMENCEMENT OF
2-G AREA WOOK
APRIL 1961

1880 HEADFRAME 2-G SHAFT

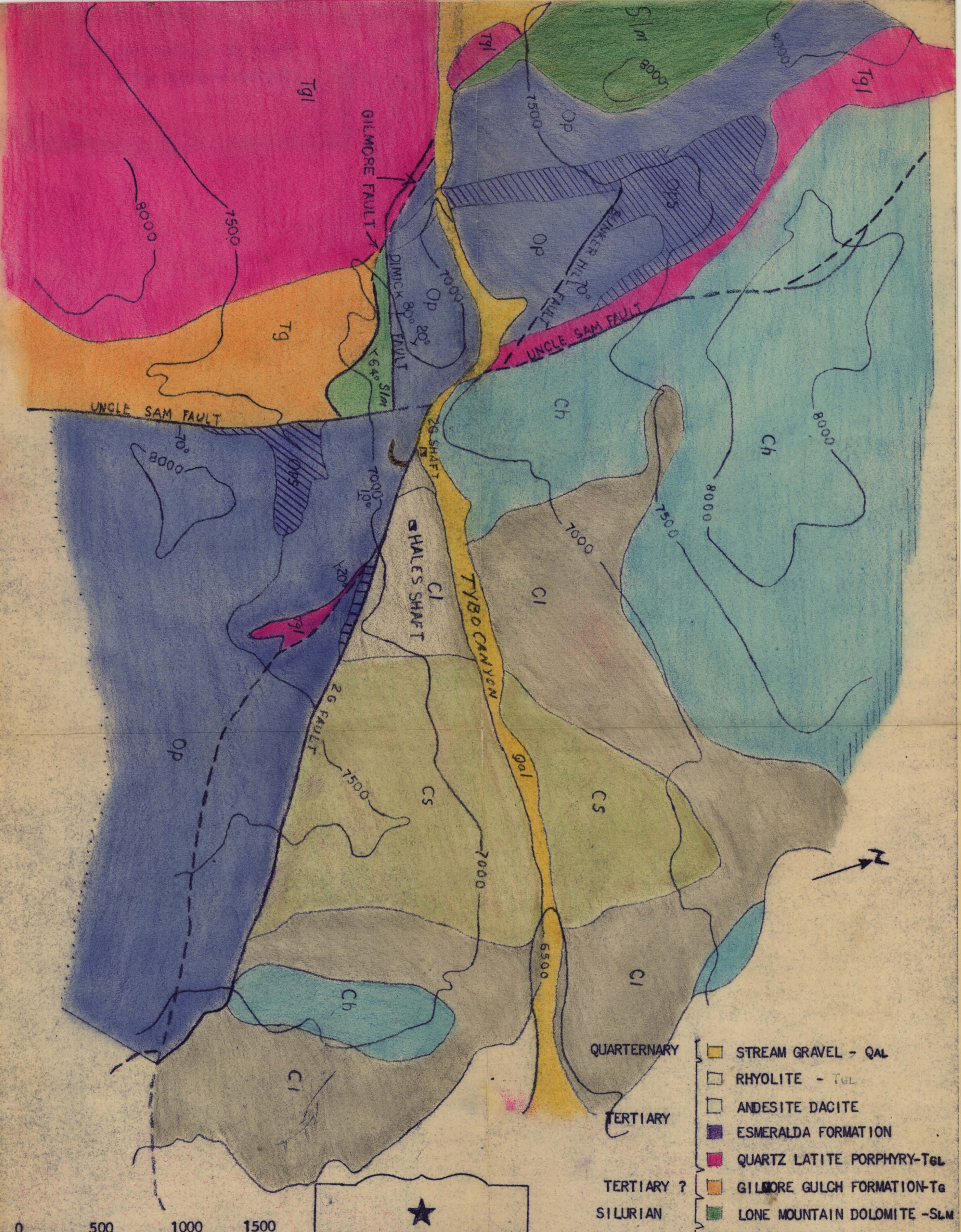
5/4/61 CUTTING TO DROP

2-G HEADFRAME MAY 4, 1961



2- G HEADFRAME MAY 4, 1961

IN AIR DROPPING



CARSON LAND & DEVELOPMENT CORPORATION
OPTIONED TYBO MINING AREA
GEOLOGIC MAP, TYBO DISTRICT
SHOWING GENERALIZED GEOLOGY ON AND IN VICINITY OF THE OPTIONED PATENTED MINERAL PROPERTY. FEB. 12, 1960

J. H. WREN & COMPANY
Consulting Mining Engineers
4297 D Street
Sacramento, California

QUARTERNARY	STREAM GRAVEL - QAL	
TERTIARY	RHYOLITE - TGL	
	ANDESITE DACITE	
	ESMERALDA FORMATION	
	QUARTZ LATITE PORPHYRY-TGL	
TERTIARY ?	GILMORE GULCH FORMATION-TG	
SILURIAN	LONE MOUNTAIN DOLOMITE -SLM	
ORDOVICAN	EUREKA QUARTZITE	
	POGONIP LIMESTONE OP-OPS ///	
CAMBRAIN	HALES LIMESTONE CH	
	TYBO SHALE CL	
	SWARBRICK FORMATION: CS	

4970 0044