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M I N E R A L   R I D G E

Silver Peak, Esmeralda County Nevada

November, 1939

By John G. Barry

See also map files (8 maps)

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Ore Deposits (cont'd)

JOHN G. BARRY, CONSULTING MINING GEOLOGIST & ENGINEER
MILLS BUILDING, EL PASO, TEXAS

COPY

At Mary Mine, Silver Peak, Nevada,
November 20, 1939.

Mr. E. L. Cord, Principal,
Nevada Development Company,
Prescott Lease,
Black Mammoth Consolidated Mining Company.

Dear Sir:

In this I am reporting to you the results of the several studies of the general geologic controls and the possibilities for large additional ore bodies in the various properties in which you have important interests, which are located on Mineral Ridge, near Silver Peak, Esmeralda County, Nevada.

You will see that from the nature of the cases, any ideas which are formulated for the existence of ore bodies must be purely speculative. But, the tonnages thus derived are so great - 328,000 for the Mine Blocks; and 819,000 for the First Five, and most favorable, Areas beyond the reach of such workings; - that it is highly advisable to begin to prospect them quickly and cheaply.

GENERAL SUMMARY

The properties of the Black Mammoth Consolidated Mining Company, Prescott Lease, and Nevada Development Company are located on Mineral Ridge, near Silver Peak, in central Esmeralda County, Nevada. The largest sub-structure, the Drinkwater Anticline, probably had an original mineralization of high temperature gold ores of about 2,000,000 tons. The district has already yielded about 1,350,000 tons which probably averaged 0.3 oz. gold per ton. The properties cover an area of about 5519 acres. Of this, 250 acres have already been of greatest importance, while an additional 1,000 acres is likely to be of nearby importance if the proposed prospecting be successful.

Mineral Ridge is a fairly gentle and open anticline of northwesterly strike which is an outlier in the Sierra Nevadan Province. It was uplifted by thrusting forces, with a concurrent invasion by granitic rocks as pressure was released. All information relating to the invasion and subsequent mineralization point to the existence of very long, slow processes. The ore occurrences are on the upper northeastern flank of the southeastern quarter of the structure. They occur in the relatively thin shell of sedimentaries which now remains between the core of the Ridge and the surface. The sedimentaries contain relatively competent limy beds, which were favorable for pre-mineral brecciation, in the Mary Limestone, in the lowest 150 feet of the Schist, and in the highest 150 feet of Schist.

The thrusting forces which formed the Mineral Ridge Anticline also formed several strike and dip anticlinals. The Alaskite tended to conform to the anticlinals and to invade higher in the synclinals. It also deposited in the Schist in the anticlinals in the form of phacoliths or concavo-convex lenses with convexity outwards.

Later, small thrusts concentrated their effects in the pre-existing anticlinals. They prepared phacolitic limy breccias which the solutions, released at the same time, replaced to form ore bodies. As observed by Spurr, the ore lenses are generally similar to but much smaller than the Alaskite lenses. The ore bodies are evidently localized at the crossings of smaller strike and dip anticlinals, which occur within the crossings of the larger strike and dip anticlinals on the flank of the Mineral Ridge Anticline. Thus, the ore bodies occur as small, lenticular domes on the curvature of the larger anticlinals of the Ridge.

The Diorite cuts the mineralization, and is an altered lamprophyre or rock complementary to the silicic Alaskite and mineralization. In occurrence it favors strong contacts.

Beginning in the Jurassic, erosion had worn the rocks down to approximately their present surfaces by the beginning of the Tertiary. Only small remnants of the extensive Tertiary rocks are now left on Mineral Ridge. Small Tertiary faults occur. Late bed slips occur profusely in the hangings of ore bodies near the ends of lenses. It is likely that Mineral Ridge was further elevated as a block during the Tertiary.

Until about 1936 the ore bodies mined had occurred principally in the Drinkwater Anticline. Since then the work on the Lease has found large bodies on the southeastern end of the Lease Anticline, which is the next anticline down the dip. The geologic mapping has shown that there should be many analogous anticlinal crossings on the northeastern flank of the Ridge. From such analogies schedules have been prepared to cover the existence of such speculative ores. These also cover northwestern extensions in the Drinkwater Anticline in the Mammoth block. These speculations as to ore bodies being possible on anticlinal crossings have been grouped into fourteen areas on the ground which is beyond reach from present mine workings. The first five areas are of greatest importance, and it should be possible to find out about them cheaply and quickly by diamond drilling which might be followed by prospecting shafts and drifts.

The Speculative Tonnages may be summarized as follows:

	Thousands of Tons			
	Mammoth	Lease	Nev. Devel't	Total
Mammoth Mine Block	242		46	288
Lease Mine Block		40		40
Areas Nos. 1 to 11	535	154	364	1053
	777	194	410	1381

Other possibilities might raise the total to 1,637,000 tons. But, it should be noted that all of this is subject to very large variations in probabilities.

Diamond drilling might give a quick cheap resolution as to the possibilities of the first five areas. If it progressed in steps because of successes its total cost should not exceed $30,000. If it were followed by prospecting by shafts and drifts the total cost should be kept within $0.30 per ton of ores expected. With success additional capital would be required for aerial tramways, for changes of the Lease mill to a 300-ton daily capacity for complete cyanidation process, and for a fund for final development. The grand total might reach $835,000. or about $1. per ton for the speculative ores in the first five areas. With a unification of the properties, mills, managements, and services it should be possible to get costs of about $6. per ton. It is assumed that the ores mentioned will give a gross recovery of $10. per ton.

Consequently, the speculative outlook is so large and favorable that preliminary prospecting on the ground which is beyond reach of the present mine workings is strongly recommended.

I N T R O D U C T I O N

LOCATION

Mineral Ridge and the Silver Peak (Red Mountain) Mining District is located in the crescentic Silver Peak Range (and quadrangle of the U. S. Geological Survey) in central Esmeralda County, Nevada, near 37 -45 N, 117 - 45 W. The southeastern half of Mineral Ridge is in the NW 1/4 of T 2 S, R 39 E, the NE 1/4 of T 2 S, R 38 E, and the SE 1/4 of T 1 S, R 38 E. These are all related to southings from the Mount Diablo Base Line. The most active and productive workings of Mineral Ridge, those associated with the well known Drinkwater and Mary Mines, are located in the adjoining Sections 6 and 1 of the first two townships mentioned.

TOPOGRAPHY

The elevations in the district vary from 4355 in the Silver Peak Marsh to 7805 at the Silver Peak triangulation station near Eagle Nest Canyon, but the outlying Red Mountain is much higher. It is a moderate mountainous country with some bluffs near the crest of the Ridge. The transverse gulches are usually deeply incised and have steep walls.

Below the Mary Tunnel Level, the "B" Level of the Lease is at about 6370, and the "339" Winze Level of the northwestern end of the Mammoth is at about 6420. Between these two localities the Mary Level varies in elevations from about 6465 to 6485, over a distance of about 3500 feet. Other approximate elevations are:

Lower Elizabeth, 6580; Wasson, 6660; Soldier workings about between 6660 and 6850; Intermediate, 6745; Drinkwater, 6835; Shovel, 6922; Headhouse, 7045; and the Croppings up and down from about 7145.

The climate is semi-arid, with winters which are medium cold but very windy and accompanied by only small snow. The summer days are hot.

Roads are generally good, and easily maintained.

HISTORY

Silver ores in outlying properties were of principal interest between 1864 and 1869. A gold mill for the Drinkwater (or Blair properties) was completed near Silver Peak village about 1867. Between then and about 1900 the properties were worked in a desultory way during a few periods of a few years each, litigation having hindered progress for a considerable time. Between 1900 and 1906 there was considerable small scale activity on high grade ores.

The principal properties were taken over by the Pittsburg Silver Peak about 1906. The properties were extensively explored and worked by them until about 1915. Equipment was extensive, consisting in part of branch railroad from Blair Junction to Blair, aerial tramway from Mary Tunnel to mill at Blair. The mill at Blair had a capacity of about 500 tons daily. The mines were well equipped and organized for the period. Under the old price of gold large tonnages of low grade ore, about $6. per ton, were handled, and unusually low costs were attained. Probably the mill was too large for the mine. Also it is probable that these operators did not remunerate themselves from operating profits.

Between 1917 and 1930 the district was dormant except for several spasms of small leasing operations. These became greater after 1930, and several parties of individuals, partnerships, and small companies were involved. Out of these attempts grew the present activities of the Black Mammoth Consolidated Mining Company, under the principal guidance of Mr. F. A. Vollmar, Jr. From them Mr. Basil Prescott secured the Prescott Lease, which covers the southeastern half, mostly "blind," of the old Pittsburg Silver Peak holdings. Mr. Prescott interested Messrs A. N. Sweet and E. L. Cord in the matter. The last, as principal, acquired in steps dominant interests in the Lease and the Black Mammoth. Considerable ground was located and/or acquired for the Black Mammoth. Beyond that very extensive claims were located for the Nevada Development in which were interested Messrs Cord, Vollmar, and Sweet. Operations on the Lease began in the fall of 1936, and they grew in intensity until a large mill was built at the elevation of the Mary Tunnel. This mill began operations in the Spring of 1938 as a flotation plant. Alterations and additions for the use of cyanidation of concentrates and sand tails were completed about January, 1939. Earlier than the Lease activities the Black Mammoth had constructed a cyanidation plant at Silver Peak village which now has a capacity of about 140 tons daily, but which involves a truck haul of about nine miles.

PRODUCTION

It is almost impossible to get complete production figures for the district. But, it is likely that the omissions are only a small percentage of the total.

Spurr showed money productions before 1906 of:

Drinkwater-Mary Group	$1,080,000.
Vega	3,000.
Great Gulch	6,000.
	$1,089,000.

For the Drinkwater-Mary, this might have been equivalent to 50,000 tons before sorting.

From the Drinkwater Anticline the total potential might be:

Prior to 1906		50,000 tons
Pittsburg Silver Peak		1,200,000
Black Mammoth		50,000
Lease		50,000
	Estimated production	1,350,000 tons
	Estimated outlook	288,000 ?
	Estimated low grade	200,000
	Total Original ?	1,838,000 tons

So, it is reasonable to think that the Drinkwater Anticline had an original mineralization of a magnitude of about 2,000,000 tons

REFERENCES

There is a large quantity of published material relating to the general region which is of aid in understanding the very important and controlling general geology; but there is only a small amount which deals specifically with the district. Free use has been made of all sources. Among those used most are:

Spurr, J. E., Ore Deposits of the Silver Peak Quadrangle, Nevada, Prof. Pa. 55, U. S. G. S., 1906

Spurr, J. E., Geology of Nevada South of the 40th Parallel, Bull. 208, U. S. G. S., 1903

Ball, S. H., Notes on the Ore Deposits of Southwestern Nevada and Eastern California, Bull.285,U. S. G. S.,1906

Ball, S. H., A Geologic Reconnaissance of Southwestern Nevada and Eastern California, Bull.308,U. S. G. S.,1907

Ransome, F. L., W. H. Emmons, and G. H. Garrey, Manhattan, Goldfield, Bullfrog, and Other Districts in Southern Nevada, Bull. 303, U. S. G. S. , 1906

Ransome, F. L., Notes on Some Mining Districts in Humboldt County, Nevada, Bull.414, U. S. G. S., 1909

Knopf, A., assisted by F. H. Lahee, and Edwin Kirk(stratigraphy) A Geological Reconnaissance of the Inyo Range (White Mountains) and the Eastern Slope of the Sierra Nevada,California. Prof. Pa.110, U. S. G. S., 1918 (1912)

Lincoln, F. C., Mining Districts of Nevada, private publication, 1928?

University of Nevada, Vol. XXVI, No. 6, Metal and Nonmetal Occurrences in Nevada, 1932.

ACKNOWLEDGMENTS

The writer is also greatly indebted to the managers and their operating staffs for unlimited assistance and cooperation in many phases of the business which related to the geology and ore deposits.

PROPERTIES

Most of the claims on the northeastern flank of the district are owned or held by persons in which Mr. E. L. Cord holds the dominant interest. These are the Nevada Development Company, which holds the so-called outside ground; the Black Mammoth Consolidated Mining Company, which owns the old holdings of the Pittsburg Silver Peak as well as some newer adjoining ground; and the Prescott Lease, which leases from the Black Mammoth the southeastern half of the old ground and some several other claims.

Black Mammoth

The old holdings of the Pittsburg Silver Peak, now owned by the Black Mammoth Consolidated Mining Company, include the following claims:

Duplex, New York, Brooklyn, Chieftain, Prince, Golden Gate, Nevada, Sentinel, Blair, Mohawk No. 2, Mohawk No. 1, Savage, Oro Fino, Poor, Antelope, Sapphire, Defiance, Bangor, Mary, Mary Extension, Elizabeth, Western Soldier, Snow Drift, Ophir, April, Last Chance, Summit, and Canyon Crest. These patented claims cover other, much older, small patented claims which are not now commonly shown on the maps, such: U. S. Lot 65A, Glory 44, and Homestake. These claims cover about 380 acres.

Adjoining this old group on the southeast are the claims Laddie, and Laddie Nos. 1, 2, and 3. These cover about 60 acres.

The Black Mammoth also holds ground which generally surrounds the preceding on the northeast, southeast and southwest. This includes:

Mantos, and Mantos Nos. 1, 2, 3, 4, 5, 6, and 7, covering about 132 acres; Gold Run Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, and 16, covering about 300 acres; and Gold Venture Nos. 1 and 2, covering about 25 acres. Top Row Nos. 1, 2, 3, 4, 5, 6, and 7, covering about 102 acres.

The Black Mammoth holdings may be summarized as follows:

Old Pittsburg Silver Peak Holdings	380	Acres
Laddies	60	"
Mantos	132	"
Gold Runs	300	"
Top Rows	102	"
Gold Ventures	25	"
TOTAL	999	Acres

Prescott Lease

The Black Mammoth leases to the Prescott Lease approximately the southeastern half of the old Pittsburg Silver Peak holdings, amounting to about 195 acres; and the Laddies of about 60 acres; or a total of about 255 acres. The mining operation of the Black Mammoth itself is now conducted in the northwestern half of the old Pittsburg Silver Peak Holdings, amounting to about 185 acres.

Nevada Development

The Nevada Development Company holds the so-called outside ground on the northeastern flank of the district. These claims include;

Gold Basin Nos. 1 to 14,	approx.	280	Acres
Golden Queen Nos. 1 to 14,	"	280	"
Tia Nos. 1 to 4,	"	80	"
Royal Nos. 1 to 20,	"	393	"
Gold Channel Nos. 1 and 2,	"	31	"
Mantos Nos. 8 to 21,	"	279	"
Gold Crown Nos. 1 to 15,	"	294	"
Gold Coin No. 1 and Mohawk No. 4,	"	23	"
Gold Coin Nos. 2 to 24,	"	460	"
Krona Nos. 1 to 16,	"	310	"
Balboa Nos. 1 to 12,	"	240	"
Golden Fleece Nos. 1 to 34,	"	651	"
Scepter Nos. 1 to 8,	"	136	"
Gold Run Nos. 17, and 18,	"	40	"
Arum (no number)	"	2	"
Arum Nos. 1 to 9,	"	155	"
Arum Nos. 11 to 24,	"	280	"
Arum Nos. 28 to 38,	"	220	"
Arum Nos. 40, 42, 44, 46, and 48,	"	100	"
Arum Nos. 26, 27, 39, and Clipper,	"	66	"
TOTAL	"	4320	Acres

The Arum claims show no numbers 10, 25, 41, 43, 45, and 47.

A claim named Nancy has been recently filed to cover the abandoned Cubby in the southeastern part of the district, so that the ground now listed above as covered by the Clipper and others is essentially correct.

The maps show ten old claims near the old Blair mill-site of the Pittsburg Silver Peak which are joined to the Nevada Development claims; they would cover an additional 200 acres.

Important Inside Foreign Holdings

The Vega claim is said to be held by Stanley Chiatovich, et al. It might be acquired on a cheap lease, or lease and bond. It is not likely to contain important tonnages of ore.

The Great Gulch and Terminal patents are now held by the Calumet company, amounting to about 35 acres. They are well situated and have yielded a small high grade production. They might have some considerable monetaryfuture, and arrangements to acquire them should be made before undertaking any exploration in that part of the district.

The Mohawk No. 3 of some 18 acres is held by the Gold Wedge company, which holds a lease and bond on the Rock and Keeler properties. The Gold Wedge may be liquidated in the not distant future, and this claim may become cheaply available. It should be acquired under such conditions, both for its value as mill-site for Prescott Lease and also for its potentialities as containing ores.

General

None of the claims which touch the outside boundaries of the ground in which Mr. E. L. Cord is interested, as cited above, are believed to be of great value as potential ore producers.

The extreme limits of ground covered in the district is about 4.6 miles long from northwest to southeast by about 2.8 miles wide. The ground mentioned above gives a total acreage of 5,519.

Other Holdings

Prescott Lease holds surface rights for mill-site on Mohawk No. 3. It also holds several recent placer claims near the northwestern limits of Silver Peak Marsh for the storage of tailings. Other holdings include real estate in Silver Peak, water rights and pumping station site, and rights of way for power lines and water lines.

Black Mammoth has similar holdings, largely concentrated in Silver Peak where the value of mill-site, water rights, and real estate is probably relatively large.

FACILITIES

All facilities for a mining and milling operation, such as power supply, labor supply, water supply and tailings disposal, should be considered as now existing in a good condition.

DRAWINGS

The drawings accompanying this report consist of:

General Legend Sheet

Two Columnar Sections

General Surface Geology in Central Strip of Holdings, showing Structural Trends and Intersections, Scale: 1" :: 1200'

General Mine Map, Showing Important Structures and Landmarks, Scale: 1" :: 200'

Six Cross-Sections, Nos. 15, 21, 26, 36, 48, and 53, showing essentials of structures and possibilities in extensions down the flank.

The general map is derived from three sheets which show the detailed surface geology on a scale of 1" :: 200'. These are available for detailed consideration. The general map is also designed for superposition over an aerial photographic map of the district which also shows specific locations of the claims. A separate claim map on the same scale is also available. At the mines there are many detailed maps and sections on scales 1" :: 50', and 1" :: 20', which are also explained by two sets of models.

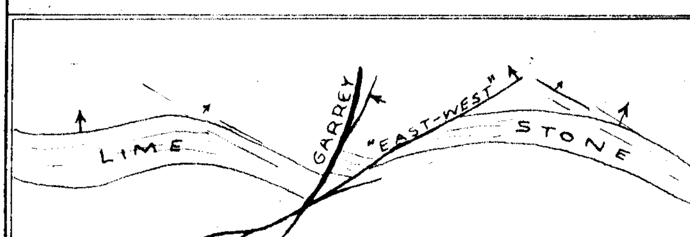
NEVADA DEVELOPMENT CO.

GENERAL LEGEND

Blue	FAULTS
Q blue red yellow	QUARTZ WITH FAULTS
Green	DIORITE, COMPLEMENTARY LAMPROPHYRE
Q Red	QUARTZ OF ORE STAGE
A orange	ALASKITE, MUSCOVITE BINARY GRANITE. PEG. AT CONT.
DOL. violet	DOLOMITE
HY.	HYBRID, ALASKITE IMBIBED SHALE
SH. Brown	SCHIST, IMPURE SHALY
LSH	LIMY SHALE
SSH	SANDY SHALE
TW	THIN WHITE SHALE
LS. Yellow & Blue	LIMESTONE, THIN BEDDED IMPURE
BLS	LIMESTONE, BLUE BLOCKY
	FORMATION CONTACTS
	AXIS OF STRUCTURAL FOLDS

	LINE OF VERTICAL SECTION
	PROPERTY
	OBSERVED ATTITUDE OF SHALE & LS.
	COMPUTED ATTITUDE OF DOL.
	INTERMITTENT STREAMS
	MINE TUNNEL
	MINE SHAFT
	PROSPECT PIT
	MINE WORKING
	FAIRCHILD TRIANGULATION STA.
	PLANETABLE TRIANGULATION STA.
	CLAIM CORNERS
	CLAIM CORNERS FIELD POSITION
	PROPERTY LIMITS

PATTERN OF FLEXURES AND TYPE SLIPS BY L.K. WILSON



GENERAL GEOLOGY

In its origin and processes of formation, Mineral Ridge is directly related to the Sierra Nevadan Province. It is a small part and an outlier of this continental division. It now remains as a fairly gentle and open anticline of north-westerly strike. The continental change with which it was connected involved thick deposits in a geosyncline. They were uplifted by folding caused by tangential thrusts against a worn down borderland which lay to the southwest. This mountain building process was long continued and slow. It was accompanied by a similarly slow upward invasion of granitic rocks whose composition had probably resulted from the assimilation of huge quantities of the deep seated sedimentaries by a sub-crustal magma.

Long times, slow and gentle uplift, and slow invasion of the granitics were probably a part of the general process in this region. It seems likely that under such circumstances at Mineral Ridge the granitic rock could follow up slowly, and that it could continue in a molten condition in its present relative position during such time as was necessary to form a pegmatitic top on an Alaskite differentiate.

The locality of the Mary Mine is on the upper northeast flank of the southeastern quarter of the structure. It is within a few miles of steep pitch to the southeast, but several miles from the pitch to the northwest. The core of the Ridge is formed of the invading, granitic Alaskite, while the remaining overlying sedimentaries are relatively thin compared to the whole bulk. They are not much thicker than 1,000 feet, which between erosion and invasion is all that is left from the original thickness of some 30,000 feet. They were about in the upper part of the lowest third of the Silver Peak Group of the Lower Cambrian.

The existing sedimentaries show all possible variations between limestone and shale, and the shale variations are especially numerous. This indicates that they were deposited on a varying sea bottom; it was becoming generally deeper, as shown by the steady upward transitions to limestone. If not completely eliminated by the Alaskite, the Mary Limestone may be present to a thickness of 150 feet. It is thin-bedded, recrystallized, and contains some shaly streaks. The 150 feet of Schist next above contains several thin limy beds which may be of commercial importance in various places. The next 250 feet of Schist is highly argillaceous and thin bedded. Above it lies another 150 feet of Schist which contains several limy beds, the Soldier beds. Above this lies the thick-bedded Dolomite, whose bottom is of importance as a marker of structure on the surface.

The Mineral Ridge Anticline is a large structure. It was uplifted by thrusting as is shown by the accumulated intensity of the longitudinal or strike flexures toward the crest. The uppermost or Drinkwater Anticline was broken by a thrust fault slightly before the upward invasion of the Alaskite reached it. The dip-slip is about 600 feet. Below the Drinkwater Anticline down the northeastern flank succeed the Wasson Syncline, the Lease Anticline, the Dump Syncline which in places contains a sub-anticline, the Mill Anticline, the Houses Syncline, and the Garbage Anticline. These strike flexures are measured from the general slope of the structure. The first five tend to merge in the ridge to the southeast of Custer Gulch so as to pass around the nose of the Mineral Ridge Anticline. East from there the Great Gulch Anticline is known, and in part it is accompanied by a thrust fault which is about one-fourth the size of the Foot Fault. These structures are crossed by anticlinals down the dip, which seem commonly to be associated with the largest transverse ridges.

The invasion of the Alaskite took place concurrently with the release of pressure afforded by the uplift of the Mineral Ridge Anticline. It forms the core of the Ridge, and is present in large amount. It seems to have invaded higher in the strike and dip synclines, thus having contrary lobes of its own. It invaded the Schist hanging in phacolitic shapes, concavo-convex lenses with convexity outward. Near the top of the main body there are large irregularities of occurrence, with large blocks of sedimentaries detached by hanging wall sills.

The small bodies of Alaskite are often aplitic in texture; but it is especially noteworthy that the cover was so tight and thick and the time of cooling so long that the Alaskite developed a pegmatitic upper surface which is often as thick as thirty feet.

It is the belief of the writer that the Alaskite in some hundreds of feet will pass downward into muscovite granite, and still deeper into biotite-muscovite granite.

The total time of uplift, invasion and cooling was enough to permit the erosion of some 20,000 feet of sediments, leaving as much as 10,000 feet of cover at the time of mineralization.

The mineralization was preceded by a renewal of thrusting which was only small in magnitude. It seems to have brecciated the thicker and more rigid limy beds which lay between thin shaly ones or thinner limy ones. But, the forces were not large enough to brecciate the thicker sills of Alaskite, which may have acted as buttresses. The thrusting forces seem to have accumulated in the pre-existing anticlinals.

The mineralization was probably derived from further differentiation of the underlying igneous rock while the upper part was cooling. It consists largely of white, gold bearing, high temperature quartz, which carries only small quantities of sulphides, galena and sphalerite being the most certain of them. The bulk of the quartz mined runs about 0.3 oz. gold per ton.

The mineralizing solutions seeped upward over a long time and replaced pre-mineral breccias of limestone which had phacolitic forms. These occurred most commonly at the crossings of strike and dip minor anticlinals. Ore may occur in several beds, and it and the minor crossings may occur at intervals up the dip of the larger structures. This is shown especially well in the northwestern part of the Drinkwater Anticline.

The textures and minerals, such as muscovite, indicate that the mineralization replaced and deposited during a long time. Meanwhile erosion doubtless still continued; and after an interval the magmatic source continued to differentiate, but now with the separation of basic or complementary components.

With later shrinkage of the underlying igneous mass tension cracks developed which became the channels and seats for the deposition of Diorite. This is now a green, thoroughly altered rock which was probably a complementary lamprophyre composed of major hornblende, or a camptonite. It occurs in irregular masses, sills, and dikes. It favors strong contacts whether sides or ends, including those of ore bodies.

The uplift and invasion took place during most of Jurassic, Lower Cretaceous, and Upper Cretaceous times. At the end erosion had worn the rocks down to approximately their present relationships.

The Tertiary involved the deposition of several complex series of volcanics and lake beds. These are now almost gone from Mineral Ridge. During that era strong faulting and mineralization also occurred at various places. This is probably represented in Mineral Ridge by those faults which are healed with a typical near-surface quartz. One of the strongest of these faults is the Chiatovich, which has an east-west strike and medium dips to the north. It displaces the Foot Fault about 120 feet, left-handed along strike-slip. Another conspicuous occurrence of quartz is in connection with the Hanging Fault, which is probably due to bedding slips near the change from Wasson Syncline to Lease Anticline. The near-surface quartz does not persist strongly in depth.

Other prominent and important faults are the Garreys, which are normal, with strikes in the NNE octant. Some of them have displacements measured in tens of feet, and some of them are healed with small amounts of quartz and carbonates. They are transverse to many of the stronger and earlier features, and tend to be concentrated near weakness of mineralization and in the spaces between ore bodies.

It seems likely that Mineral Ridge was further elevated as a block during one of the periods of major faulting which occurred during the Tertiary.

Bed slips, which are late and unhealed, occur profusely on the hanging near interruptions in ore bodies, "rolls" occuring on the southeastern ends, "east-westers" on the northwestern end of the next lense, with Garreys between. As effects these may be used as guides to ore.

COPY

GEOLOGIC COLUMN and HISTORY

As in all other phases of this work and report, full advantage has been taken of all convenient, existing information regarding the region and district. Among authorities consulted have been the writings of J. E. Spurr, including his final report on the Silver Peak District in Professional Paper 55; those of S. H. Ball, including his excellent work on generalities of Southwestern Nevada and Eastern California in Bulletin 308; and those of F. L. Ransome, including his generalities regarding Humboldt, Pershing, and Churchill Counties in Bulletin 414. These gentlemen were of the U. S. Geological Survey which published much of the above. They also made full use of the earlier work of G. K. Gilbert, Arnold Hague, and others which related to the geology of Nevada, as well as other more special writers like Louderback. Full use has also been made of the work of Adolph Knopf and Edwin Kirk on the Inyo(White) Mountains in Professional Paper 110; and of F. C. Calkins on Yosemite in Professional Paper 160.

The drawings accompanying this show the regional column of sedimentary rocks which existed prior to the events of mountain building(orogeny,) intrusion, mineralization, and erosion which took place during much of the Jurassic, Lower Cretaceous, and Upper Cretaceous Periods, during possibly as much as 100,000,000 years. They show the position of the part of the Silver Peak Group which now exists near the Mary Mine, as well as some details regarding that part.

Pre-Cambrian

Because it occurs only rarely and in poor exposures the Pre-Cambrian is but little known in Nevada and in no great detail. The study of the White Mountains which are as near as 30 miles

COPY

from Mineral Ridge showed the existence of several thousand feet of these rocks, as indicated in the diagram. Their characters indicate a heavy sedimentation within a shallow inland sea. The material of which they are made was probably derived from a continental mass which then existed to the west of the present Sierra Nevada. This land mass contined to exist and to furnish material during the times indicated by the diagrammatic column.

As elsewhere in the earth a pronounced unconformity separates these formations from the bottom of the Paleozoic section. This means that profound changes in the crust, elevation, warping and mountain building elevated them above sea level and subjected them to erosion, so that some thousands of feet were carried away, before the surface was again lowered for the deposition of the Lower Cambrian sediments.

<u>Cambrian</u>

Throughout the region the surface warped down below a shallow sea at the beginning of the Cambrian. It will be noted that thereafter, as shown in the column, the bottom warped up and down, being shallow during the deposition of sandstones and shales, and approaching deep sea conditions during the deposition of limestones and dolomites.

At first the sea in this locality was shallow over a long time, as shown by the 3,200 feet of arkosic Campito sandstone found in the White Mountains.

Thereafter, during the deposition of the Silver Peak Group, the sea was deeper as shown by the deposition of dolomite in the series, as well as of the thin bedded limestones now known at the mine. The depth varied, becoming shallower at times, as

NEVADA DEVELOPMENT COMPANY

FROM EDWIN KIRK U.S.G.S.; P.P. 110

EASTERN SIERRA NEVADAN PROVINCE

ERA	PERIOD	THICKNESS	LITHOLOGY	FORMATION
MESOZOIC	TRIASSIC UPPER	5000		Andesitic tuffs, Breccias and shales
	MIDDLE LOWER	1500		Calcareous Shale and Sandy Limestones
PALEOZOIC	PERMIAN			Unconformity Limestone
	PENNSYLVANIAN			Reward Conglomerate (Weber?)
		3000		Shale and Limestone Fusilina
		3500		Quartzite (Diamond Peak)
		1000		Limestone
	MISSISSIPPIAN	1000		Shale (White Pine)
	DEVONIAN	1400		Impure, thin Limestone (Nevada)
	SILURIAN	750		Missing (unconformity)
	ORDOVICIAN	500		Aranaceous shale
				Argillaceous ls. (chazy)
	LOWER	3500		Pogonip Limestone (Beekmantown)
		300		Sandstone
	CAMBRIAN UPPER	1000		Arenaceous limestone + shale
	MIDDLE	900		Calcareous sandstone + ls.
	LOWER	7000		Silver Peak Group Shales and Limestones uppermost 1000' of lowest third See column for Mary Mine + 30,000' overlying { 340' Dolomite, 510' Shales, Mary Limestone }
		3200		Campito Sandstone Profound Unconformity
PROTEROZOIC	PRE-CAMBRIAN	1600		Deep Spring Sandstone
		2000		Reed Dolomite
		?		Oldest ? mostly unknown sandstone and dolomites

SCALE 1" = 4000'

JOHN G. BARRY

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LOWER THIRD OF SILVER PEAK GROUP OF LOWER CAMBRIAN

THICK-NESS	WALCOTT
650'	Bluish-gray limestone, with sandstone and thin limestone Numerous fragments of Olenellus Arenaceous limestone Brown sandstone and sandy shale Interbedded thin lime-stone
200'	Shale and Sandy shale. Few thin limestones. Obolella, sp.?; Tremotoolus excelsis Walcott
575'	Alternating arenaceous limestone, shale and dirty-brown sandstone. Archeocyathus very abundant
450'	Annelid trails, Cruziana, Tremotobolus excelsis Walcott, Holmia rowei. Sholey indurated sandstone. Archaeocyathus, Ethmophyllum gracile Meek, Mickwitzia occidens Walcott, Obollela, Tramatobelus, Hyolithes, Helmia Rowai.

THICK-NESS	MARY MINE SECTION
340	Mg. limestone. "Dolomite"
150'	Limy bands in shale. Soldier
210'	Shale, schistose and considerable quartzite.
150'	Limy bands in schist 379
?	Mary limestone. Greatest thickness known Sept. 1939 150'. Intrusive alaskite below.

SCALE I INCH = 250'

SEPTEMBER 1939

TO ACCOMPANY REPORT BY

JOHN G. BARRY

shown by the shales and sandy shales near the Mary Mine. In general, however, there was a deepening, with limestones predominating in the whole group, to make over a long time a deposition of not less than 7,000 feet of sediments.

Near the Mary Mine the sediments now known, which have been left between the upward invasion of the granitic rocks and the downward progress of erosion, represent about 1,000 feet of the column. They lie about 1,000 feet to 2,000 feet up in the 7,000 feet of Silver Peak Group, which in turn forms a principal part of the Lower Cambrian of the region.

The upper remainder of the Silver Peak Group is known in Mineral Ridge,however, within stretches of about ten miles to both northwest and southeast along the ridge, where the beds dip out in those directions. That they are there has been shown by H. W. Turner by the identification of beds lying above them; but further study of them is needed in these stretches.

The smaller remainder of the Cambrian is shown in the column.

<u>Cambrian to Permian</u>

The column shows the sequence found between the Cambrian and Permian in the White Mountains. Certain generalities may be noted. Only a very small proportion of the formations known in other regions has been found, but this lack has been counterbalanced by the very heavy sedimentation shown. One break is further indicated by the unconformity which exists near the top of the Lower Ordovician. In this case the Middle and Upper Ordovician are missing as well as the Silurian in toto, but the last is not necessarily true elsewhere in Nevada.

Other breaks are also evidenced by disconformities and heavy shaly and sandy beds, which may have concealed former unconformities, or made them less conspicuous.

Some of the formations found are well known in Nevada, corresponding to those first found by Hague at Eureka, such as the Pogonip limestone, Nevada limestone, White Pine shale, and Diamond Peak quartzite.

A small amount of Permian remains beneath a pronounced unconformity.

Triassic and above

The largely volcanic character of some 6,500' of Triassic is shown in the columnar diagram. These have been found both in the White Mountains and to the north of the region through a few hundred miles. In the latter direction small occurrences of Jurassic are also reported, but it is generally believed that this period showed here an interruption of sedimentation and the beginning of mountain building.

Total Column

It is important to note the tremendous thicknesses of sediments that were present at the initiation of orogenic processes. From a consideration of the whole column one would guess that the total thickness of sediments would approach 40,000 feet, thus forming one of the worlds major geosynclines, or a long trough of deposits in an inland sea. Such a condition, leading to heating and relative flexibility toward the bottom is generally accepted as one of the essentials to the formation of the worlds outstanding mountain systems, like the Sierra Nevada of California and its satellites.

The matter of overlying thicknesses with respect to inflow and differentiation of igneous rock and to the consequent mineralization is also of critical importance in considering them in Mineral Ridge. From the column it seems likely that the thickness of sediments above the rocks now existing at the mines was not less than 30,000 feet when the folding of Mineral Ridge began.

Jurassic to Eocene

During much of the Jurassic and all of the Lower Cretaceous and Upper Cretaceous no sediments were deposited in the Sierra Nevadan Province. The Province includes outliers with a geologic history similar to the Sierra Nevada, such as the Inyo Mountains, and Mineral Ridge in the Silver Peak Range.

The borderland, or continental extension, which lay to the west of the present locus of the central valleys of California had been in existence since the beginning of the Paleozoic. With the lapse of such long time it should have been worn down to a base level approaching that of the sea.

To the east of it lay the immense geosyncline with the great thicknesses of sediments listed above. These accumulations approached a thickness of 40,000 feet. Under the static conditions which may have existed toward the end of sedimentation it is likely that the lower two-thirds of the column had already been cemented to firm rocks. At the same time the static load pressures toward the bottom must have exceeded 40,000 lbs. per square inch. Other estimates make it seem likely that the temperatures toward the bottom must have exceeded the critical temperature of water, 364 degrees C. Thus the lower parts of the column were well within the zone of anamorphism, where it is believed that the original minerals of the sediments were being steadily subjected to processes involving dehydration and reduction. They would have been below depths at which directed, tangential pressures of the crust were in effect, and were thus in a zone of plutonic metamorphism where solution and recrystallization of the original minerals would have been proceeding under conditions approaching aqueo-igneous fusion. The oldest Pre-Cambrian rocks, now unknown, would have been approaching a condition in which they were being slowly incorporated in the underlying crustal magmas.

It is, of course, true that a static condition never prevails in geology, that constant change is the only dependable condition; but the above has been cited to show the general governing conditions which might have existed. From this we see that the oldest rocks at the bottom were completing the geologic cycle and were about to enter an igneous phase to begin again (palingenesis) another cycle in their connection with the history of the crust.

In considering all of the events between the Triassic and Eocene it should be kept constantly in mind that very long times were involved. Various estimates indicate that the Jurassic, Lower Cretaceous and Upper Cretaceous periods involved time of a magnitude of 100,000,000 years. During this tremendous space of time a series of critical processes were occurring in a general order, as follows:

1. Orogeny and invasion;
2. Differentiation and cooling of invasion, involving
3. Long interval with erosion;
4. Pre-mineral stresses and phacolitic breccias;
5. Long interval, involving solidification of mineralization, and erosion;
6. Pre-dioritic stresses and its invasion;
7. Continued erosion until Eocene, when Mineral Ridge attained its present form.

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It seems likely that during the first three events 20,000 feet of the total of 30,000 feet of sediments were removed. This would have involved about 65,000,000 years, of which about 50,000,000 years would have been used for the first two events. This would have left a cover of about 10,000 feet of sediments at the time of mineralization, and a period of 35,000,000 years for the last four events. This time might have been divided about equally between the group of (4) and (5,) and the group of (6) and (7.) Further, it is essential to realize that erosion was fairly continuous throughout this whole space of time. Similarly, the lapse of time permitted gradual cooling of the deeper parts of the column and its invader as they were raised and as erosion wore off their insulating blanket.

Formation of Sierra Nevadan Province

In profound changes in the crust of the earth three agents were necessary: pressure and movement, water solutions, and heat. It is also known that continental changes in the earth occurred at critical times which were related to the base leveling of one part and the deposit of thick sediments adjoining. It is believed further that the continents were in relative tension in their central parts and in compression toward their borders. The thick sediments gave rise to heat and the effect of water solutions in depth, while the tangential pressures, partly due to shrinkage of the interior, caused movement and differential pressures in the upper part. By the reactions of such conditions and forces, changes in the continents, epeirogenesis, were brought about. In general the old, worn out part of the continent sank below the sea, while the adjoining region of thick newer sediments was thrust up by tangential stresses and invaded by granitoid rocks to form major mountain systems (orogenesis.)

In this case the old, base-leveled, continental fringe or borderland, variously known as Cascadis and Californis, sank below the sea; and the geosyncline to the east was elevated by folding which was accompanied by the invasion of granitoid rocks. This epeirogenetic change formed the Sierra Nevadan Province which included nearly all of Nevada; by it Nevada was raised from the sea, above which it has since remained. The Sierra Nevadan System of mountains included not only the Sierra Nevada itself but also several ranges lying to the northeast of it. Some of the other ranges are the White-Inyo Mountains, the Silver Peak Range, Lone Mountain, and their extensions. In general these ranges were formed at the same time, by the same forces, and under similar conditions. The effects, including folding and intrusion seem to have been less accentuated toward the east.

In the Sierra Nevada the remnants of sediments usually show close and steep isoclinal folding. This would have resulted from an accentuated directed horizontal stress near the top reacting on thicker sediments abutting a rigid crustal projection. In the Inyo Mountains there is a western syncline and an eastern anticline, which run out northwesterly and diagonally to the modern trend of the range; but these are fairly open folds. Mineral Ridge in the Silver Peak Range is a long gentle and open anticline. Any heavy thrust faults which are likely to have existed in the Sierra Nevada now seem to have been obliterated by the granitoid intrusives and by the latest faulting on the flanks. But it is also reported that no thrusts are found in the Inyo Mountains. In Mineral Ridge there is only one prominent,

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relatively small, thrust fault, known as the Foot Fault; but there are probably other very small ones, like the two known in the Great Gulch locality near the nose of the anticline. Although direct thrust effects are not now plain, it is likely that the folds were formed by tangential pressure from northeast to southwest. In Mineral Ridge the drag folds of the old shale beneath the more rigid dolomite show this. It seems likely that the valleys in the Province represent synclinal stretches which were invaded by the granitoid rocks; and that such intrusives attained higher elevations in such structures and also progressively toward the southwest.

Invasion of Igneous Rocks

Throughout the world it has been found that profound epeirogenic changes have been accompanied by orogeny, and that this in turn has been accompanied by profound upwellings or intrusions of granitic rocks. This was also true in the Sierra Nevadan Province. It seems likely that the source of these rocks was a subcrustal, permanent magma of intermediate composition, to which had been added huge quantities of superincumbent rocks. These had been so deeply buried as to contain water above its critical temperature, and they were in a condition of incipient fusion. With the release of load pressure by the arching of higher rocks, when tangential compression was applied to them, the deeper rocks which were prepared to form an aqueo-igneous solution did so and followed upward step by step with the folding. As would be expected they thus tended to conform to the structure of the country rocks which overlay them. Their masses are generally parallel to the tectonic axes of the ranges, with dome-like tops, and with walls which slope downward and outward fairly smoothly but usually slightly steeper than the wall rocks. The larger masses are believed to enlarge downward and to have no floor of earlier rocks. In Mineral Ridge the granitics form a reasonably perfect cast of the structures of the other rocks.

The assimilation of the deeper rocks must have changed the composition of the resultant rock and the proportion of minerals present, but it did not change the minerals themselves, because in general the minerals were few and restricted to those which would be stable under the conditions. They include principally potash-feldspars, soda-lime-feldspars, quartz, and very small quantities of micas, especially the white muscovite, and minerals like hornblende. One of the most important agents effecting this upwelling is water, which has an extreme power of solubility and combination when above its critical temperature. When accompanied by other mineralizers, like boron, fluorine, carbon dioxide, sulphur dioxide, chlorine, and hydrogen, its solvent power is greatly increased. Moreover, the other mineral forming radicals when thus treated become mutually intersoluble. Thus there existed a rock solution which was not very hot and which could move freely, in contrast to the pasty viscous mass which would have resulted from a dry melt. As long as the openings for it were prepared gradually over a long period of time and did not extend to relatively cool rocks, this solution, without cooling and crystallizing, could move in through even small cavities and conform to the arches and lenses as they formed.

During the early days of geologic studies present ideas as to physico-chemical laws and their application to geology did not exist.While deep-seated igneous rocks were studied they were also compared mentally to igneous phenomena occurring near the surface. In the latter cases it is true that relatively superficial gashes had opened to the atmosphere suddenly and that they had filled with igneous material which, because of the relatively cool surrounding rocks and the escape of mineralizers had solidified quickly. Because of these relationships the idea of cataclysmic action began earlier and persisted longer with respect to such studies than with respect to other phases of geology. In contrast, it is now generally believedthat, with few superficial exceptions, geologic forces act very slowly over long periods of time. But, because of the earlier ideas certain words have been used for a long time in connection with igneous rocks, such as intrusive, irruptive, and injected. These mean, and are likely still to imply in the minds of even those who disbelieve in such action, that a relatively sudden and violent force producing breaking and thrusting in the country rock proceeded from the igneous rock itself. On the contrary it now seems likely that large bodies of igneous rocks welled upward as load pressure above them was released by the buckling of superincumbent rocks in response to tangential stresses. The action was rather in the nature of a pacific upward invasion, in which only small differentials of pressure were concerned. It also seems true that if a thick cover of hot rocks had been concerned the igneous solution without solidifying could have moved up gradually over a long period of time pari passu with the folding. Thus, the absence of deformation in the igneous rock does not necessarily prove that it invaded the structures late in the mountain building process, because it might have been present throughout while remaining in a molten soluble condition.

It is true however that such bodies do not show such ideal histories near their tops, where they are most frequently observed. There they show greater or less stoping action on the nearby country rocks. This was caused by invasion and infiltration along fractures, followed by the consequent detachment of fracture blocks, some of which sank in the molten invader. The The invader caused some minor metamorphism and absorption. Also, since finally the invader rose into the zone of stress it may have transmitted such forces and may have indirectly caused some deformation of the country rocks. If it should have become solid earlier the invading rock will often show the effects of later, minor stresses.

That the preceding ideas are true in a general way is shown very clearly in the Sierra Nevadan Province. Near the upper part of Bishop Creek thin and very deep, vertical roof pendants show that the invasion must have occurred without deforming disturbance but that considerable stoping and assimilation must have also occurred. In Mineral Ridge all the effects are those of a long continued quiet invasion accompanied by thorough differentiation in place. Deformation of the cover has been noted near Waucoba Mountain in the Inyo Range, but this is near the top of the mass, and evidence to show all the possibilities of deformation by folding stresses has not been shown.

During the long processes gradual cooling of the deeper parts of the column and its invader took place as they were raised and as erosion wore off their insulating blanket. That such gradual cooling and contemporaneous differentiation of the invading igneous rock occurred in the Sierra Nevadan Province is well known. The evidence occurs in extreme form in the Silver Peak Range and Mineral Ridge. In this case it seems likely that the rate of uplift and erosion was slower than in the central part of the Sierra Nevada. The rocks were less

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MILLS BUILDING, EL PASO, TEXAS

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acutely folded and were less broken upward, so that they acted as an insulating capping below which differentiation could take place slowly over a long time and with an upward movement and concentration of the more mobile, volatile solutions and mineralizers and the minerals resulting therefrom. This effect was concentrated at the central longitudinal arch of the anticline near the Mary Mine. At the southern end of the Silver Peak Range the granitic rocks are as basic as quartz monzonite, and as silicic as alaskite. In Mineral Ridge the alaskite has a pegmatitic top of some tens of feet thick, while it seems likely that in some hundreds of feet depth the alaskite would change to a muscovite granite, which would still be relatively silicic. In both the Inyo Mountains and the Sierra Nevada the general sequence is from basic to silicic, but it seems that there was sufficient movement and opportunity for escape to enable the successive differentiates there to invade in separate bodies from a deep source.

The large bodies of invading rock which are associated with such large changes affecting continents are known as batholiths. Although small as compared to those like the British Columbia-Alaska batholith, the Sierra Nevada is of large magnitude, about 275 miles long by 80 miles wide, an area of about 22,000 square miles. The masses of the Inyo Mountains, the Silver Peak Range, and Lone Mountain doubtless have a direct connection and within shallow depths are too large to be called stocks; sub-batholiths or satellitic batholiths would be good names for them. These subordinate bodies are distinctly concordant generally with the country rocks and structure, especially in the case of Mineral Ridge. Sills are also seen, but in many cases it is likely that they are disguised parts of phacoliths. The last word is used to designate those concordant bodies which are concavo-convex lenses occurring in buckles of beds. Many of them occur at the intersections of anticlinal flexures of both strike and dip, thus forming shallow flat domes in buckles. As will be seen later many quartz occurrences have similar structural relationships. The most important and largest sills are those which extend laterally from the invader into the country beds near the top of the anticline.

Cooling, Differentiation and Mineralization

From the preceding it will be seen that the sedimentaries were folded and raised by tangential stresses. This process was accompanied by an upward quiet invasion by the granitic rocks. It seems certain that at Mineral Ridge the relations of the two kinds of rocks and their structure have since remained generally the same. While in their present general positions a long time elapsed while the granitic rock was cooling and crystallizing. The cooling was brought about in large part by the continuance of erosion which removed the overlying blanket of hot insulating rocks.

During this period of stability, when Physical equilibrium had been reestablished to the satisfaction of the tangential forces, the aqueo-igneous melt had the opportunity to arrive at equilibria within itself while cooling very slowly. The differentiates near its top have already been referred to. Of especial interest are the upper layers of pegmatitic rocks, which are composed essentially of quartz, microcline, and minor amounts of muscovite. This material indicates the presence of a locality rich in mineralizers, especially water and carbon dioxide. These more fluid melts must have segregated at the top because of greater mobility and because of upward travel of the mineralizers themselves. The indication of this process is important to Mineral Ridge in showing that conditions would have permitted such differentiation in place, and thus suggesting that the ore-bearing quartz was being segregated and kept available in some other place. It probably was trapped deeper and to one side in the slowly cooling mass. In general, it is possible that other localities with similar intrusions but without mineralization may represent places where the folding was so severe as to render the capping over the invader more fractured and permeable, thus permitting the invader and its fractions and mineralizers so to move to mix and to escape as to prevent the segregation of mineralization on any large scale.

It seems likely that with progressive cooling of the igneous rock shrinkage toward the center of the region could have developed stresses tangential to the general anticlinal structure. The existing evidence shows that these stresses were weak and not great enough to fracture the granitic rock to any considerable extent. Thus, weak thrusts were applied to the overlying beds. Those beds which showed relatively greater competency, but not too great rigidity like the igneous, were brecciated. Only small differentials of stress and resistance were involved. The ideal was the case of thicker beds of limestone lying between thinner beds or between shaly beds. The thinner or shaly beds would have glided and healed internally, thus increasing the resultant stresses on the thicker enclosed beds. With the smaller folding of crumples and longitudinal flexures the concave synclinal areas were in relative tension while the concomitant anticlinals were in compression. With respect to the whole structure many small phacolithic areas of brecciated limestone were developed. These were relatively small, thin, concavo-convex, lenticular buckles. They were the localities into which highly mobile, fairly hot, quartz solutions could have migrated, replaced limestone, and come to rest under both physical and chemical equilibria. The movement of the solutions probably took place step by step with the fracturing. The effect of the fracturing, movement and segregation was such as to leave isolated bodies of quartz which have no great apparent interconnection either with one another or with their source. It seems likely that the solutions moved upward near the top of the igneous from a deeper source of differentiation and infiltrated and lodged in the localities of favorable brecciation and easy flow. The derivation of the solutions was analogous to that of the pegmatites, but differed in being cooler, in taking greater time for separating while the rock was crystallizing below, and in being finally more mobile and more chemically active. The solutions were probably highly charged with water, carbon dioxide and alkalies. The limestone was probably removed upward as very mobile solutions of calcium bicarbonate in highly aqueous alkaline solutions, the silica being left behind as a pasty mass in the lenses. It will be obvious that this process took a long time for the formation of the lenses of breccia and the flow of the solutions, and then the cooling and crystallization of the quartz, during all of which erosion of the overlying surface continued. It seems likely that the overlying cover varied downward from about 10,000 feet to a few thousand feet while this was going on, and that equilibria had been generally reestablished. It is important also to note that thus far the igneous rock had been so differentiating as to produce successively more silicic fractions through the ranges of muscovite granite, alaskite, pegmatite, and quartz mineralization.

Complementary (Dioritic) Dikes

While the last was proceeding the deeper igneous rock continued to cool, crystallize, shrink, and differentiate further as circumstances would permit. As a result of the separation and escape of the silicic differentiates the remaining magma produced basic ones. These are complementary to the earlier fractions and are called lamprophyres. Later breaks permitted their movement and deposition. The term diorite has been unfortunately applied to them locally. Their original mineral composition was dominant hornblende accompanied by minor medium plagioclase. Thus they are related to camptonite. As seen now they are highly altered, and of a distinctly greenish color, the resultant minerals also being reported as dominant chlorite and epidote accompanied by other minor products of the change. It seems likely that their alteration was accomplished by the later flow of other solutions, such as those which put some filling in some of the Garrey faults. It seems likely that the stresses which caused opening for the basic dikes were small and thus generally restricted to places of great differences of resistance. As found these seem to be at or near large quartz bodies and the stronger contacts, such as the top of the alaskite, the contact between the Mary limestone and the shales, and the contact between the top of the shales and the bottom of the dolomite. The basic dikes are definitely later than the bodies of quartz of the ore type. Following the inflow of the basic dikes, erosion continued until the Eocene. It seems likely that at this time the country generally assumed its present outward form with respect to the mountains; this is definitely so at Mineral Ridge, because remnants of uneroded Eocene can be found on the upper reaches.

Tertiary and later

The country differed, however, by having deep valleys before the additional deep fills of Tertiary deposits; thus it was probably much more mountainous. This was probably further accentuated by a lifting of the mountains and a sinking of the valleys by north-south faults bounding the ranges longitudinally . Mineral Ridge probably stood so high and kept being elevated so much that it received no great quantity of the Tertiary lavas and pyroclastics. But, to the south and southwest in the Silver Peak Range there are great thicknesses of them between Clayton Valley and Fish Lake Valley. They abound near the Nivloc Mine and thence up the ridge to the west which extends southerly from the andesitics of Red Mountain. Throughout Nevada the total column of Tertiary and early Quaternary reaches a few thousand feet of deposits. In order from the oldest to youngest, they may be summarized as follows:

1. Unconformity and lake sediments;
2. Rhyolite, followed by monzonites and acidic andesites, partly intrusive;
3. Long erosion interval;
4. Mighty extrusion of rhyolite, exceeding bulk of basalts of late Pliocene and Pleistocene;
5. Latite, dacite, andesite, unimportant rhyolite;
6. Siebert lake beds. Important ore deposits. Rhyolitic eruptions;
7. Deformation with southward tilting, and rhyolite;
8. Extensive erosion, peneplains, lakes and extensive basalts;
9. Uplift,normal faulting,some folding,active erosion.

The last period finished the erosion of nearly all of the Tertiary rocks which might have been deposited on Mineral Ridge. Probably the ridge was also raised further as a block. It also seems likely that some of the Garrey transverse faults were formed at this time. In general these breaks have NNE strikes, fairly steep dips, and normal displacements. In many cases they show fillings of quartz and calcite accompanied by other carbonates and their oxidation products, which to the writer would indicate that they might have been formed early in the Pleistocene.

There is another filled fault which the writer has referred to as the Hanging Fault, whose origin and effects may be uncertain. On the surface map it is shown as running from the Foot Fault, near the Last Chance, northwesterly along the northeastern side of the Lease Anticline. It has dips approximately the same as the bulk of the shales in which it occurs. Except for a few points underground it is known only on the surface. Displacements on it are not measurable, so that it may be a bedding fault. On the surface it is marked by heavy bodies of quartz which make large showings because of approximation of dips and slopes. As far as known the filling underground seems to diminish markedly at shallow depths. The quartz filling is not of the ore type, but is bluish underground and finely porcelainic on the surface; and it is accompanied by carbonates and their products. Consequently this may represent only a bed slip of no great displacement, occurring on a break between synclinal and anticlinal structures, which occurred in Tertiary time when solutions were flowing and escaping on a surface not much above the present one.

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Mining also shows other slips, such as "rolls" and "east-westers" It seems likely that these are merely late bed slips which are very conspicuous, but without filling. They are of importance however as showing the presence and course of Flexures, thence leading to the discovery of quartz bodies whose presence has doubtless helped develop them.

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GENERAL GEOLOGY of NEVADA DEVELOPMENT

The controls and critical aspects of the general geology of that part of Mineral Ridge covered by Nevada Development are directly related to and dependent upon the general geology and geologic history of the Region and Province of the Sierra Nevada. These have been already delineated in the preceding. The Ridge is a small part of and an outlier in the Sierra Nevadan Province. It is a fairly gentle and open anticline of northwesterly strike. The locality of the Mary Mine is on the upper northeast flank of the southeasterly part of the structure and within a few miles of steep pitch to the southeast, but several miles from the pitch to the northwest. The core of the Ridge is formed of the invading granitic rocks, while the overlying sedimentaries are relatively thin when considering the whole bulk. They are not much thicker than 1,000 feet and are a small remainder of the eroded 30,000 feet of original sediments. The sedimentaries now left were about in the upper part of the lower third of the Silver Peak Group of the Lower Cambrian. With respect to the mineral deposits only the northeastern flank of the southeastern quarter of the Ridge and anticline is of present interest.

ROCKS NEAR MARY MINE.

Mary Limestone.

The oldest and lowest sedimentary rock known near the Mary Mine is the Mary limestone. This formation is a thin-bedded, recrystallized, light bluish gray to white, limestone. It is in general believed to be low in magnesia, but streakily impure with shaly constituents. The shaly layers are fairly common but not often thicker than one inch. There are many layers of thin bedded limy material. The formation in general has a distinctly sheared appearance. It is not known to contain in the mines any recognizable

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fossil content; but, it is possible that work on microscopic organisms might disclose their presence.

The bottom of the Mary limestone is unknown in the district. It seems likely that the missing part of the Lower Cambrian which originally lay below it included: some one thousand feet of Silver Peak Group, principally limestones; and some few thousand feet of Campito sandstone, which contained shaly members as well as sandstones and quartzites. It is also possible that there had existed before the granitic invasion some few thousand feet of quartzites and dolomites of the Proterozoic, or upper pre-Cambrian, which were separated from the overlying Lower Cambrian by a profound epeirogenetic unconformity. Consequently, it is possible that several thousand feet of formations have been melted, dissolved and assimilated because of deep burial, high temperatures accompanied by mineralizers, and the slow invasion by the still deeper aqueo-igneous melts which occurred with continental uplift.

The known thickness of Mary limestone ranges from zero to 150 feet. This depends upon the height to which the granitic rock has invaded in various places. The greatest thicknesses have been exposed in the extreme northwestern end of the Mary Tunnel, and in D. D. Hole No. 58. At many places the formation is non-existent. This is due to upward bulges in the top of the invading granitic rock, as for instance in the general neighborhood of the Flat Raise; and to pre-alaskite faulting which dropped the formation into the later locus of the alaskite. In general, however, it is common to find a 50 foot thickness of the formation over long stretches. It is believed that the thickness of the Mary limestone will generally increase with progressive exploration down the dip,

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because the top of the granitic rock probably dips more steeply than the overlying invaded rocks.

The next preceding paragraph gives a general idea of the distribution of the Mary limestone in the underground workings. On the surface it is seen in but few places, such as, in Great Gulch near the Calumet holdings, in the hanging wall of Lower Elizabeth portal, and at the extreme southeastern end of the Headhouse Level. This is because the cross ridges nearly conform to dips and expose the middle of the overlying shales, while the deep canyons are most often eroded where there are upward bulges of the granitic rock which have invaded higher in the column. From the foregoing it will be seen that the formation is rarely useful as a marker in surface mapping.

Underground the Mary limestone has been important both as a marker and as a highly productive formation. To the southeast of the Mary Tunnel in the Lease, the upper 20 feet have been very important, while to the northwest two horizons exist and have been productive. In the Mammoth from the Lease line to the northwest for a considerable distance it seems likely that as many as three horizons have been highly productive under the very favorable structural conditions prevailing, In the extreme northwestern part of the Mammoth, beyond the Winze, the indications on the Mary Tunnel are that the thickness of Mary Limestone will prove great and that it will have more than one productive horizon when it is worked in the proper anticlinal flexures.

The Schist

The Schist is the formation overlying the Mary limestone. The formation is schistose only in part, so that phyllite would probably be the best name for it; but the name schist is

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so ingrained in the usage of the district that it is best to retain it. Shale also makes a convenient field name.

The formation is a dirty, highly variable sequence of deposition. It lies between the Mary limestone and the Dolomite, so has limy transitional deposits at top and bottom. Moreover, during deposition the surface warped up and down, so that it contains many layers that were more sandy than muddy, and many that combine the characteristics of limy, muddy and sandy beds. In general it is thin-bedded, the limy beds being a few feet thick. Some of the members seem to represent paper shales of originally kaolinic material. The small amount of purest argillaceous matter is thick-bedded, up to ten feet thick forming an argillite. From this it will be seen that the beds were highly complex in original characteristics.

The formation has been subjected to mild dynamic metamorphism. The great variation and impurity has prevented the formation of slates. The dynamic metamorphism has also been accompanied by small amounts of thermal and pneumatolytic metamorphism, which occurred in the order named, and which generally increased in intensity with approach to the large bodies of granitic rock.

The agents of these types of metamorphism are essentially heat, pressure, and fluids, whether liquid or gaseous and whether derived from the rock or from nearby invading rocks and their differentiation effluents. Depth of burial and orogenic stresses are directly responsible for the development of heat and pressure. With the cooling and crystallization of the invading rock the highly aqueous and mobile residuals would have developed greatly increased pressure and thus would have been able to move and penetrate easily. The hot chemical

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agents having been directed by pressure would have caused new combinations and recrystallization of minerals with elongations of more stable crystals normal to the direction of stress. Among the minerals which can result from such processes and which have been found in the district are feldspars, quartz, micas, epidote, talc, chlorites, small graphite, apatite and vesuvianite.

Marmorization (forming marble) and dolomitization are processes connected with dynamic metamorphism which occur easily. Marble, in the sense of recrystallization, occurs in all the limy and magnesian limestones of the district. But many of the limy beds are lacking in magnesia content, notably those in the Mary limestone and those in both the lower and upper part of the Schist. The Dolomite, on the other hand, has a considerable magnesian content. So, it must be concluded that the magnesian content was not derived by addition from solutions which were circulating during the later geologic changes, but that its origin was connected with conditions which existed at about the time of deposition of the rock. The magnesian content may have been derived from a concentration of salts of magnesia in a warm sea, either by chemical reaction, or more likely by the secreting action of some corals or lower organisms.

Dynamic metamorphism in the district was probably largely due to deep burial and static load pressure. In the schist the minerals believed to have resulted from it include chlorites, micas, talc, epidote and zoisite, basic feldspars, and small graphite. Thus, the bulk of the schist could be called chloritic phyllite. Many of these minerals cause an increased and conspicuous foliation in the rocks. The feldspars are often glassy like quartz, and the zoisite is inconspicuous. Talc and similar minerals are restricted to a few beds. The harder beds

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probably contain quartzite resulting from a cementation and recrystallization of the original sandy contents. Many members of the schist contain small quantities of graphite which have no doubt resulted from carbon in organic debris.

One part of thermal metamorphism is pyrometamorphism which results from heat alone from nearby igneous rocks. Such effects are present in only small amount. There are no large bodies of hornfels or similar rocks, but it is quite possible that such heat played some part in the development of part of the zoisite, andesine feldspar, etc.

That part of thermal metamorphism which is called contact metamorphism and which involves the development of minerals by additions from without, such as garnet, andalusite, diopside, wollastonite, scapolite, etc., is conspicuously absent in the district. This may be because the invasion took place under conditions of even temperature, long time, unbroken capping, and gradual differentiation in place and without great or sudden disturbance of equilibria, so that the granitic rock was not permitted to emit a series of greatly different products.

It is common to find in the district a small amount of pneumatolytic metamorphism superposed on dynamic metamorphism. Especially in the schist are found albite, and small quantities of apatite and vesuvianite. But it is noteworthy that many minerals supposed to be derived from pegmatitic juices such as tourmaline, fluorite, axinite, topaz, beryl, etc., are conspicuously absent. Muscovite, however, is present in large amount. The minerals microcline, quartz and muscovite are present in large amount in the pegmatitic top of the granitic rock, and similarly they are abundant in any abutting schist. The resultant effect is to form a hybrid rock which often resembles either

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a medium gray diorite or an "injection" gneiss. The nearby permeable schist has been able to soak up or imbibe considerable quantities of the partial magmatic products which with their contained mineralizers are very mobile. In the schist this has resulted usually in bands of light colored newer material, and darker bands of highly altered old material. The light colored consist essentially of microcline and muscovite, the darker of zoisite and albite. Still later sericite and chlorite have developed. In purer argillaceous rocks andesine feldspar wrapped in biotite have been formed. Thus, in general the metamorphism of the schist has developed albite,other feldspars, zoisite and micas.

Complete, clean-cut sections of the schist are rare. Composite sections based on observations in Great Gulch and New York Canyon indicate that it is between 520 and 600 feet thick. In this report the thickness is assumed as 550 feet. The lowest 150 feet of the schist is a zone in which limestone bands up to several feet in thickness are likely to occur. Very often several bands lie close together within a thickness of 20 feet,as in the "379" area. They seem to have especial importance at 60 feet and 120 feet above the top of the Mary limestone, but others are likely to intervene especially in the lowest 80 feet. This is shown distinctly well in the extreme northwestern workings of the Wasson Tunnel, Mary Tunnel, and the first worked occurrences above the Drinkwater and Church. These limestone bands have been important ore producers, and it is important to test for the presence of ore in them in favorable structures, which can best be done from existing stopes. Similarly the uppermost 150 feet of the schist is likely to contain limestone bands which may contain ore under favorable structural conditions and proximity to the alaskite, as has been found in the deposits at the Western Soldier, April, Last Chance and Vega.

The schist is widely distributed in the district, generally covering the surface between New York and Great Gulches for about half of the distance down the northeastern flank of the anticline. To the northwest of New York Canyon it is the only sedimentary rock present in a similar area, but it occurs only in overlying thin patches and scabs, and also as inclusions in the alaskite. The rock has shared in the general development of the structure of the anticline. But, being thin-bedded and plastic it has folded and contorted readily, so that beneath the rigid Dolomite there are a profusion of drag folds which approach an expected ideal for such structures.

<u>The Dolomite</u>

The so-called Dolomite overlies the Schist. It has a thickness of at least a few hundred feet. From 100 feet to 150 feet above its bottom occur beds of bluish limestone which are shaly in some places, in others cavernous. They vary in distances above the bottom and do not seem to be very continuous laterally. They are exposed best near the top of the anticline and especially on its southeastern part.

The Dolomite is a magnesian limestone with a magnesia content in excess of 10%. It has been thoroughly recrystallized to a medium to coarse grained marble. On the surface it weathers to a light brownish buff color, and is rough and hackly. Because of lack of vegetation, the color is distinctive, as are others in the district, such as the dark brown of the Schist and the white of the Alaskite.

In the neighborhood of the Mary Mine the Dolomite extends about half way up the northeastern flank of the mountain

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and it is equally as extensive to the east. To the southeast it extends to the top of the ridge passing around the point to the south and southwest. It also lies on the southwestern flank of the anticline and ridge and up to the crest, having been dropped relatively down by the thrust action of the Foot Wall Fault.

The bottom of the Dolomite serves as a very convenient marker in mapping the surface geology and structure. Although the formation has been so rigid that it has not been subject to drag folds, yet it reflects in its attitudes all the important minor folds which lie on the flank of the anticline. These are important as potential loci for the deposition of ores, and they can be mapped and traced by observations of the Dolomite.

No ores directly related to the mineralization of the Mary Mine have been found in the Dolomite. This indicates that, as in the case of the Alaskite, the formation was too rigid to be broken by the slight thrusting stresses which formed the pre-mineral breccias. At the foot of the range, in the Black Warrior, Foley and Palmetto prospects quartz mineralization with "black metal" carrying copper is known to occur in the Dolomite; but, this may be later than the Diorite near which it occurs.

Sedimentaries Later Than Dolomite

To the east and southeast from the Mary Mine, toward the village of Silver Peak, considerable additional thicknesses of sedimentary rocks are seen to lie above the Dolomite as given above. It is likely that the latter is merely the bottom of a thick series of similar rocks, ~~of similar color~~, which contain minor quantities of darker beds representing shales and quartzites. The Silver Peak Group should have above the Dolomite a thickness of slightly less than 5,000 feet. It has been shown by others that the Upper Cambrian is probably located about nine miles to the southeast, and about twelve miles to the northwest.

A few miles to the southeast the silver mineralization of the old Vanderbilt Mine is associated with the top of a boss-like protrusion of the granitic rock into the Dolomite series. Otherwise the upper beds have been generally non-productive of ores of the Mary type.

Pre-Granitic Structure

In the section on Geologic History it has already been shown that Mineral Ridge in its origin and processes of formation is directly related to and a part of the Sierra Nevadan Province. The continental change involved thick deposits in a geosyncline which were uplifted by folding because of tangential thrusts against a worn down borderland to the southwest. The mountain building process which involved folding and uplift was long continued and slow. It was accompanied by a similarly slow upward invasion of granitic rocks whose composition had probably resulted from the assimilation of huge quantities of the deep seated sedimentaries by a sub-crustal magna. It seems likely that, due to the thick sediments and gentle structure involved in Mineral Ridge, the granitic rock could follow up slowly in a molten condition until the present

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structure was formed in its major outline, and that it could continue thereafter in its present position and in a molten form during such time as was necessary to form a pegmatitic top on the Alaskite.

From this it will be seen that the structure cannot be separated sharply from the invasion, because they progressed together step by step, but it is convenient to consider much of the structure separately and first.

In general, Mineral Ridge is a fairly open anticline, which from all the data available seems fairly symmetrical. Within about five miles southeasterly from the locality of Mary Mine to the village of Silver Peak the anticline forms a nose and pitches down to the southeast so as to expose at least one thousand feet of the similar beds which overlie the Dolomite. Its northwestern nose lies at least about thirteen miles to the northwest, near Emigrant Pass, and probably much farther. The crest of the anticline shows fairly flat beds across a stretch of about one-half mile. From this it will be seen that the anticline has a gentle longitudinal arch as long as twenty miles. Across the structure near the Mary Mine it is about five miles from northeastern valley to southwestern valley.

Details of the structure are not well known on the southwestern side, but the beds appear to have slightly greater dips than on the other side of the anticline. The crest of the anticline shows fairly flat beds across a stretch of about one-half mile. From the crest down the northeastern flank near the Mary Mine, which is better known than any other part, over a distance of about two and one-half miles the surface slope on the

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average is less than ten degrees. The average northeastern component of dip of the beds in this same stretch is about twenty degrees. In the upper mile, which has been and is most likely to be of greatest importance for mining, the average dip of the beds is somewhat greater, about five degrees, in its northeastern component. True dips, in a more easterly direction, are about five degrees still greater in each case.

As would be expected, the northeastern flank contains many minor longitudinal, or strike, flexures. These increase in width and intensity toward the crest, while in the lower half of the flank they seem to be more closely spaced, narrower, and of less importance. From Custer Gulch to New York Canyon the strike of the flexures swings from NNW to NW; and in that direction also they seem to increase in width, intensity, and importance. They appear to bow down between the Elizabeth and Wasson Tunnels, as though there were a basin in the upper surface of the Alaskite. To the northwest of New York Canyon there are but few sedimentary rocks because of the upward extent of the Alaskite.

Many of the flexures seem to fade into the general arched structure on nearing the northwestern side of Custer Gulch. From such an even structure on the southeastern side of Custer Gulch flexures occur again toward the southeast, toward the nose of the anticline, and become intense in the Great Gulch locality. In this direction also the upper surface of the Alaskite has dipped down from the Custer Gulch locality.

From this it would seem that if there are synclinal flexures down the dip on the upper surface of the Alaskite, longitudinal flexures in the sedimentaries will be found.

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The converse also seems true, that upward protrusions of the Alaskite surface eliminate flexures. It seems likely that these effects are due to relative tension and compression in the formation of the range, and that the disposition of the Alaskite is an effect rather than a cause.

Some of the longitudinal flexures of the range are definite synclines or anticlines, but others are denoted synclinal or anticlinal when in effect the strips in question do not contain respectively dips toward or away from their central axes. Rather these are variants which are depressed below or raised above the general curve of the structure. They follow one another alternately. They would be true synclines and anticlines if dips were measured from the average curve of the structure instead of from the horizontal.

Fr om what has been said it will be seen that the axial plane of a flexure may vary in strike and dip and its axis may vary in pitch. This is well seen in the case of the Wasson Syncline. The strike and dip of the beds concerned will also vary accordingly. In general the dips of the axial planes seem to be close to 55 degrees or 60 degrees southwesterly.

Synclinal and anticlinal flexures also pitch down the northeastern flank of the general anticlinal structure of the Ridge. They are most easily determined in the underground workings. They are considered synclinal when the flexure of the strikes points southwesterly or westerly, that is into the mountain or structure; and anticlinal when they have a reverse relationship.

In combination the longitudinal and transverse flexures present a number of possibilities. In general, the

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longitudinal flexures are more important and the transverse class modify them. It seems that for maximum "tightness," the combination would be transverse synclinal modifying longitudinal synclinal. It is certain that for maximum brecciation and opening the combination would be transverse anticlinal modifying longitudinal anticlinal. The latter is readily noted in the phacolitic bodies, whether Alaskite or Quartz.

A consideration of both maps and sections shows generalities and details of the pre-granitic structure. As to general outlines, forms, spacing, and extent the pre-granitic structure was almost the same as that now existing. Hence, the later modification which preceded the flow of mineralizing juices was extremely small and only a shadowy reflection of the earlier and larger mountain forming processes.

It will be seen that the flexures increase in width and accentuation up the northeastern flank of the anticline, to the southwest. The culmination is in the large, dominant Drink water Anticline which forms the crest of the mountain and Mineral Ridge Anticline. The tangential thrust forces reached a maximum in folding effect in that longitudinal zone. The forces became so great that the sub-fold at the crest, Drinkwater Anticline, broke in the center of itself and the main structure.

This resulted in the formation of the Foot Fault, a readily measurable thrust fault. It begins on the southeastern side of Custer Gulch, as shown on the maps. It did not extend farther to the southeast because of many smaller, weakening structures which are connected with the rounding of the nose

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of the Mineral Ridge Anticline to the southeast and south. From Custer Gulch to Elizabeth Gulch, its southeastern 3500 feet, the Foot Fault has an attitude of about N 50 W, 47 NE. Because of its pre-Alaskite age and the subsequent effect upon it of the Alaskite and other later events it is difficult to find it in depth and thus get better dips. From Elizabeth Gulch to the pass to the southeast of the Wedge the Foot Fault seems to form a wide zone, the strike swinging to N 75 W, giving a surface trace to the south of west, and the dips seem to be flatter, about 42 NE. This change was probably due to the development of the fault in a more central part of the large fold on the crest of the Mineral Ridge Anticline. Thence to Eagle Nest Canyon the fault runs northwesterly, swinging to the North, and with very steep dips to the northeast. In the last stretch it can be observed only as pegmatitic zones in the Alaskite and in distortions in the capping shale.remnants or scabs.

In the neighborhood of the Church and Western Soldier-Elizabeth the Foot Fault is readily demonstrable and measurable. The presence and upward projection of the Mary Limestone and beds slightly above are seen there, while on the surface to the foot of the Foot Fault the bottom of the Dolomite can be mapped. The reconstructions on the sections show that the movement of the Dolomite upward on the hanging side of the Foot Fault is about 600 feet measured on the slip, while the columnar measurements show an offset of about 400 feet. The movement of the Foot Fault may decrease between the Wedge and Eagle Nest Canyon, while it dies out in Custer Gulch.

The Foot Fault is known to be pre-Alaskite in age. A General consideration of the maps and sections shows that the top of the Alaskite has a fairly even surface across the fault,

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except for some branch dikes which take advantage of it. Thus, the fault caused no pronounced displacement of the top of the Alaskite as it did in the case of the beds. So, it should be assumed that the fault was an effect of the folding and mountain forming processes and that the invasion followed, but probably only slightly later if at all.

Several of the preceding paragraphs show that the Mineral Ridge Anticline, its subsidiary longitudinal Drinkwater Anticline, and the Foot Fault were generally contemporaneous with the granitic invasion. A further consideration of the maps and sections shows that the remaining subsidiary longitudinal flexures, at least as far down the flank as the Mill Anticline, were in their major features a reflection of the mountain forming and invasive processes. The sections show also down the flank a decrease in width and accentuation of the longitudinal flexures.

The dominant Drinkwater Anticline is shown on the various maps and sections. To the southeast of Section 26 its lower limit lies near the center line of sections. But, it will be noted that the next lower flexure, the Wasson Syncline, dies out to the southeast near Section 18. Thus, the second lower flexure, the Lease Anticline, virtually joins the Drinkwater Anticline and becomes a part of it. So, the anticline becomes broader and its lower limit moves down the flank in this vicinity. Similarly, to the southeast the Dump Syncline seems to be flattened out near the northwestern part of Gold Run No.5, and the Mill Anticline swings into the central part of Gold Run No.5. Consequently, the Drinkwater Anticline, Wasson Syncline, Lease Anticline, Dump Syncline, and Mill Anticline seem to have united

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into one broad anticlinal flexure in the central part of the southeastern third of Laddie No. 1. Within it there are probably minor flexures, as a result of its origin, which should be important loci for Alaskite and ore deposition. This united anticline, which may still be called the Drinkwater, is a part of the central crest of the Mineral Ridge Anticline and thus swings south and southwest around the southeastern nose of the major structure, probably with its lower limit running through the northwestern third of Gold Run No. 17, the western corner of Arum No. 26, and into and across the northwestern part of Arum No. 27. From the preceding it will be seen on the other hand that to the northwest of Custer Gulch the northeastern flank of the crest of the Mineral Ridge Anticline develops four other longitudinal flexures which generally diverge and become wider to the northwest.

To the northwest of Custer Gulch as far as Elizabeth Gulch the bottom limit of the Drinkwater Anticline runs close to the Foot Fault. Since the upper limit of the Alaskite outcrops at only short distances to the southwest there are left only small widths of sedimentaries, the Soldier limestone beds, for mineralization. To the northwest of Elizabeth Gulch the lower limit of the Drinkwater Anticline runs more northerly while the Foot Fault runs westerly. As shown on the sections and maps this leaves a large amount of favorable structure and beds for mineralization. This region in which the Black Mammoth operation is conducted comprises the most productive area of the district. Within it there are still large blocks of high potentiality to the northwest of the Flat Raise and below the Drinkwater Level. The mine workings show that the ore occurrences are connected with minor flexures within the Drinkwater

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Anticline, so that these are probably of a later and separate age from the large pre-Alaskite one.

To the northwest of Section 18 the Wasson Syncline lies next down the northeastern flank of the ridge and anticline. It widens rapidly to the north and northwest and shows its typical form and development to the northwest.of Elizabeth Gulch, and e specially on both sides of Wasson Gulch. The maps show the variation in strike of the axial plane which changes direction fairly rapidly. Similarly, from Wasson Gulch the bottom of the Dolomite in the center of the Wasson Syncline pitches up to both northwest and southeast. As the sections show, the Wasson Syncline is invaded to considerable height by the Alaskite. Section 48 also shows the pronounced synclinal form. In general, it will be seen further that the folding is more accentuated to the northwest, and that in the ridge to the northwest of Wasson Gulch the Schist in the adjoining part of the Lease Anticline shows isoclinal attitudes. Farther northwest the structures are not readily apparent because the Alaskite has invaded so far upward as now to occup y nearly all of the present surface. However, to the southwest of the trend of the Wasson Syncline the remnants of Schist seem to indicate the broad sweeping structure of the Drinkwater Anticline and its southwestern extent has furnished many flat embayed strips of Schist which have been mineralized in the Wedge Mine.

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The dip slope width of the Wasson Syncline is in excess of 600 feet in the northwestern half of its extent, reaching a maximum of about 1000 feet, and with a stretch of 1000 feet of a width in excess of 800 feet. In its northwestern half the invasion has reached high in the Wasson Syncline.

Down the northeastern flank the Wasson Syncline is adjoined by the Lease Anticline. This structure is well exposed where it is cut through by Elizabeth Gulch. At that place it is accentuated, as shown(also) on Sections 36, and 48. It is also much narrower than the Wasson Syncline. The Lease Anticline branches to the northwest from the general arch and Drinkwater Anticline where the downward fold of the Wasson Syncline begins at about Section 18. Its southeastern half is about 700 feet wide measured down the general dip slope, while its northwestern half narrows to about 500 feet. As shown on the sections the Lease Anticline is, however, wide enough to contain on its flanks and in its center favorable sub-structures of an anticlinal nature. The Lease Anticline is of great interest in that between 1937 and 1940 its southeastern end was considerably explored and yielded large tonnages of good ore, thereby giving a large new outlook to the district.

The Dump Syncline adjoins the Lease Anticline down the flank to the northeast. As noted above it forms from and diverges from the general structure in the region slightly southeast of Custer Gulch. It runs northerly as a small structure and assumes importance in the ridge above the southeastern Lease workings. In its southeastern half it is a flattish, depressed, unaccentuated structure, with a dip slope width of about 1000 feet. Farther northwest it is more accentuated. In its central stretch of about

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1,500 feet it has a dip slope width of about 700 feet, toward the northwestern end of which a central anticlinal axis develops. Its northwestern half shows a width of about 1,100 feet, within which the central anticlinal strip develops a width of about 400 feet, as shown on the maps and sections where it is marked the Dump Anticline. The sections indicate that the Dump Syncline is likely to be invaded high by Alaskite, especially to the southeastern and northwestern ends.

The Mill Anticline is next down the flank. In its southeastern half it shows a width of about 400 feet, but seems to have been considerably invaded by Alaskite. Its central stretch of 1,500 feet shows a width of about 500 feet and a central anticlinal axis. In its northwestern half it narrows to about 350 feet, with the Alaskite invasion becoming more pronounced to the northwest.

In the southeastern central part of the stretches a syncline and an anticline are known to succeed down the flank. They have widths of about 500 and 400 feet, and are indicated on the maps and sections. Not a great deal of detail is known about these structures, and they will warrant more careful attention in the future with the progress of exploration work.

Since the longitudinal flexures were generally contemporaneous with the Alaskite it is important to note their general interrelationships. As noted earlier the Alaskite invades the upper center of the Ridge. With respect to the uppermost, northeastern flank structure, the Drinkwater Anticline, from the southeast near Custer Gulch to the northwest the Alaskite lies relatively lower in the structure, thus in that direction leaving unstoped a greater width of favorable beds. As the sections show,

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the Wasson Syncline was invaded to great height by the Alaskite at Section 36 and farther northwest. The southeastern end of the Lease Anticline was considerably invaded by the Alaskite not far from the Custer Gulch Lobe. In the lower half of the southeastern half of the Dump Syncline the Alaskite invaded to great height, its top now outcropping in many places. The southeastern 8,000 feet of the Mill Anticline next to Custer Gulch contains a high Alaskite invasion related to that in the adjoining Dump Syncline.

In general, then, all structures were invaded to height in the neighborhoods of Custer Gulch and New York Canyon. In the long stretches between, the synclinal structures show very much wider and higher invasions of Alaskite than do the anticlinals.

To the northwest of New York Canyon the extension of all of the mass of the Alaskite rises sharply to great height.

The northeastern flank of the Alaskite mass probably dips down slightly more steeply than the mass of the sedimentaries. This is shown especially well on Sections 26, and 36; it is likely that other sections which do not show this general relationship may be in error.

Thus far the stretches between Custer Gulch and New York Canyon have been the principal subjects. It has been noted that they tend to join in the general arch and nose to the southeast and that the large, pre-Alaskite thrust, Foot Fault, similarly dies out. But, to the southeast of Custer Gulch toward Great Gulch they are succeeded down the flank to the northeast and east by at least three other anticlinal flank axes which are not nearly so well known or observable. The lowest of these which might be related to the second anticline below the Mill Anticline may be

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called the Great Gulch Axis, as shown on the maps. It will also be noted that above this and about mid-way between it and the next higher axis there is a thrust fault, which may be called the Great Gulch Thrust Fault. This is, however, much smaller than the Foot Fault;it has a probable columnar displacement of only 100 feet. In the neighborhood of the Great Gulch Thrust Fault there is probably some thickening and duplication of the beds due to acute folding resulting from the overthrow.

As is always expected in the formation of such a major anticline by thrusting, the northeastern flank of Mineral Ridge shows pronounced drag folding in many places. Similarly, the thickness of thin bedded sedimentaries is expected to be greater in the anticlinals (stretches of relative compression) than in the synclinals. There is a very large exposure of large and pronounced drag folds on the northwestern side of the Road Gulch in the Mill Anticline. The attitudes are so diverse that at first glance one might expect that the Dolomite lies on top in unconformity. But, many other observations in the district disclose the true conformable relationship. The Schist, derived from a thickness of about 550 feet of very thin bedded and impure, generally argillaceous rocks is especially and almost exclusively prone to the development of drag folds. Lying between the Mary Limestone and the thick rigid Dolomite it was undoubtedly pliable, and it folded tightly in a complex manner, almost flowing, when the adjoining formations were thrust and bent. The axes of the minute isoclinals dip outward much more steeply than the dips of the other beds, say about 60 degrees. The drag folding produced an extreme duplication of beds. It also follows that the attitudes

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of the Schist usually cannot be taken as as index to the general structure unless first a great deal of large scale, detailed work be done which would show all the minutiae of the drag folds. An extremely large drag fold, synclinal in nature, was found in the sectioning of the mountain flank to the east of Great Gulch. All the evidence show that neither the Mary Limestone nor the Dolomite have shared in this pronounced distortion.

It would also be expected that the strikes of the beds in the longitudinal flexures would vary, in places converging toward the mountain, and in other places converging outwardly. Thus would be formed flexures down the dip, respectively synclinal and anticlinal. From this it will be seen that four combinations are possible between strike and dip flexures. Undoubtedly the crossing of strike and dip anticlinals would be of greatest importance in the development of phacolitic bodies, whether pre-Alaskite or pre-Mineral. The presence and course of the dip flexures may be seen by a general view of the surface, using the bottom of the Dolomite as a marker, as well as by detailed mapping. Certain of them are outstanding, and are indicated on the maps for the localities believed to be anticlinal. They are named as follows:

A. Generally in the ridge to the southeast of Wasson Gulch;

B. Generally lying to the northwest of Elizabeth Gulch, and Road Gulch;

C. On the southeastern crest of Mill Ridge;

D. Along lower Custer Gulch;

E. Running northeasterly from the Original Black Mammoth, to the southeast of Canyon Crest claim;

F. Running northeasterly from the Vega and Laddie Nos.3 and 1;

G. Running through Gold Run Nos. 10, 8, and 6;

H. Running northeasterly through the western parts of Golden Scepter Nos. 7, 5, 3, and 1;

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I. Running northeasterly through the central part of Golden Scepter Nos. 7, 5, 3, and 1;

J. Running northeasterly through the Clipper;

K. Running easterly through Gold Run 10 and Golden Scepter 1;

L. Running easterly through Gold Run 17 and Golden Scepter 5;

M. Running easterly through Arum 26 and Golden Scepter 7.

The easterly trending dip flexures are undoubtedly due to the swing of beds in the southeastern nose of the Mineral Ridge Anticline.

The most important of the dip flexures seem to be A, B, E, F, I, J, K, and L, based on accuracy of knowledge of geology, and of past results in prospecting and production. The most important strike anticlinals have already been listed; but, it should be noted that in the Great Gulch area the crossings of northeasterly and easterly flexures might become important.

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Granitic Invasion and The Alaskite

Consonant with its part in the Sierra Nevadan Province the Mineral Ridge Anticline was invaded by granitic rocks as it was raised by the thrusting forces connected with the continental uplift and the associated mountain building. The predominant granitic and igneous rock in the major structure is Alaskite, which forms the core and the bulk of Mineral Ridge as it now exists.

In the ridge to the southeast of Custer Gulch, near the Vega claim, the Alaskite dips under the sedimentaries and continues under them for a long distance to the southeast. There is a fairly large mass of similar rock outcropping at the extreme southeastern end of Mineral Ridge, near the Pocatello and Vanderbilt Mines; but, this occurrence in the limy beds high above the bottom of the Dolomite was not studied in connection with this report.

Between Custer Gulch and New York Canyon the Alaskite occurs over large areas along the northeastern crest of Mineral Ridge. To the southwest it extends under the Dolomite beds which form the southwestern crest of the mountain. To the northeast it dips under the beds of the lower half of the Drinkwater Anticline. Between Custer Gulch and Elizabeth Gulch the Alaskite occupies greater width and rises higher geologically than it does between Elizabeth Gulch and New York Canyon.

To the northwest of New York Canyon and from the crest to the northeastern bottom of the mountain, the Alaskite is the dominant rock. Over it in places lie remnants and scabs of the Schist, but none of them are very thick. It also contains occasional remnants and strips of the Schist which although

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entirely engulfed show no great distortion, as are seen in Eagle Nest Canyon and at the Wedge Mine. In this northwestern country the Alaskite invaded very much higher than elsewhere, presumably due to it being an approach to the central longitudinal arch of the long anticline.

It has already been noted that down the flank under the sedimentaries between Custer Gulch and New York Canyon the top of the Alaskite seems to bow down with ridges of it invading higher in the longitudinal synclines. Thus, it has upward strike lobes.

The Alaskite also seems to have upward dip lobes. A pronounced one on the surface is that in Custer Gulch, where it occurs far down the dip, and with which is connected the considerable stoping in the southeastern end of the mine as well as the Lease Sill. Near the Lease-Black Mammoth boundary there also seems to be an upward protrusion down the dip in Elizabeth Gulch and to the northwest on the Mary Level, which may be connected in part with the high invasion in the nearby Wasson Syncline. On the Mary Level near the Flat Raise and extending as far northwest as the 339 Winze there is marked protrusion into the hanging. This extends up the dip through the mine and out on the surface through the large open pits above the D rinkwater workings to almost the crest of the mountain.

The upper surface of the Alaskite mass on the northeastern flank is entirely lacking in long clean contacts with the invaded sedimentaries. In general the first 200 feet above the main mass contains numerous sills of all dimensions. The sedimentaries in this border facies also vary largely in the thicknesses of their strips. Many of them are entirely cut off although remaining essentially in place with respect to other members. The absence of larg e distortion separate from the general folding is marked. As far as known now the interrelationships of the sedimentary members check in distances throughout the mine. This would lead one to believe that the sills did not push the beds apart on their entrance, but rather entered slowly and quietly, assimilating and replacing the beds which were formerly where the sills are now found. The long strip remnants which were completely embayed without distortion in the Wedge Mine and elsewhere have been referred to above. From all of this one gets the distinct impression that these and the thick border facies are evidence that a quiet and orderly stoping and assimilation was in effect over a very long time.

The interlayering of the Alaskite sills and the strips of sedimentaries in the thick border facies can be readily seen in the large open pits above the Drinkwater. There are many layers or sills of Alaskite, the uppermost of which is thick, which alternate with layers of Schist or Quartz.

The Lease Sill is also large and striking. At the southeastern end of the mine the Alaskite of Custer Gulch, near and above the Hill Tunnel, extends far to the northwest beneath the surface rocks. To the southeast of the 304 Stope it has eaten out the Mary Limestone, so that the first bed lying on top of it is about 60 feet above the top of the Mary Limestone. In and to the northwest of the 304 Stope a thin strip of the top of the Mary Limestone is present above the main body of Alaskite. In the hanging of this the Alaskite continues to the northwest as a thick sill, varying from 70 feet to 125 feet thick near the

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stope. The sill extends to the northwest beyond the 314 stope, where it cuts back to the main body of the Alaskite in the foot. It thus cuts off a very large and important block and strip of the Mary Limestone which extends upward to near the Elizabeth Level. The block of Mary Limestone between the main mass of Alaskite and the Lease Sill seems to be in place and to be relatively undistorted.

The hanging wall sill in the northwestern end of the Mammoth workings is also similarly striking and even more persistent. It lies from 120 feet to 200 feet to the hanging of the Mary Limestone, thus having a thickness of about 80 feet. It extends for long distances in strike to the northwest, and its dip extent is at least from the Winze Level to the surface, a distance of 1,000 feet. It is so large and regular that it either occurs as two sills or includes a regular strip of limy Schist, which should be of commercial importance.

The Alaskite

The bulk of the granitic rock in the district is locally and properly called Alaskite. It is a medium grained white rock. "The Alaskite consists almost wholly of quartz and feldspar, the species of the latter having been determined as orthoclase, microcline, and oligoclase-albite, with occasional muscovite, accessory zircon, and original pyrite." The silica content is high, about 76% as compared to about 72% for granite. The rock is essentially a binary granite, which is composed of quartz and feldspar in about the usual proportions of 1:2; but the other minerals of granite, which are generally dark colored, are essentially lacking. Macroscopically in the field the strikingly dominant minor mineral is muscovite, although some of this may have resulted from assimilation reactions. Another marked peculiarity is the relatively large proportion of microcline as compared to orthoclase. This is especially noteworthy in the pegmatitic phases. The texture is uniformly medium, approaching coarse grained. Variations in textures are associated with the sills, and with large contacts of the main mass.

The sills have essentially the same composition as the main mass, but they are generally finer grained. Especially in the cases of those with thicknesses of less than five feet they often become very fine grained. Since they have the proper composition and grain they would ordinarily be called granite aplites. The presumptions are that they were very mobile and active solutions, and because of their similarities the main mass also must have had the same qualities. Their mobility is often shown in zones more than 20 feet thick in the Schist which are ribboned with them in thicknesses measured in inches. Unlike ordinary aplites, which usually have a later age than the parent mass, none have been seen cutting the main mass of the Alaskite.

The other principal variant of the Alaskite is pegmatite. This rock is composed of quartz , feldspar which is principally microcline, and muscovite. The usual pegmatitic concentrations of these minerals in large crystals occur. The amount of microcline seems larger than the proportion present in the Alaskite, while the muscovite occurs in bunches and nests. Many concentrations of muscovite are no doubt due to assimilation reactions, and the unusual amounts of microcline may also be due in part to this. The microcline in both the pegmatites and the parent mass suggests, however, that it may be an indication of solutions of high internal mobility, which would accord with the idea of differentiation over a long time and under impervious capping rocks, as held by the writer for this district.

The pegmatite does not cut the main mass as dikes. It occurs in largest area and thickness on the upper surface of the main mass of Alaskite. This is seen in great perfection and over extensive areas in the ground which lies to the north-west of New York Canyon, where large surfaces of the upper contact of the Alaskite are exposed. It is also seen in the mines in many places and over long stretches of the contact. The pegmatitic upper surface of the Alaskite is often 30 feet thick.

The pegmatite is also seen underground in the Alaskite in places which are assumed to represent pre-Alaskite faults, such as the Foot Fault near the Corkscrew Raise, 305, on the Mary Level. They may also be associated with strips of assimilation where sedimentary rocks were engulfed. But these occurrences are believed by the writer not to be like ordinary pegmatite dikes, but rather to be local differentiations.

Origin

The Alaskite is an unusual relative in this consanguineous province where granitics and monzonitics are the ruling rocks. It must be related to granite in downward extent. Spurr even noted that Turner found a granitic phase in the lower Mary Tunnel. This may have originated from assimilation of other rock. In the southern part of the Silver Peak Quadrangle it is known that alaskitic rocks occur, but as aplites cutting the earlier granitics. Thus, in that locality they probably originated in depth by

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differentiation, and then came out after the granite had solidified and cracked.

At Mineral Ridge the deeper places in the canyons, such as in central Echo Canyon and in upper Custer Gulch, seem to show that the Alaskite is grading downward into muscovite granite. Therefore, it seems quite possible that there might be a downward gradation in the granitic rock at Mineral Ridge, about as follows: some 30 feet of pegmatitic top; then something more than 300 feet of Alaskite; below that an unknown thickness of muscovite granite; and in depth the more common muscovite-biotite-hornblende granite.

Such a possible extraordinary example of differentiation in place would be analogous to some of the facies tops that are known in New England. At Mineral Ridge it would have been made possible by the gentle structure, the very thick, impervious capping, the very long time necessary for its erosion; and by all of these providing sufficient time and lack of escape of mobile constituents so that differentiation could go to completion in place while the Mineral Ridge Anticline was being raised and invaded.

Such unusual circumstances seem also to be related to the immense amounts of mineralization at Mineral Ridge, which is many times greater than any other mineralization occurring under analogous circumstances in the province.

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From what has already preceded in the more general sections of this report it will be understood that in the cases of the batholiths and sub-batholiths of the province, in which Mineral Ridge is included, one should not expect to find sedimentary rocks preserved to any considerable depths, or to find them existing below the granitic rocks. In other words it is now believed that batholiths are bottomless.

Mineralization

The mineral deposits of Mineral Ridge are of great commercial importance and the associated geologic events occurring before and during deposition are also of great importance in the general geology. But, this great importance and interest warrants a separate and long discussion of them which will be found under Ore Deposits.

From the general remarks already made about the series of events between the Jurassic and the Eocene in the history of the Sierra Nevadan Province it will be seen that there are many details of interest which may be grouped in sequence and by causes. The invasion of the Alaskite took a long time which was followed by another long period during which the mass cooled and crystallized. While this was going on, the igneous mass in depth was differentiating still further with the formation of the mineralizing juices. At the same time enormous quantities of sediments were being eroded from the surface. Then, further small thrusting forces followed, which prepared certain favorable structural localities for the invasion and deposition of the solutions. Slightly thereafter the mineralization began to flow. It lodged in prepared places by replacing already brecciated rocks; and then cooled and

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crystallized. All of this took a very long time, as already indicated.

The Diorite

A great deal has already been said about the Diorite in the more general sections of this report. From this it will be understood that during the long time during which the mineralization was flowing, erosion was still active on the surface, while below in the depths of the igneous mass differentiation was still proceeding in step with some slow cooling. Because such a large volume of silicic fractions had already been formed from the parent mass, including the silicic granite, Alaskite, and Quartz, the tendency was to form more basic fractions, commonly called complementaries (with respect to silicic rocks) or lamprophyres. The Diorite was probably generated in this manner and because of such earlier events.

The so-called Diorite in Mineral Ridge was probably originally a camptonite, consisting essentially of large proportions of hornblende and small proportions of medium soda-lime feldspar. As now found it is a thoroughly altered rock of distinctly green color which contains large amounts of chlorite and epidote.

The Diorite occurs in large and small irregular masses and in large and small dikes and sills. The sills are commonly found at and near large strong contacts, such as (with Alaskite) the bottom of the Dolomite, and the top of the Alaskite. The dikes generally cross locally between masses and sills. The masses are often found in connection with areas of complex contacts and rapidly varying rocks, such as near the Foot Fault where there are dikes and sills of Alaskite and veins of mineralization. The rock is also not uncommonly in abundance near large masses of Quartz. It will be seen that the Diorite has a generally highly irregular distribution, and that it cannot always be found under the same circumstances.

Stresses to form cracks were necessary for the entry of the Diorite. It seems likely that these had some connection with the shrinkage of the large underlying mass of igneous rock as it cooled, and that they were tensive and not compressive stresses. The breaks evidently occurred only in places of extreme differences of resistance. With respect to ore, if ore should occur nearby, then the Diorite seems to indicate that important bodies are involved. But, the Diorite does not of itself indicate the presence of ore, and contrariwise very important ore bodies occur without the presence of nearby Diorite. So, the presence of the Diorite only indicates the presence of great differences in resistance to stresses and deductions from these should be made with great caution.

Events Between the Diorite and the Eocene

There is no evidence known to the writer for estimating the amount of sedimentary cover which remained at the time of the inflow of the Diorite, nor of estimating the amount of erosion that followed. Probably the Diorite flowed in during a comparatively short time while there were at least a few hundred feet more of sedimentaries than now.

It seems certain that at the beginning of the Tertiary, the Eocene, the surface of Mineral Ridge was nearly the same as now, although it may have been somewhat lower topographically. This is believed because the upper slopes and crest show remnants of the Tertiary volcanic series in scattered places. One such is near the Missouri, and another larger one is on the crest to the southwest of Great Gulch. Tertiary sedimentary and pyroclastic deposits are found also around the foot of Mineral Ridge. The sedimentaries are seen to the southwest, near Coyote Springs, and it is seen there that they underlie the mass of volcanics which form the present bulk of the southern extension of the Silver Peak Range at least as far south as the Nivloc Mine. No doubt the eroded surface of the Lower Paleozoic underlie them.

Post-Eocene Events

The neighborhood and the Silver Peak Range participated in many Post-Eocene events, although none of them are of much consequence in the mineral deposits of Mineral Ridge. Many volcanic and warping events were connected with the whole Tertiary. Probably the Miocene is represented at the Nivloc Mine by the volcanic series and the mineralization. It is probable that late block faulting in part elevated Mineral Ridge to its present topographic position with respect to the nearby desert basins. The actual fault traces have been since concealed by detritus.

It also seems likely that some of the northeasterly, normal, transverse faults occurred during the Tertiary, possibly at the time or slightly later than the Miocene mineralization. The barren chalcedonic quartz which carries oxides of manganese and iron almost certainly occurred at this time. In many places it was deposited in bed slips especially near the surface and in the hanging of the Lease Anticline. Some of the transverse faults, popularly known as Garreys, have calcite and quartz fillings which may have originated at the same general time. Some of the dioritic dikes even have such directions. The transverse faults have caused

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small displacements which give no great trouble in solution.

There are also many late slips which show no evidence of healing. They may be either parallel to bedding, especially when small strike flexures occur, called "rolls;" or tangential to the flanks of small flexures, either in strike or dip or both, when because of ENE strikes they are called "east-westers."

It seems unnecessary to detail completely the late history of the Ridge and its physiography, but certain late outstanding features may be noted. The ores are of such character that although they are somewhat oxidized within a few hundred feet of the surface, and especially if they occur in the zones in the Schist, they should not be expected to furnish any types of secondary enrichment, nor is such found other than very superficially. Another peculiar outstanding fact is that the district surprisingly shows no record of having had placer deposits. The gravels in the gulches are very thin, so that there is a possibility that early placer deposits were washed away and now lie beneath the nearby valley fills. Since the block raising there has been but little erosion of the ores.

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As a summary it may be said that the ore deposits in the Nevada Development and allied properties consist of high temperature, white quartz which carries gold as a principal commercial value in varying amounts which seem to average 0.30 oz. per ton. Certain beds in the sedimentary series, and they only, are now known to be favorable for the deposition of ores, including those in the uppermost 150 feet of the Schist, several in the lowermost 150 feet of the Schist, and those in the uppermost 100 feet of the Mary Limestone. Thus far the deposits have been found in great concentration in the upper central part of the area, in the old claims of the Pittsburg Silver Peak. The Nevada Development ground to the northwest is generally of little importance. But, the ground of both the Black Mammoth and the Nevada Development to the southeast is as yet untried, and should become important. The general structure was defined earlier, about contemporaneously with the invasion of the Alaskite core of the major Mineral Ridge Anticline. The mineralizing solutions resulted from a further differentiation of the deeper seated granitic rocks from which the Alaskite itself was derived originally. The ore bodies occur as replacement deposits of limy beds in phacolitic forms concavo-convex lenses, which resulted from pre-mineral brecciation at the intersections of strike and dip anticlinal flexures. These were caused by thrusts which were concentrated in places in the earlier and larger anticlinals. The more rigid beds were broken, the thin beds were self-healing, but the forces were too small to break the very rigid, nearby Alaskite bodies. Minor, post-mineral slips and faults resulted from the presence of the ore

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bodies, and they can be used as guides in detailed prospecting. The outlook for finding more ore both down the flank and laterally is reasonably good. The determination of the crossing of both strike and dip anticlinals, whether large or small is the best general guide to large scale prospecting.

Minerals of the Ore Stage

Throughout most of the district nearly all of the ore mineral, whether commercially valuable or not, is white, crystalline quartz, which has a milky and pearly cast. This quartz is said to be rich in liquid inclusions, and to contain in many places an unusual amount of primary muscovite. There are two other types of quartz which attract attention. That which is earlier than the mineralization is connected with pegmatitic segregations of the quartz in the Alaskite. This variety is generally vitreous and transparent. The other kind of quartz must be connected with later mineralization, probably the Tertiary. It usually occurs as healing matter in localities where late bed slips on the flanks of anticlines are likely to occur. On the surface it weathers to a white porcelainic appearance, and shows a bluish vitreous effect when fresh. In the mass it is distinguished by a vuggy aggregation, and the association of oxides of iron and manganese in small amounts, which were evidently derived from carbonates. The silica of the ore stage seems also to have partly replaced nearby rocks in some places, without producing a pure quartz. This material has a horny dead gray color which defines it.

Encased in the quartz of the ore stage is gold, which is the commercial mineral. The gold occurs largely free and in

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very fine particles. The larger particles are subject to panning, and thus furnish an index to the value of the ores. The occurrences which are not subject to panning are generally silicified limestones, which notwithstanding this may be valuable. Probably in such cases the gold is present in particles too fine to pan.

Silver is commonly present with the ore in amounts of about 40% of the gold by weight, so that it is of only minor commercial importance. The form in which the silver occurs is unknown in most of the occurrences; it may be alloyed in part with the gold, but more likely it is associated with the small quantities of galena and other sulphides. In some of the outlying mines of the district, such as the Black Warrior, Pocatello, and Vanderbilt, silver associated with copper minerals is believed to be due to a late mineralization, post-Diorite, in which some mineral like stetefeldite originally occurred.

A great deal is said in the district about "blue metal." This may have actually occurred in the early days in connection with some of the later outlying mineralization, and may be still more likely a term inherited from the Comstock. Nothing has been seen by the writer to suggest a mixture of complex silver minerals with a large associated gold content.

However, this term is applied to the segregations of fine grained sulphides which occur fairly commonly. In general they form about 1.5% of the ore. Fine grained galena is common. There is also considerable fine grained, brown sphalerite. Pyrite is also fairly common, but a great deal of it probably resulted from the action of the hot solutions on fragments of argillaceous wall rocks. It has been shown that the gold associated with the

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sulphides is also largely very fine and free.

In the upper parts of the mines the sulphides have been regarded as indicating high grade ore. But, in the lower parts, below the Savage and Elizabeth Levels, this will often not hold true. It may be that the sulphides are more persistent minerals, likely to separate first, and that they may mark the margins of ore shoots, and lenses. The association of values with them may have been accidental and not constant. This seems to apply with special force in the case of sphalerite.

The gold values vary greatly in their distribution. There are large masses of quartz which contain no values of importance. In many cases these are on the foot of some lenses and localities. But the values also vary erratically throughout the bodies. They are known to occur without any definite relationship whatever to the walls and ends of the lenses. Similarly, there are many separate quartz occurrences which have no commercial values. Thus there is no dependable guide to the exact localization of commercial ore either within quartz masses or between the various lenses of it. It seems likely that the gold values generally remained with the last fraction of quartz to crystallize, because there would have been a very high concentration of heat and mineralizers in such remainders. Reticulated seams, and very rarely vugs, with high values seem to substantiate this.

From the foregoing it will be seen that great variations in values may be found, from large masses of barren in certain places to small quantities of very high values in others. However, long experience with large tonnages has shown that in most of the occurrences, provided mining be reasonably careful and dilution not too great, the grade of production from necessary thicknesses can be held up to about 0.30 oz. gold per ton. In any later mention of ore with respect to bodies mined, or prospective and speculative ores yet to be found, such an average is in the mind of the writer.

The foregoing also relates to the well known principal occurrences near the Mary Mine. In the district as a whole, however, other minerals are known to occur in outlying places. At Great Gulch arseno-pyrite is found cutting both the usual quartz and the Alaskite. Around the borders of the district silver mineralization in connection with copper minerals has been found, as at Black Warrior, Pocatello, and Vanderbilt. The mineral may be related to stetefeldite and other complex sulphides. It seems likely to be later than the Diorite, and therefore may be Tertiary in age.

Distribution in Rocks and Horizons.

Within the column of sedimentary rocks the ores have been found in certain horizons. The top of the Mary Limestone, and including the limy Schist immediately overlying, is an especially favorable place. The ore is also likely to be found below the top of the Mary Limestone at distances of about 50 feet and 100 feet.

The lowermost 150 feet of the Schist is a transition zone from the Mary Limestone to the main body of the Schist which is likely to contain limy zones which are not necessarily individually continuous throughout the district. But, they seem most likely to occur at distances above the top of the

Mary Limestone of 20 feet, 40 feet, 60 feet, 80 feet, and 120 feet. Probably there are some still higher, up to 150 feet, but they are not yet well known. Between 150 feet and 400 feet above the Mary Limestone, the central part of the Schist, it is unlikely that limy bodies containing ore occur.

Similarly, the uppermost 150 feet of the Schist is a transition zone between the Schist and the Dolomite which is likely to contain limy beds and associated ores. Such mineralization generally occurred in places where the Alaskite had invaded nearly as high in the column and where lower favorable beds had been eliminated. Such circumstances are known in only restricted localities, such as between Elizabeth Gulch and the Vega. These occurrences are complex and often near the Foot Fault, so that similar details as to the exact spacing of the beds are not known. However, the same general relationships apply.

No gold quartz mineralization has been found yet in the Dolomite. However, the possibility should be kept in mind for the future.

The Alaskite generally does not contain ore. Like the Dolomite it may have been too rigid and lacking in varying competency to form pre-mineral cracks or breccias. Occasional small veinlets of ore quartz are seen penetrating it for only short distances. However, where mineralized Schist zones are also ribboned with Alaskite it is difficult to say whether or not some of the values are also in the ribbons. At Great Gulch, Spurr has shown that the late arsenopyrite definitely cuts the Alaskite.

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It has already been shown that the Diorite is later than the gold quartz mineralization.

Spurr's sampling showed that the limy Schist and the Alaskite by themselves contained no values of importance.

Areal Distribution

Part of the holdings of Nevada Development extends as a wide block as far as 8,000 feet to the northwest of New York Canyon. In general this large area of some 50 claims of 1,000 acres is occupied by the unfavorable Alaskite core which has invaded higher in this neighborhood. Quartz of the ore stage was seen in small amount in a few localities, such as: the southwestern central part of Royal No. 8; the central part of Golden Queen No. 1; the eastern part of the boundary between Golden Queen No. 4 and No. 6; and the western part of the boundary between Golden Queen No. 4 and No. 2. As in the case of the unsuccessful prospecting which was done in Eagle Nest Canyon, these occurrences are connected with thin remnants of Schist. They do not appear to have much promise. But, before any abandonment it would be wise to recheck them by further sampling and some minor prospecting.

To the southeast of Custer Gulch there is an area of claims about nine wide by five long, (?) about 5,400 feet by 7,500 feet, about 900 acres, which should be of great prospective importance. About nineteen of the central northwestern claims belong to Black Mammoth, the balance to Nevada Development. The area is known to be mineralized on the northwestern and southeastern ends, respectively at Canyon Crest, Laddie No. 3, and Vega; and at the Great Gulch and Terminal of Calumet, and the

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Clipper of Nevada Development. As will be seen later the structure in this area should lead to selected prospecting.

The southwestern part of the area between Custer Gulch and New York Canyon is by all odds the most important area in the district. This is covered by the upper part of the old claims of the Pittsburg Silver Peak, about 6,000 feet long by 1,500 feet, about 200 acres. In this area the most prolific mineralization has centered in the neighborhood of the Drinkwater workings. It has extended as far southeast as Elizabeth Gulch, but this part has been fairly completely mined out down as far as the Mary Level, below which the outlook is poor because of the Wasson Syncline. To the northwest and above the Drinkwater the occurrences have been considerably mined in part; but below there and to the northwest as far as New York Canyon there are large areas to be prospected which may yield large tonnages.

Prior to 1936 mining in the upper part of the Lease ground had been restricted to work on the Soldier beds, near their outcrops on the foot wall side of the Foot Fault and within 150 feet below the bottom of the Dolomite. This had extended to only shallow depths along the Western Soldier, April, and Last Chance. The northwestern end of this extended down the southeastern wall of Elizabeth Gulch to the portal of the Lower Elizabeth Tunnel. Since then the Lower Elizabeth has been driven a long distance to the southeast. Considerable tonnages have been extracted from the complex occurrences which are related to both the Foot Fault as a feeding zone and to the Soldier beds. Because of the complexities in this locality related to the invasion of the Alaskite and the distortion of the beds near the Foot Fault, the areas yielding ore nearby are not cleancut with

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respect to the Wasson Syncline. The tonnage obtained from this work has been about 48,000 with a grade slightly greater than 0.26 oz. gold per ton.

Prior to 1936 only small tonnages had been extracted below the Elizabeth. These had come largely from near the elevation of the Mary Tunnel and between the main crosscut and the 314 Stope. Since then the tunnel has been extended far to the southeast with attendant prospecting. This and other work near the Mary Level has disclosed bodies which have yielded a tonnage of about 94, 000 with an average grade of but slightly less than 0.33 oz. gold per ton. Of this about 58,000 tons running about 0.347 oz. gold per ton have come from one body at the top of the Mary Limestone. Another body at about 60 feet above the top of the Mary Limestone has yielded about 24,000 tons running about 0.30 oz. gold per ton. These two bodies have a close connection with the major strike structure known as the Lease Anticline. This disclosure of ore bodies of such large importance in the Lease Anticline is interpreted as arguing in favor of a large future for the properties and the district which should be disclosed by suitable prospecting. Further, as in the case of the Lease Anticline discoveries, it should be noted that all ore occurrences down the dip in favorable structures below the Drinkwater Anticline will be "blind."

From the foregoing it will be seen that the central area of the upper northeastern flank near the Mary Mine shows mineralization over a length of some 6,000 feet. Within the sedimentary column the ultimate known thickness in which beds can occur mineralized at the bottom is nearly 200 feet. This forms the long zones in which ore lenses can occur as mentioned by Spurr.

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A general consideration of the district between Custer Gulch and New York Canyon with respect both to length of mineralization and to the distribution of it in horizons shows that it is unusually heavily mineralized. Thus, it is not illogical to expect that additional important commercial tonnages will be found "blind" in favorable structures as has already occurred in the Lease Anticline.

<u>General Form and Pre-Mineral Structures</u>

The general structures, both anticlinal and synclinal, and both along strike and down dip, which exist on the northeastern flank of the major mountain and anticline called Mineral Ridge have already been described. It has also been noted that they were formed about contemporaneously with the upward invasion of the regional granitic rock. It was also pointed out that the minor buckles on the flanks of the anticlines were invaded by Alaskite in the form of phacoliths, or anticlinal bodies in the form of lenses which are concavo-convex outward. It should be assumed that all weaknesses then existing were healed by the very mobile Alaskite. So, still later stresses were necessary to form openings which would be post-Alaskitic and pre-mineral.

In general, the juices which deposited the ores had to travel through openings, which might have been minute if they were only to serve as feeders over a long time. In the places where they deposited the bulk of their load they had to have either large openings or considerable masses of brecciated rock which they could replace. It is difficult to see, in a sphere of ground in complete equilibrium, how large openings could be formed unless juices were ready to enter and completely to fill and to keep them open under the same conditions of pressure. If

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such had been the case the openings could have occured in many places without localization in certain beds. In fact the thin-bedded central Schist would have been more susceptible than other rocks. Such would also have been the case if any forcible "injection" had taken place. But, the district shows distinctly that the central fissile beds of the Schist are not mineralized. On the contrary, where the Schist was involved, the mineralization was restricted to the limy horizons within its upper and lower transition zones. Furthermore, it is easy to see that the deposition took place in the limy beds of the Schist and in selected beds in the Mary Limestone. There is no evidence to show that the bodies are in prior lenticular openings, because there are no forms to show the doubly convex openings which would have been mechanically necessary.

Since the other possibility seems impossible one must assume that the ore deposited in brecciated masses by replacement. To such an end the limy layers are especially suitable. Those lying between thin, fissile shaly layers would be more competent or more rigid. With even small flexing stresses applied to such an assembly, the fissile layers would begin to glide and would tend to become self healing. This would transmit increased stress on the more rigid limy layer, which would finally brecciate. The breccia might be very coarse and the dividing cracks might be minute, but with the lapse of time the rock so prepared would be replaced by some of the ingredients of the hot mineralizing solutions. It is well known that limy rocks lend themselves well to such a purpose. In fact in the district the remnants of rock which are seen within the quartz seem to have resulted from less easily digestible argillaceous portions. The digestion of the limestone would change the chemical equilibrium of the mineralizing solution causing it to leave behind some of its ingredients, mineralizers with silica and gold, and causing it to continue to flow farther away with the lime contained in another fraction of the solution. In this process long times, slow reactions, and slow minute flows were involved.

No doubt the selected layers in the Mary Limestone underwent a similar process due to differences in the thickness of bedding of adjoining members. This has been observed by the writer in many districts, where only slight differences in bedding and competency have been necessary for the formation of large ore bodies.

In general the bodies of nearby Alaskite may have assisted in the pre-mineral brecciation. None of them of any considerable thickness are found with more than small veins of the gold bearing quartz. Therefore, they were too rigid to have broken. This indicates that the stresses were relatively small and that the various bodies of Alaskite probably acted as rigid buttresses to concentrate the stresses in the brecciation of nearby or adjacent more crumbly limy beds.

There is a general parallelism between the Alaskite sills and the ore bodies. It may be found that some of the more important limy beds were replaced earlier by some of the Alaskite bodies. This is particularly suggested by a tendency to have a hanging wall sill where a 120 foot bed should occur in the Schist. But, the ore bodies are much smaller and show more complicated details of occurrence.

Some of the generalities are shown in the Drinkwater Anticline in the Black Mammoth ground, as shown on Cross Section No.48.

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It will be noted that the anticline itself is a large, general, gently curving structure which contains a similar hanging wall sill of Alaskite. Within the anticline the ore beds show many minor anticlinal sub-curves between which are found unmineralized rock. This applies equally well in plan. Thus, the shoots are related to later, minor anticlinals within the flank of the Drinkwater Anticline, just as it is a subsidiary feature of the flank of Mineral Ridge.

Prior to mineralization the general structure of the Mineral Ridge Anticline had been defined, including its flank sub-structures of strike and dip anticlines, and its core and satellitic bodies of Alaskite. As already stated there still remained considerable cover of sediments, perhaps as much as 10,000 feet. Small additional stresses followed. These were in the form of tangential thrusts which would be concentrated naturally at the already existing anticlinal structures which functioned as protrusions or buttresses. But, since the forces were small and the cover much less they did not cause large sweeping changes, but concentrated on many minor points within the larger structures with the formation of phacolitic, lenticular bodies of breccia in the more rigid beds. The mineralizing solutions were freed about the same time and in response to the same forces, and then seeped upward over a long period of time.

The bodies are greatest and best where the changes of curvature are at a maximum. This is a mechanical effect of greater crushing at greater flexure. Experienced men in the district state that when following ore upward on relatively steep beds it should improve in quantity and quality when flatter beds are reached.

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Details of Form and Structure

From the preceding it follows that in a larger structure like the Drinkwater Anticline one would expect to find a smaller, analogous repetition of anticlinal strike and dip axes. The crossings of these should be important places for the deposition of ore. This is believed shown, especially to the northwest of the Flat Raise by the pattern of disposition of known stopes. Their centers seem to lie near certain lines of elevations, corresponding to anticlinal strike axes; and they align down the dip as though on common dip axes. A few cheap trials and observations should show soon whether this idea can be applied in finding additional bodies of ore, either by finding mineralization of additional beds in the column, above or below known stopes; or finding bodies on intersections which have not yet been prospected.

The phacolitic form of the bodies both in strike and dip can be seen clearly in a number of places. This form is that of a spherical converging concavo-convex, or converging meniscus, lense. Both convexities are outward from the center of the mountain. The most striking place is on the southeastern end of the Savage Level; but it has also been seen in many other less accessible places. Spurr stated in effect that he could not find any crushing as evidence of post-mineral forces which could have caused the curved forms of the lenses.

Spurr referred to overlapping lenses, but some of these may have been due to mineralization of different limy beds. He also noted that the lenses pinched very rapidly near their limits.

Within the bodies the disposition of the quartz is often complex. Not all of the mass is solid quartz. There are splits in the quartz where certain strips of country rock, often argillaceous, were either not brecciated in advance or were not susceptible to replacement. Quartz stringers can be seen uniting to form larger bodies. Blocks of shaly material will be found with only low values, even in the centers of large bodies. Such extreme conditions occur most often in the bodies occurring in the Schist. This was exemplified recently in the case of the "379" Stope area of the Lease, where the ore occurs on the 60-foot bed. Notwithstanding such complexity the mining was comparatively easy, the tonnage high, and the values as mined better than average. Such things are also found to lesser degree in the bodies in limestone, such as the "340" at the top of the Mary Limestone in the Lease. Blocks of low grade quartz and of bands of limestone varying in silicification and values were encountered, but the body yielded a very good tonnage of fairly rich ore.

Thin sills of Alaskite in or near the bodies seem to be more favorable than otherwise. They may have assisted in a more complete brecciation, especially if the body is in a zone where shaly material predominates over limy.

It has already been noted that the gold values vary from place to place in the same body of quartz, this probably being due to segregation during cooling and crystallizing. Similarly, separate lenses may have somewhat different gold values. As exemplified near the northwestern crest of the Drinkwater Anticline, it is known that the extremely large bodies of quartz have much smaller gold values than those of average size.

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The effect of structural variations is best shown in the unusual example in the Lease of the important 340-304-394 Stope. This may have contained as many as three strike flexures. Because of the nearby turning of the flank of the main structure of the Lease Anticline by the cessation of the Wasson Syncline and by the nearby invasion of the Alaskite lobe in Custer Gulch, the dip "crumples" have pitches that are easterly instead of northeasterly. This combination has caused the length of the body to pitch down northerly, instead of showing a relatively long center line, or three of them, with a NNW direction.

Post-Mineral Structures Related to Ore Bodies

Certain of the minor structures are readily determined to be post-mineral. None of them are known to be folds of any large magnitude. The earliest of the post-mineral openings were those which acted as channels for the Diorite which has already been discussed. Generally they did not have movements which made the complex geology any more confusing, having been confined to strong existing contacts as noted above. Among the exceptions are those having ENE strikes which show on the Elizabeth Level near Section No. 22 and farther in near Raise 309. These appear to displace the Foot Fault considerably, but in the case of the former this may be due to a nearby and later fault.

The fault is strong and persistent and should be called the Chiatovich Fault. On the surface it is shown by a considerable outcrop of that quartz which is considered to be Tertiary and measured along it by a left-handed horizontal displacement of the Foot Fault of about 120 feet. The lines of stopes on the Lower Elizabeth indicate 160 feet, and the displacement may be slightly greater on the "B" Level. The general strike varies some several

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degrees both sides of west and the dip is medium to the north. The fault marks the northern end of the Chiatovich Stope and separates it from the 314 Stope farther down on the Mary Level. If it has not broken through their common crest of dip anticlinal flexure it lies along the northwestern flank of a still smaller one belonging to the Chiatovich. It is also said to mark the northwesterly end of the bottom of the 340-T Stope as it is now known. To the northwest of this on the "B" Level the extension of the Mary Limestone and the ore seems now to be gone, but it might be well later to drill a long hole into the Alaskite to prove beyond doubt that it is not hidden because of a still greater displacement there. No Diorite is known definitely along this fault, although it is nearby on the Lower Elizabeth Level. The filling of Tertiary quartz gives some idea of its age. On account of its direction and size of displacement it may be assumed to be earlier than the Garreys. It may have been caused by the southeastern side of a dip lobe of the Alaskite.

The Garrey Faults were named for George H. Garrey, who made a study of the property about 1915. The name is applied to all breaks with a NNE direction; these are transverse to most of the major structures and ore bodies. The so-called Calumet faults are not greatly different. Both may have steep dips in either direction, and the bulk of them have caused only small normal displacements . Striking large ones exist along Wasson Gulch and near the Flat Raise, in and near Savage Gulch, between the 304 and 379 ore bodies (on the surface in Mary Gulch,) and on the surface between the April and Last Chance. Some of them have been definitely healed by solutions which deposited small amounts of quartz and carbonates, and which were probably late

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in age following the Tertiary mineralization. Many others may be found open. The Garreys are usually concentrated where there are extreme differences in resistance, such as on or near the flanks of dip lobes of Alaskite, as near the Flat Raise and in the 304-379 separation. Both of these seem to show no great displacement. They are also likely to occur near the ends of ore bodies and concentrated in spaces separating them along the strike. Thus they can become an effect which can be used with caution in guessing at the localization of ore bodies.

There are many varieties of late bed slips which probably have only very little movement, but which are so apparent as to cause much comment. They are analogous to the post-mineral walls of veins. One group are the "rolls" which are usually related to the hanging of the ore bodies, but occurring on the southeastern end of the lenses where they bend back to the SSE and S. The similar slips on the other ends are known as "east-westers," such bed slips occurring where the flank is made by swinging slightly to the west. Thus as pointed out by the local assistant, Mr. L. K. Wilson, in passing from one ore lense to another in a southeasterly direction, rolls will be first encountered, then a zone of varying Garreys, and then "east-westers." Attention has possibly been concentrated more on minor bed slips because they are more prolific and attention has been more acute when ore was found dying out.

From the foregoing it will be understood that the late faults and slips may not be large in displacements, but that they are often of great local economic importance in solving continuances of ore bodies.

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General

Cross sections, especially those of scale as large as 1" ::50' such as are kept at the mines, show many of the generalities and irregularities very clearly. With this report are included six of them on scale 1" :: 200', and extended far down the flank of the mountain to show future outlooks.

Section 15. Like the others this is a vertical plane with bearing of N 45 E. To the southeast of it the outlook is not very promising, but there is a possibility that another anticlinal strike flexure may be found by diamond drilling from the surface, and by southeasterly extension of the 379-A drift from the productive center and elevation of the 379 area. This section shows some of the generalities in the 379 Area, including the disposition of the beds and the restoration of the top of the Mary Limestone which has been eliminated by the Alaskite. The Wasson Syncline does not exist this far to the southeast, but the quartz and faults on the surface may be related to bedding plane slips on flexures connected with its origin. The tendency for a thick sill of Alaskite in the hanging is shown. The Foot Fault is shown, and its approximate dip slip as measured from a restoration of the bottom of the Dolomite. The Soldier beds which lie below the Dolomite and which are mineralized in the April and Last Chance (to the southeast) are shown.

If Section 18 were presented it would show that the Wasson Syncline begins near there and that the top of the Mary Limestone exists in conjunction with the important 304 Stope.

Section 21 This shows similar general facts regarding the beds, the Alaskite, the Foot Fault, and the Hanging Fault with its quartz on the surface. The restoration of the bottom of the Dolomite may be considered fairly dependable in this section, as it is easy to check it both from exposures and distances in known parts of the column. It will be noted that the results of diamond drilling show the sequence of the beds and the Alaskite irregularities in the hanging. The stoping of the northeastern flank of the Dump Syncline is well shown on this section. The possibility of a small anticlinal sub-flexure in the center of the Dump Syncline is also shown; this might become productive later and should be kept in mind.

If Section 23 were presented it would show the Chiatovich Fault where it passes along the northern end of that stope and near the flank of that sub-flexure.

Section 26 This section shows the restored top of the Mary Limestone and the bottom of the Dolomite. The hanging wall sill of Alaskite is shown. The beds in and above the top of the Mary Limestone are shown in the results of D. D. Hole No. 58. The high invasion of the Dump Syncline by the Alaskite is also shown.

Thence to Section 30 the generalities do not change much. The exception is that the swing of the Mary Tunnel to the west puts it through the downward pitch of the Wasson Syncline which has been heavily invaded by Alaskite. The prospecting of the Lease Anticline in this region is now under way by diamond drilling from the surface and by the northwesterly extension of the "B" Level, also known as "260."

Between Sections No. 30 and 36 many beds have been eliminated by the Alaskite. This has probably happened both

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in connection with the invasion of the Wasson Syncline and also by a dip lobe of the Alaskite.

<u>Section 36</u> This section shows the considerable invasion of the Drinkwater Anticline in the southeastern end of the Mammoth ground, probably due to the northwestern side of the dip lobe of Alaskite near Elizabeth Gulch. The Savage stope may not be more than 40 feet above the top of the Mary Limestone, which probably does not exist below the Intermediate Level. The general indications near here are that three ore beds were stoped, and this becomes more definite to the northwest. But, this part of the mine is but little known to the writer, and many critical places are no doubt now inaccessible. The section shows the high invasion of the Wasson Syncline. It also shows the possibility of the existence of favorable beds in the Lease Anticline; and that they could be reached by deep diamond drilling of about 300 feet from a point about 400 feet to the northeast of the portal of the Savage Crosscut.

<u>Section 48</u> The writer is fairly familiar with the workings which lie near this section and to the northwest of it, and which lie at and below the Intermediate Level. This block of ground is now being prospected, by the application of ideas which will appear later, and it is hoped that they will prove fruitful not only in the block indicated but also at higher elevations. This section is in the Calumet country and somewhat to the southeast of the 339 Winze. The general block lies to the northwest of the dip lobe of Alaskite which divides the Black Mammoth ground into two parts, such division generally passing near the Flat Raise and the Drinkwater-Shovel pits.

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Section 48 is best known between the Wasson and Winze Levels, and shows the details of the accentuated ore flexure in the Calumet workings. The section is also along the anticlinal dip flexure. Roughly indicated is the large important strike flexure which begins slightly above the Wasson Level and extends to some little distance above the Drinkwater Level. It may prove that in this locality the top of the Mary Limestone has been eliminated above the Drinkwater, but it is likely to have been left farther to the northwest. Other horizons should supplant it as host rocks for ores. The existence of the persistent sill in the hanging is shown. The section shows the negative importance of the high invasion of the Wasson Syncline by the Alaskite. It shows further the possibility of the existence of beds favorable for ore deposition in the Lease Anticline and in the Dump Sub-Anticline.

Section 53 This section shows some of the generalities which corroborate those already noted. Only little is definitely known in this country, and considerable more work in detail should be done.

Genetic Theories

Prolonged discussions and descriptions of stages of mineralization other than the gold quartz have been purposely omitted. The following concise remarks as to origin will be similarly limited.

The analogy between the differentiation which formed the Alaskite and that which formed the mineralization is very striking. Likewise, there is close similarity between the pegmatitic end products of the Alaskite and the gold quartz.

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The Alaskite shows after the first generation of feldspar a reheating and increase in mineralizers as shown by the muscovite and microcline; the quartz shows a segregation of values and the presence of muscovite, which indicates the presence of similar mineralizers. There is nothing to show that the general ranges of temperatures and pressures during consolidation were greatly different. The muscovite indicates the presence of fluorine, the calcite the presence of carbon dioxide and water, the pyrite the presence of hydrogen, water, and sulphur among the mineralizers when these primary minerals were formed in the Alaskite. No doubt the same were present when the highly siliceous solutions which were to result in the gold quartz were active.

But none of this proves that the two things were contemporaneous. Spurr believed that the pegmatitic rocks had ends and margins that were truly gold quartz, but the writer has seen acres and miles of such rocks in the district without once being able to detect such a transition. Spurr also mentions an invariable presence of feldspar in the gold quartz, and the sidewise grading of gold quartz into pegmatite, but the idea must have been a misconception based on the use of candle light in underground work. It is true that the two occur close together, and that they may be confused on casual inspection, but to the writer's knowledge no close examination has ever shown identity.

The writer believes that the ideas he has expressed herein regarding the differentiation of the molten rocks and the derivation of the mineralizing solutions will square with all modern ideas and tests of physical-chemistry. ~~These ideas~~

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These ideas and tests have been becoming rapidly clearer with the progress of work by men like J. H. L. Vogt, P. Niggli, and the workers and experimenters in Washington for both the U. S. G. S. , and the Carnegie Institution, such as A. L. Day, E. S. Shepherd, O. Anderson, and especially N. L. Bowen.

The material for the mineralization was derived from a further deep differentiation of the underlying igneous rock mass while the Alaskite was in place above. The mineralization did not come up until the upper portions of the Alaskite had solidified.

The ore bodies were definitely formed by replacement of limy beds in favorable structures. As in the other questions referred to above, the writer made a complete examination of all the criteria necessary for any one of the results. The bodies cannot have resulted from "injection." As to "continuity," no other district could have been picked which would have disproved it so easily.

The formation of the ore bodies by replacement involved slow seepage, slow reactions, and long times. The channels by which the solutions entered from below cannot be definitely identified; neither can the channels which carried off the limy products resulting from the exchange. Both need have been only minute.

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Guides for Prospecting

To ensure its future the district is in urgent need of prospecting. This applies to the Black Mammoth ground laterally to the northwest, to the Black Mammoth down the dip in new structures, to the Lease laterally on the Lease Anticline and down the dip on additional new structures, and to the Nevada Development in entirely new projects.

In the order of importance and priority the critical things to be established in the search for new ores are:

1. the existence of crossings of important strike and dip anticlinal flexures, in the cases of both large and small structures;

2. the probing and penetration within such structures of all the existent beds and horizons which are known or suspected to be favorable for ore deposits;

3. the development and following of structural patterns and indications in any attempts to go from one body to another, whether along the strike or down the dip--it goes almost without saying that one should be constantly on the alert for irregularities in structure, such as those which are due to lobes of Alaskite, and those near the upper border of the Alaskite which may cause ores to exist in remnants, xenoliths, and roof pendants;

4. a clear but empty head, ready to see and record facts and keep them free from interpretations, skeptical as to all theories including all these above, and ready to try new ideas without being oversold on them so that they may be discarded quickly and economically when disproven.

Persistence down the Flank

Persistency of the ore deposits is obviously necessary to make a large, dependable mining property of long life, so that this matter is always open to question and criticism.

Four adverse factors are known to the writer:

First, there must have been a limit to the amount of mineralizing material, and no one can foretell how much it was and how many favorable structures and bodies it might have supplied.

Second, no one can foretell changes in gold content, which may diminish down the flank because of upward migration of mineralizers and gold during the long time involved in mineralization.

Third, in passing down the flank one should pass the lowest place where there was any considerable concentration of the channels up which the mineralization came, and this cannot be foretold.

Fourth, one should expect in proceeding down the flank that the favorable structures would become fewer, broader and less acute, and therefore less favorable.

In favor of considerable persistence down the flank are: the large and intense mineralization already known to exist; and, the actual finding of ores in the Lease Anticline in the next anticlinal structure below the formerly exclusive Drinkwater Anticline. Outwardly the structures down the flank seem favorable at least as far as the northeastern side of the Mill Anticline.

From all this it will be obvious that the large future of the properties and the district will depend on prospecting by diamond drilling and/or shaft sinking in the best places that can humanly be picked. Later on it might be found feasible to use some geo-physical method of prospecting as a preliminary. The method chosen would probably have to depend on a determination of relative rigidity of quartz because it is doubtful if any of the electrical methods would give dependable results.

S P E C U L A T I V E   O U T L O O K S

In this section of the report an attempt is made to formulate a tangible statement of the general future outlook for ore supplies in the Nevada Development and associated properties. It is important to note that in general the estimates are entirely of a speculative nature. This is necessarily so because of the nature of the case, the lack of exposures and the need of presenting a scheme for consideration and work plans.

It is important now to have a clear idea of the limitations of precision involved in such an estimate. The only reason for making it is that the owners have much at stake, much remains to be done in the future to prolong the ore supplies, and they naturally wish to know the risk in the gamble of searching for more ore. This is naturally very great. This should not be considered an estimate in any sense of that term. In developed mines, engineers commonly use terms that are understood to express the degree of precision and the percentage of probability between the classes of blocked or partially blocked ore as follows:

"Positive" ore, being that which is blocked on four sides, gold ores being subject to considerable adverse suspicion in the centers because of the general tricky character of the mineralizations;

"Probable" ore, that which is blocked on three sides;

"Possible" ore, that which is blocked on two sides, or on one side with greatly restricted presumptions as to extension from known workings. Instead of applying "possible" to ore extending from one side, others use the term:

"Prospective" ore, to indicate an exposure of only one side, but permit the limits of the block to extend farther than if they had used the term "possible."

It is obvious that in even the apparently certain cases the estimate cannot be made mechanically, because the degree of variation in the mineralization will naturally cause a degree of independability in tonnage and grade. So, geologic knowledge of the mineralization must always be applied.

In this evaluation, however, there is a paucity of the usual data, so that it might be called equally well a conjecture, or a surmise, or a suspicion, or a guess, all of which indicate an opinion formed without sufficient evidence. However, the writer likes the term "speculative" ore, as this infers a theorizing from conjectures without sufficient evidence, and also has a colloquial meaning which indicates the great chances that are taken in making and considering it. But, the conjectures may be of some assistance, if not taken too seriously, in formulating ideas as to the relative strength of areas potential for ore, and in planning preliminary diamond drilling and prospecting. The results of the latter should be progressively used to correct the speculations, and thus to render them progressively more useful and certain. They will thus provide a skeletal form for organizing work and recording it, and for formulating additional guesses as to the separate and total potentialities of the properties.

From what has preceded under ORE DEPOSITS it will be seen that the writer believes that deposition of the gold bearing, high temperature white quartz has taken place in favorable structures which are at the intersection of strike and dip anticlinals. This formulation is based upon that belief which might be disproved to greater or lesser degree by the progress of the recommended pro_specting. It was also pointed out that ore deposition in sub-structures farther down the flank of the Mineral Ridge Anticline might be affected adversely by a progressive diminution of the accentuation of them, by a bottom limit to the amount of mineralizing material, by a decrease in gold value, and by passing below the main zone of feeders. These unknowns are factors in the uncertainty of the speculation.

This is followed by a fairly complete list of flexure intersections, which are shown on the district maps. It is believed that phacolitic, pre-mineral breccias which have been replaced by ore should exist at these places. The approximate locations of them with reference to claims have also been given. A number has been assigned to each; and it will be noted that the first fourteen had already been assigned to some for the purpose of starting the diamond drilling campaign. An attempt has also been made to assign a letter of estimated quality. This relates principally to the probability of the intersection existing in view of actual knowledge. The scale ranges from AA and A to F. A column headed Method gives some idea of how the speculation may be studied for resolution. It seems obvious to suppose that within certain practicable areas it would be well to drill the objectives in the order of their quality unless later more detailed field work and the results of drilling should change their order.

No.	Strike Flexure	Dip Flexure	Location	Quality	Method
15	Drinkwater	A	NW Mammoth Mine	AA	Mining
16	"	B1	Mammoth-Savage	AA	"
17	"	B2	NW Lease	A	"
18	"	B3	SE Lease	A	"
19	"	C	Last Chance	B	"
20	"	E	Custer Gulch & Vega	F	????? To Mine?
9	"	F	Laddie No.3	B	To Drill
5	S. Lease	A	Mantos No.5	B	To Drill
21	S. Lease	B1	NW Mohawk No.2	B	Drill Later
1	S. Lease	B2	Mary-Mohawk No.2	B	Now Drilling
22	S. Lease	B3	"260"	B	Mining
23	S. Lease	C	Lease	A	Mined? Nearby drilling of"213" and"379-A"Areas
24	N.Lease	B1	Mantos No.2	B	Drill later
25	N.Lease	B3	Mohawk No.2&No.1	C	
7	N.Lease	E	Canyon Crest-Gold Run No.5-Laddie No.1	B	To Drill
6	Dump Sub-Anti	A	Mantos No.7	C	To Drill
26	Dump Sub-Anti	B1	Mantos No.2	B	Drill later
14	Dump Sub-Anti	B3	Mohawk-Mohawk No.2-Mohawk No.1	C	To Drill
27	Dump Sub-Anti	C	Mohawk No.1-Mohawk No.3-Gold Run No.1	D	Drill later
28	S. Mill	A	Mantos No.8	C	" "
29	S. Mill	B1	Mantos No.2-Mantos No.1	B	" "
3	Central Mill	B2	Mantos No.1	C	To Drill

No.	Strike Flexure	Dip Flexure	Location	Quality	Method
2	S. Mill	B3	Mohawk	B	Now Drilling
30	S. Mill	C	Gold Run Nos.15&13	D	Drill later
8	S.Mill & Dump Sub-Anti	E	Gold Run No.5	C	To Drill
10	S.Mill-N.Mill	F	Laddie No.1	B	To Drill
31	N. Mill	A	Mantos No.10	D	Drill later
32	N. Mill	B1	Mantos No.2 - Mohawk No.4	C	Drill later
4	N. Mill	B2	Mohawk No.4	C	To Drill
33	N. Mill	B3	Mohawk No.4	D	Drill later
34	N. Mill	C	Gold Run Nos.15&14	E	??????
35	N. Mill	E	Gold Run No.4	C	Drill later
36	S.Garbage	B3	Gold Coin No.1	E	??????
37	S. Garbage	C	Gold Coin No.1	D	Drill later
38	S. Garbage	D	Gold Run Nos.14&13	E	??????
39	S. Garbage	E	Gold Run No.2	D	Drill Later
40	S. Garbage	F	Gold Run No.4	C	Drill Later
41	S. Garbage	G & K	Gold Run No.16	B	Drill Later
42	N. Garbage	C	Gold Coin Nos.3&4	E	??????
43	N. Garbage	D	Gold Run No.14	F	??????
44	N. Garbage	E	Gold Run No.7	E	??????
45	N. Garbage	F	Gold Run Nos.2&6	D	Drill later
46	N. Garbage	G	Gold Run No.8	C	Drill later
47	N. Garbage	K	Gold Run No.10	D	Drill later
48	N. Garbage	H & L	Scepter Nos.5&7	C	Drill later
49	N. Garbage	M & I	Scepter NO.7- Arum No.26	C	Drill later

No.	Strike Flexure	Dip Flexure	Location	Quality	Method
50	Great Gulch	D	Gold Coin No.4	F	??????
51	Great Gulch	E	Gold Coin Nos.7&5	E	??????
52	Great Gulch	F	Gold Run No.12	D	Drill later
53	Great Gulch	G	Gold Run Nos.12&8	D	Drill later
54	Great Gulch	H	Gold Coin No.11-Scepter No.1	D	Drill later
11	Great Gulch	I & K	Scepter No. 1	B	To Drill
12	Great Gulch	L	Great Gulch(foreign) (Calumet)	C	To Drill
55	Great Gulch	M	Great Gulch-Terminal (foreign)-Scepter No.6	D	Drill later
13	Great Gulch	J	Scepter No.8	C	To Drill
56	G. G. Fault	J	Clipper	C	Drill later
57	I Dip	L	Scepter No. 5	E	??????
58	H Dip	K	Scepter Nos.1&3	E	??????

SPECULATIVE ORES IN MAMMOTH MINE BLOCK

The ore possibilities in the Mammoth Mine Block are entirely within the Drinkwater Anticline, which has been extremely productive in this region. As is usual in mines of this type, there is rarely present any ore or possibilities of a greater degree of probability than "prospective" and "speculative." This is because the ore bodies are usually completely worked out from the first face opened on them. Consequently, if a mine has been thoroughly worked many of the possibilities will always be of a "speculative" nature.

As in other areas of the district, much of the outlined "speculative" ores are based on conjectures derived from geologic theories, but in the Mammoth Block they have a considerably higher degree of precision because it is possible to limit them in accordance with demonstrated facts observed in the nearby stopes.

Over long stretches in that part of the block which lies to the northwest of the Flat Raise, the strike anticlinals seem to lie at fairly constant elevations. One which is only slightly known, and which may prove to be relatively small lies between the Mary Level and the Winze Level, at an elevation of about 6450. Another much larger is shown by the old stopes and workings to lie between the Mary and Wasson Levels, its extreme limits lying between 60 feet above the Mary and 40 feet below the Wasson. The strongest part of the lower limit lies some 20 feet higher or 80 feet above the Mary. From this it will be seen that the weaker bodies, although of considerable commercial importance, would not be found by mining exploration on the Mary and Wasson Levels. Similarly, although better placed and available for long drifting, the Intermediate Level lies about 20 feet above bodies which begin 30 feet above the Wasson, and about 20 feet below bodies which extend farther upward. Levels which would have more desirable elevations are the northwestern end of the Shirley-Chiatovich Stope Sub-Level, the 601 Sub-Level, and one above that. The last and the Drinkwater to the northwest are not well known to the writer, but should have good possibilities as prospecting bases. One important strike anticlinal seems to extend as low as the 601 Sub-Level.

In addition to the foregoing, flexures have been found extending down the dip in a general direction of N 45 E. Those most likely to be important with respect to ore are anticlinal or convex outward. The localities of maximum ore deposition, which would involve weaker beds not elsewhere productive, would be at the crossing of these anticlinal, strike and dip flexures. Such localities would form flat domes on the flank of the Drinkwater Anticline which would be phacolithic, or concavo-convex lenses convex outward. It will be understood of course that ore bodies on the strongest beds will persist farther in both strike and dip than the limits indicated, as they have done in the old stopes, but such limits should be used to be sure of getting all possible bodies in all possible beds.

For prospecting, the important horizontal strips lie between elevations, about as follows: at about 6450; between

6565 and 6615; between 6685 and 6725; and above 6765.

From a consideration of the general mine maps and a geologic mapping of the Mary Level, the dip anticlinals are indicated to lie along axes about as follows:

one between 555 and 333, unknown between the Wasson and Mary;

the Calumet, mined near the foot between the Wasson and Mary;

the Winze, related to it and the northwestern end of the Shirley-Chiatovich Stope;

the Johnny, which should cross the Mary Level near Section 51, but which was not observed there;

the "3386" which lies about 80 feet southeast of the "3380" Raise, whose northwestern extension is probably now being mined in the upper southeastern side of that working;

the "3389" which lies about 40 feet to the northwest of the bottom of the "3380" Raise and somewhat to the southeast of the bottom of the "3383" Raise, and whose southeastern extension probably is being encountered in the northwestern central part of the "3380" Raise;

assuming a similar spacing it should be expected that five more dip anticlinals would be found by extending the drifting, preferably at favorable elevations, so far to the northwest as to meet the main body of Alaskite cutting across the sedimentaries to the southeast of New York Canyon, a drift distance of about 700 feet.

Beds which are likely to yield ore should also be considered. To study them, the results of diamond drilling and other explorations, and their relations to the underlying irregular Alaskite as well as Alaskite sills, the existing set of sections should have all the information posted on them as soon as found. References to the beds are based on measurements in the column, at right angles to both dip and strike. The top of the Mary Limestone, and the Schist immediately overlying it, is likely to be especially productive; but, where it is present in thickness, two other favorable horizons are also likely to be important in the next lower 100 feet of it. Measured from the top of the Mary Limestone, limy layers in the shaly Schist above have been productive, as follows; approximately at 20 feet, 40 feet, 60 feet, 80 feet, and 120 feet. But the last should not be assumed to be the highest for all time, because certain diamond drill holes indicate the presence of quartz at higher horizons, and more information in most favorable structures should be sought by further diamond drilling when feasible. An adverse circumstance is that the hanging wall Alaskite seems to exist between 80 and 160 feet either as one sill or two sills, and with the 120 foot bed either included or lying between; but in either event there will doubtless be many places where the 120 foot bed will not be found.

The foregoing is summarized in the following tabular list. The insignia "?" means that there is a grave question if the bed exists; "---" indicates that the locality has probably been mined; and "$" that the locality should be of some promise. This listing is not extended above the 80 foot bed. Some indication is also given as to methods which might be used cheaply in substantiation or disproof of the scheme.

Tentative outline of ore possibilities in northwestern end of Black Mammoth.

Anticlinal Dip Axes	Lower Mary	Top Mary	20	40	60	80	Methods
555-333							
Elev. 6550	?	$	?	?	$	$	D.D.from Wasson and/or Mary. Mining from 412
6710	---	---	?	?	$	?	D.D. from stopes
6770	---	---	---	---	$	$	D.D. " "
6815	Near Chappel Stope, mined and caved. Entirely?						
Calumet							
6550	$	---	$	$	$	$	D.D. from stope
6710	---	---	---	---	$	$	D.D. " "
6770) 6815)	Questionable, account Chappel Stope. Study further.						
Winze							
6550	?	$	$	$	$	$	D.D.? Or wait for Raise or sub-level
6710	?	565	$	$	$	$	565 high enough? Raise and D.D.
6770	---	---	---	$	$	$	D.D. from Shirley-Chiatovich
6815	Partly mined		---	$	$	$	D.D. from stopes
Johnnie							
6550	$	$	$	$	$	$	Wait for sub-level
6710	$	$	$	---	$	$	D.D. from stope
6770	$	$	$	$	$	$	Mining northwest drift
6815	---	$	$	$	$	$	D.D. from NW of 601

Anticlinal Dip Axes	Lower Mary Bed	Top Mary	20	40	60	80	Methods
3386							
6550	$	$	$	$	$	$	Depends on Sub-Level, and then D.D.
6710	$	$	$	$	$	$	D.D. from new Wasson Xcut? Drifting NW from Johnnie Stope and Intermediate?
6770	$	$	$	$	$	$	D.D. from NW of 601. Drift extension of Intermediate
6815	$	$	$	$	$	$	D.D. from Drinkwater
3389							
6550	$	$	$	$	$	$	Main sub-level in near future; then D.D.
6710	$	$	$	$	$	$	Future extension of Wasson, Raise, D.D.
6770	$	$	$	$	$	$	Future, NW extension Intermediate; Raising on ore from Wasson
6815	$	$	$	$	$	$	D.D. from NW Drinkwater

Other flexures down dip as yet unknown farther northwest. Finding them, there should be several in next several hundred feet, would depend on formal mining development at proper elevations, going progressively out from last known ore. Best levels to consider are: 6550 Sub, and/or Intermediate or Shirley-Chistovich Sub, and/or 601 Sub.

6445 Sub, down Winze, is not mentioned in foregoing. Similar work on it can wait for future and checking of these ideas, possibly for a better located Main Winze, as work should preferably be on or near foot and nearby best ore.

Speculative Tonnages in Mammoth Mine Block

From the preceding list of suggested possible localities for the existence of ore bodies, and the implications which are obvious, one can guess as to the magnitude of the speculative ores.

1. From the list, allowing for analogous discoveries farther northwest, assume about 274,600 tons, of which about 1/3 has already been mined on the southeastern end;	183,000 tons
2. Allowance below Mary Level, 1/5 of first	55,000
3. Unknown possibilities in southeastern block,	50,000
(normal ores) TOTAL	288,000
Less Deduction in Favor of Nevada Development	46,000
Total Net to Black Mammoth	242,000
4. Unknown possibilities as to tonnage, grade, and mining methods and costs of the large, low grade quartz and silicified bodies in the outcrop country, which would probably run less than 0.20 oz. gold per ton	200,000
Grand Speculative Total	442, 000

It should be understood that the possibility of variations in the speculation is very great, so that the sum of the first three above might vary between 144,000 tons and 576,000 tons. The prospecting by mining and diamond drilling which will probably be done during the ensuing three months should determine the magnitude and dependability of about 60% of the first item. The enticing part of the gamble is to hope that the first two items will be found double the assumed magnitude, so that the total for the first three items of normal ores would reach 526,000 tons, which is not impossible.

SPECULATIVE ORES IN LEASE MINE BLOCK

The possibilities of ores in the Lease Mine Block fall under several categories. The first is that related to occurrences in the Soldier Beds on the foot wall side of the reverse Foot Fault. The remains of old bodies and small new ones are assumed in the Soldier block. The "435" has had a great deal of attention, and as a new find on a possible lower bed, which is exposed on one face, may have some little promise. The "560" is known only in one diamond drill hole, toward which driving is now proceeding, but because of the lack of nearby past production of much tonnage from the southeastern end of the April, only small tonnage is assigned to it. The "484" country has its greatest promise above the Intermediate Level on remnants of bodies which extend southeasterly from the old Mammoth stopes toward the Alaskite of Elizabeth Gulch. The "379-A" is used to denominate a theoretical possibility which might occur to the southeast of the "379" area and on the same elevation, but in another dip anticlinal. During the next few months diamond drilling from the surface and driving of the "379-A" face will show whether this is more than an idea. The "213-379" body is also in the doubtful list, but is less so than the next preceding; it is based on the assumption that between the 379 body and the "B" Level there might be another body located on another strike anticlinal. The "340-R" winze body is on an exploration which is now proceeding below the bottom of the large "340-T" stope. It seems to be following down on a steeply dipping tit of limestone which may be embayed in the Alaskite near the northeastern edge of the Lease Anticline. The "260" refers to northwestern extensions near the "B" Level toward Elizabeth Gulch and between it and the Mary Level, on the southwestern side of the Lease Anticline. Ore has been extracted farther southeast in the "314" stope, and has been indicated at a similar elevation by diamond drilling from the surface. Mining work to explore this country is now in progress from the "B" Level as a base. Possibilities similar to the "260" but on the northeastern flank of the Lease Anticline are listed among those outside of the present mine workings, because they would lie much deeper and would require separate and new shaft or winze.

Speculative Tonnages in Lease Mine Block

The following tabulation shows the conjectural extent of tonnages mentioned in the preceding. Notes are attached as to the probability of the speculation, and as to possible methods for resolution.

Block	Speculative Tonnages	Quality Grading	Methods
Soldier	5,000	D	Slow mining
"560"	5,000	E	Indicated by D. D. Now on mining exploration
"435"	10,000	C	Exposed on one face at bottom of large space in Soldier
"484"	4,000	C	Remnants exposed by old stopes
"379-A"	10,000	F	Still needs D.D. from surface and drifting
"213-379"	10,000	E	Still needs D.D. from surface
"340-R"	2,500	C	Now being opened by winzing
"260"	10,000	D	Indicated by D.D. from surface Mining exploration now going
	10,000	F	
	15,000	E	
	15,000	D	
	16,500	C	
	56,500	TOTAL	

SPECULATIVE ORES OUTSIDE OF MINE BLOCKS

The first several pages of this section of the report include a complete list of intersections of structures, which, in view of present knowledge, seem likely to be loci for ore deposits. These are shown on the more detailed sheets of 1" :: 200' and on the generalized map of a scale to accompany the aerial photograph, 1" :: 1200'. The strike flexures are known best in the central area, except that the Great Gulch is best known in the locality of the same name. The dip flexures have been mapped in part, but the greater stretches of them are known by various observations down the dip; on the maps they have been lettered. It is noteworthy that the dip anticlinals often coincide with the larger dip ridges, such as in the region of Wasson Gulch, the Savage ridge in the central area, the ridge to the southeast of Custer Gulch, etc. As to actual observations, the dip synclinals can be more readily observed than the anticlinals, because of their very evident flexure of strikes toward the center of the mountain as one looks down the dip on them. It is of course true that in preparing any detailed drilling program, especially in outlying areas, it would be wise to check these intersections by making more detailed observations and mapping in the localities.

From the maps it will be seen that in order to pass to the southeast and south around the anticlinal nose of Mineral Ridge, the strike anticlinals swing and tend to merge together successively toward the southeast. This is especially marked in the cases of the Drinkwater, Lease, and Mill to the southeast of Custer Gulch. In the central area the strike anticlinals are not well known below the Mill Anticline, but lower ones are known successively better to the southeast.

It is assumed that in any case of prospecting in the southeastern area, and especially if it be near Great Gulch, the two patented claims owned by the Calumet company would have been earlier acquired.

On the maps, and especially carefully on the large scale ones, areas which represent the writer's ideas as to possibilities have been drawn around the intersections. These areas have varied in accordance with both actual knowledge and belief as to the strength and importance of the structures concerned. By the use of transparent quadrille paper these areas have been compared with the areas of structures in known productive localities. Varying with belief in the importance of the areas arbitrary figures, based on similar productive areas, have been applied to them. From this process lump speculative tonnages have been assumed for the many intersections. The intersections have then been grouped by areas which would be suitable for various operations and observations. It need scarcely be repeated that the whole process is purely speculative, that it is based on many theories, assumptions, and possibly unfair comparisons, and that necessarily the personal errors and variants are very high.

Nevertheless, to the writer this has seemed the only feasible manner in which he could make the speculations. The general results have been tabulated in the following.

SPECULATIVE ORES OUTSIDE OF MINE BLOCKS

	Groups of Structures	Thousands of Tons: Mammoth	Nev. Devel.	Cumulative
1.	Lease Anticline - Savage Ridge	168		168
2.	Mill Anticline - Savage Ridge	120	84	372
3.	Drinkwater, Lease, & Mill at Ridge SE of Custer Gulch	120		492
4.	In and near Great Gulch		168	660
5.	In and near Ridge, SE of Wasson Gulch	111	48	819
6.	On Garbage between Custer Gulch and Great Gulch	56		875
7.	Extensions south of 6		56	931
8.	Dump Sub-Anticline Savage Ridge	48		979
9.	Garbage Savage Ridge	8	8	995
10.	Mill Anticline and Dump Sub-Anticline on Mill Ridge	28		1023
11.	Garbage SE of Custer Gulch	30		1053
12.	Garbage and Great Gulch Structures, Lower Custer Gulch and Mill Ridge	16	16	1085
13.	NW Extensions of Great Gulch Structure	16	4	1105
14.	Intersections of Dip Flexures West of Great Gulch		4	1109
15.	Deductions from NW End of Mammoth Mine Block		46	1155
	TOTALS	721	434	1155

GENERAL COMMENTS

With regard to the Mammoth Mine Blocks, principally the northwestern, but little more need be said. It should be noted that some 46,000 tons which might be discovered to the northwest might lie in Nevada ground.

With regard to the Lease ground, within the mine area the speculative tonnages are relatively small. It may be said that the "260" country should yield 20,000 tons instead of 10,000; but it is also true that some of the other ore mentioned is very uncertain. So, it is difficult to see how the speculative outlook is much greater than 40,000 tons within easy reach of the existing workings. It will also be seen in a following rearrangement of the tonnages that the Lease might have as much as 154,000 tons tributary to it in the outside ground.

With reference to the outside ground, the first five areas are of greatest importance, followed by area 15, and areas 6 - 11. With respect to present operating holdings the tonnages would be divided about as follows:

	THOUSANDS OF TONS			
	Mammoth	Lease	Nev.Devel.	Total
First 11 Areas	535	154	364	1,053
Area 15			46	46
TOTALS	535	154	410	1, 099

Of greatest importance for immediate trials are the first five areas and area 15, which will be taken care of in part by the northwesterly work in the Mammoth Mine Block.

The speculative tonnages of first importance may be summarized as follows;

Blocks	Mammoth	Lease	Nev.Devel.	Totals
	THOUSANDS OF TONS			
Mammoth Mine Blocks	242		(Area 15) 46	288
Lease Mine Block		40		40
First Eleven Outside Areas	535	154	364	1,053
Totals	777	194	410	1,381
Of greater uncertainty				
Mammoth Mine Blocks (Unknown Low Grade)	200			200
Outside Areas, 12 - 14	32		24	56
TOTALS	1,009	194	434	1,637

From this it will be seen that all the blocks and areas present speculative possibilities which should be very attractive commercially, and which are so disposed as to be readily and cheaply tried. If all were to go well, it might be found that the tonnages could be greatly enlarged, both within the areas now supposed and in additional areas farther down the flank of the Mineral Ridge Anticline where present knowledge is scanty. Thus, the eventual possibilities might aggregate several millions of tons.

EXPLORATION AND EXPLOITATION

The preceding discussion and tabulation of speculative ores make clear that they are of large potential magnitude and worthy of a unified scheme for their exploration, and probable later exploitation. It is clear that the predicted ores which are in or near the present mine areas are already under exploration and working plans of their managers, who have effective equipment and methods for dealing with them. But, the handling of these matters with respect to the outside blocks, and the matter of a general unified control is worthy of some discussion.

EXPLORATION

The speculative ores in the outside blocks have been specified by the intersections of structures, and in turn these have been grouped into areas in which they have possibly common features of occurrence and of operation. It will be noted further that the first five areas of outside ground are considered of greatest nearby importance and that they might contain the bulk of the speculative tonnages.

In each of these five areas the first step would be to test them by diamond drilling. If the suspicions seem to be realized, then the next step would be to test them more thoroughly by development shafts and by considerable drifting as the findings warranted. It is estimated that each of the areas might require from $5,000, to $10,000. of preliminary diamond drilling, limiting the total for the five to $30,000. If then warranted, the shafts, their equipment, and the development in a skeletal form might bring the total expenditures for all five to about $300,000. The attempt should be made to hold these expenditures down to about $0.30 per ton of expected tonnage. It is certain from past performances in the district that further detailed development charges would raise the total for development as the mines were operated to about an additional $1. per ton of ore extracted. Of this additional total of about $750,000., part of it would be carried as an operating charge as it occurred. It is likely that not more than 40% of it would have to be spent as a circulating fund to get each area into production. These may be tabulated as follows:

No. Area	Prospecting, including D.D. and Skeletal Development	Additional Fairly Complete Development
1	$50,000.	$150,000.
2	65,000.	200,000.
3	45,000.	100,000.
4	50,000.	150,000.
5	90,000.	150,000.
	$300,000.	$750,000.

TRANSPORTATION

Such areas as were believed suitable for operation, following the first step, would have to be equipped with transportation to the mill. Assuming the present mill site of the Lease, the ores would travel from:

Area 1, via shaft, the Savage Crosscut and the Mary Tunnel;

Upper part of Area 5, via underground through Area 1; $15,000.

Lower part of Area 5, via 4,000 foot aerial tramway;

Area 2, via 1,000 foot aerial tramway;

Area 4, via 6,000 foot aerial tramway;

Area 3, via 1,500 foot aerial tramway to angle station on line of Area 4. If adhered to as suggested, although of course one would try to find cheaper methods as the work progressed, the aerial tramways system would involve one large terminal at the Mill; 4 Loading terminals; and 1 angle station. The whole cost might be of the magnitude of $170,000. This would give a total of about $185,000. for transportation.

MILLING

The present mill of the Lease is centrally located for the tonnages thus far assumed. It would seem desirable, however, to make it more effective by remodeling it to the extent of consolidating in it much of the equipment at the Black Mammoth mill, thus to give a capacity of 300 tons daily of which the treatment would be largely fine-grinding, counter-current, cyanidation. Suitable studies by capable experts might show that such an end might be attained by an expenditure of about $50,000.

The tonnages and their locations indicate to the writer that it would be wise not to consider a milling capacity in excess of 300 tons daily until at least 400,000 tons of the outside areas were closely indicated. It also seems that the tonnages, their disposition, and the exploitation difficulties already demonstrated as likely to adhere to them also, indicate that it would not be wise to consider a milling program in excess of 500 tons daily, unless it shall be found later that large tonnages are surely easily to be found and extracted.

ADDITIONAL CAPITAL REQUIRED

Largely for the outside speculative tonnages additional money, as above, would probably be required, about as follows:

For preliminary prospecting and development	$300,000.
revolving final development fund	300,000.
transportation	185,000.
Mill changes	50,000.
TOTAL	$835,000.

This would be equivalent to about $1. per ton of speculative ores.

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COSTS

It should be possible to keep costs on a 350-ton daily capacity down to about $6.00 per ton, on about the following schedule:

	Per Ton		
Ore Breaking and delivery	$2.25		
Development	1.00		
Indirect mining	0.46	$3.71	
Milling	1.60		
Indirect	0.40	2.00	
General (offices and marketing)		0.29	$6.00

One could not expect to get such costs, however, unless it were possible to consolidate the properties, so as to have but one management and one milling plant, as well as a centralization and unification of other services. With a continuance of present costs of labor and supplies, and an enlargement of capacity to 500 tons daily, it might be possible to reduce the above costs to about $5.40 per ton.

The writer has been assuming that the ores handled would average a gross recovery of about $10. per ton. Therefore, unless economic circumstances should be greatly changed, there should be a possible operating profit of about $4. per ton, which might be applied to a tonnage of well over 1,000,000 tons. Compared to the investment, and the possibility of realizing additional speculative ores, this makes a favorable picture, which should lead to the full investigation of the district, by prospecting and other steps.

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RECOMMENDATIONS

From what has preceded it will be seen that most of the recommendations related to mining must necessarily be connected with prospecting, and that the steps taken in the programs and the methods used will vary in accordance with the conditions existing in the several blocks and areas. In principle, it is believed that wherever practicable a reasonable amount of diamond drilling results should be sought before large expenditures are made on mining explorations. Some thought should also be given toward prosecuting the prospecting in steps; and it should proceed from known or favorable toward unknown or unfavorable. The results obtained should be fully used to correct or amend any earlier conceived programs. It will also be understood that existing stopes are the best guides possible, because they probably exist on the crossings of strike and dip anticlinals. Consequently they are admirably adapted to serve as basic sites for the prosecution of prospecting, whether it be lateral along strike at the elevations of their strongest parts, or be of a crosscutting nature, to either hanging or foot, by either diamond drilling or mining work.

MAMMOTH MINE BLOCKS

The areas reserved by the Black Mammoth for its own mining operations are naturally divided into two large blocks, which are somewhat geologically separated and which offer quite different opportunities.

Southeastern Mammoth Block.

The southeastern Mammoth Block has already been heavily mined, and the opportunities left are relatively much

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smaller. But, it may still contain small but important tonnages in partially worked areas on certain beds, and also in caved areas. Likewise, it is not certain that all beds which might contain ores have already been prospected, which is likely to apply more to the hanging than the foot. Most of this prospecting can be done in a preliminary way and cheaply by diamond drilling from the centers of strong existing stopes. The management and operators are fully competent to carry out such programs without detailed recommendations. A beginning has already been made in such work from the southeastern end of the Savage Stope on the Savage and Wasson Levels.

The southeastern end of the mine is not well situated for exploration in depth by winzing because of the proximity there of the Mary Level to the southwestern side of the Wasson Syncline. Such work should be deferred until such later time as it may seem advisable following the results of similar work in the Northwestern Block.

Northwestern Mammoth Block.

The possibilities of ore in the Northwestern Mammoth Block has already been outlined in tabular form with notes as to approach; so, it is recommended that such schemes be carried out. Slight deviations for practicality will undoubtedly be made by the management. One drill has already started work in the Savage stope, whence it will probably proceed to test the 555-533 and Calumet axes below the Wasson Level. It may also prove convenient to use it farther up on these axes. Another drill has started work in the Shirley-Chiatovich Stope, and may be used for work in the upper northwestern country above the Intermediate Level.

The "3386" and "3389" anticlinal dip axes and those which may be found still farther northwest are likely to be of great importance now and in the future. The Mary Tunnel is far enough northwest to have found the first two, but the Wasson and Intermediate Levels lie to the southeast. They are not yet apparent in the 601 Sub-Level and the Drinkwater Level because those levels are too far in the foot to make them readily apparent. These can be explored in part as already indicated.

But, the full prospecting of them and the finding of additional dip axes farther northwest could be best done by the evolution of a new scheme of workings which should fit into the productive mining which is likely to be necessary. Drifting exploration should give best results if driven at the top of the Mary Limestone. The levels which would be suitable would lie at elevations of about 6550,6710, and on or near the Intermediate and 601 Sub-Level. These levels could be driven as main levels, eliminating the Mary and Wasson Levels. The new levels to the northwest would be supplied from a main raise or interior shaft which would be part and extension of the present 3380 Raise and which would connect with all the existing levels. Prospecting at these certain elevations is important in the finding of ore and the dip axes because these elevations are along strike anticlinals. When new dip axes are found the beds would then be further explored at least by drilling to both foot and hanging.

With such work firmly established at the top of the

Mary Limestone and the foot of the 3380 Raise thereon, it would be well to sink a Main Winze in downward continuation on the same horizon. It should encounter ore above 6445, at about which elevation a sub-level should be opened. The new Main Winze should then continue prospecting farther downward to determine how far ore can be found downward on the southwestern side of the Wasson Syncline. This might be as much as 300 feet, and great attention should be given to ore beds which may turn steeply down into the foot and into the Alaskite.

LEASE MINE BLOCK

Little need be said regarding recommendations in the Lease Mine Block. The management has matters well in hand and is doing nearly all the work possible in the few possible places.

It is possible that it might later prove desirable to sink a shaft to the northeast of the portal of the Savage Cross-cut, or to sink a Main Winze in the "280" country from the Mary Tunnel down. These would be taken care of as needed.

BLOCKS OF OUTSIDE GROUND

Lists have already been presented showing the principal possible structural intersections in the district, and also showing them grouped by areas. It has been pointed out that the first five areas are of greatest importance, both in themselves and as demonstrations as to all the possibilities. It has also been noted that the first fourteen numbers of the structures have been applied to localities in which the writer feels that diamond drilling should be done earliest.

These preferred structures are related to the groups by areas as follows:

Structure Nos. 1	to	Area No. 1
2, 3, 4,		2
5, 6,		5
7, 8, 9, 10,		3
11, 12, 13,		4
14,		8

From this it will be seen that most of these holes will be needed in the near future to test out the general scheme and possibilities of the district and properties. One drill is now being used on the surface on Structure No. 1, after which it will be moved onto the 213-379 surface work. Another is drilling on structure No. 2,with the intention of using it on Nos. 3, and 4. So, it will be seen that other diamond drills could be used to good advantage for testing out the areas 3, 4, and 5, with 4 possibly deferred until suitable arrangements regarding properties shall have been concluded. Additional drills to hasten the program will be needed if the results of drilling Area No. 2 are favorable. It should be possible to make schemes for the use and supplying of at least two others.

The locations of collars, bearings and slopes of holes for the fourteen structures recommended to be drilled first are given in the following:

Directions and Slopes of Diamond Drill Holes From Surface in Recommended Areas:

Structure No.	Location	Bearing	Slope, down, in degrees
1	No. 118, now drilling		
2	No. 120, now drilling	N 60W	45
3	NW side of Road Gulch, spotted	N 45 W	45
4	NW side of Road Gulch, spotted	N 85 W	50
5	1,300 feet down Wasson Gulch from Wasson Portal	Due South	60
6	2,700 feet down Wasson Gulch from Wasson Portal, then S 36 E 200 feet	S 45 W	60
7	About S 36 E, 250 feet from center Canyon Crest Workings	S 48 W	60
8	From East Corner Canyon Crest, S 22 E, 375 feet	S 68 W	60
9	440 N - 9,000 E	S 56 W	75
10	630 N - 9,335 E	S 65 W	70
11	240 S - 12,275 E	S 80 W	60
12	835 S - 12,235 E	Due West	60
13	2,000 S - 12,080 E	S 75 W	60
14	4,360 N - 7,290 E	S 62 W	55

All of these holes should be drilled well into the undoubted main foot wall body of Alaskite. Many of them will be deeper than 500 feet. Those likely to be shallow are: 1, 200 feet; 7, 8, 9, and 10, likely to vary from 200 feet to deeper; 11, 12, and 13 may be from 200 to 400 feet deep.

SUMMARY

1. Make certain of the acquirement of Mohawk No. 3 before proceeding far with the prospecting in Area No. 2 of the outside ground.

2. Make certain of the acquirement of the Calumet properties in Great Gulch before proceeding far with the prospecting in Area No. 4.

3. For the greatest profits for all concerned it would be well to do all possible to consolidate all the properties under one unified management and system of mining, milling, and auxiliary services.

4. Irrespective of geologic ideas, existing plans for work, and other ideas, it will be well at all times to follow all showings of quartz of the ore type, especially if it has or is likely to have appreciable values.

5. Wherever possible it will be desirable to precede any extensive mining exploration with reasonable amounts of diamond drilling.

6. In accordance with the plans of the management, the diamond drilling of the southeastern part of the Mammoth Mine should be continued for the purpose of finding, especially in the hanging, additional productive beds.

7. The same should apply to the northwestern part of the Mammoth.

8. The mining exploration to the northwest of "3380" on elevations likely to be fruitful, to be supplied from a central raise like "3380", should be put into effect, even in portions, as rapidly as practicable. Best results will be

obtained by using the top of the Mary Limestone as a drifting bed.

9. In a similar manner exploration should be continued downward with the "3380" below the Mary Level, thus making it a new Main Winze.

10. The prospecting now under way in the Lease by the management should be continued.

11. First attention should be given in the outside ground to the first five areas listed. If favorable results are obtained in Area No. 2, then a prospect shaft should be sunk there. At the same time drilling in other areas should be intensified, which in turn would be followed by mining exploration on obtaining favorable results.

CONCLUSIONS

The general outlook for the properties is good under present conditions. It is believed that the principles discussed herein will be helpful in leading to a rapid and orderly determination of any ore bodies they contain.

Very truly yours,

John G. Barry,
Consulting Mining Geologist and Engineer

M A P S

to

Accompany

R E P O R T

on

G E N E R A L   G E O L O G Y

and

O R E   D E P O S I T S

of

M I N E R A L   R I D G E

Silver Peak,   Esmeralda County   Nevada

November, 1939

By John G. Barry.