Geology of the Golden Sunlight Mine and Vicinity

Roy H. Earhart

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GEOLGY OF THE GOLDEN SUNLIGHT MINE AND VICINITY

by

Roy H. Earhart

A Thesis
Submitted to the Department of Geology in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Geological Engineering

MONTANA SCHOOL OF MINES
BUTTE, MONTANA
May, 1939
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The importance of the Golden Sunlight Mine and neighboring properties has never been recognized, due chiefly to the method of operation that has prevailed, that is, operation on a small scale by lessees, the production usually never reported. Thus, the publications of mineral production in the United States give the mine credit for less than $25,000, while the true figure is probably more than $2,000,000. Moreover, recent examinations and purchase by a large mining company may result in a much greater production for years to come, an enterprise that will greatly increase the population of the district and encourage further prospecting and mining in the vicinity.

In view of these facts, it seemed advisable in October, 1938, to collect such information as was available and study in some detail the geology of the immediate region.

The Golden Sunlight is mentioned briefly in U. S. Geological Survey Bulletin 574, "Mining Districts of the Dillion quadrangle, Montana", by A. N. Winchell; also, Billingsley and Grimes in volume 56 of the Transactions of the American Institute of Mining and Metallurgical Engineers present a generalized description of the igneous rocks and their relation to the ore bodies. They do not, however, describe any particular ore body specifically.
The geologic map in U. S. Geological Survey Folio 24, the Three Forks Folio by A. C. Peale, includes the southeast corner of Bull Mountain, but the geology as shown is very incomplete and inaccurate. Mr. Clyde G. Congdon's thesis submitted at the Montana School of Mines in 1935, "The Geology of the Cardwell Mining District", describes the general geology of the entire region and mentions the Golden Sunlight in speaking of economic products.

This investigation was made possible by the hearty cooperation of Mr. Wayne Fenner, superintendent in charge of the mine for the A. O. Smith Corporation during 1939. Faculty advisers, Drs. Eugene S. Perry, George F. Seager, and Laurence L. Sloss, gave valuable help in field and laboratory work and also in preparing the manuscript. The assistance of Mr. John M. Harlan in mapping and interpreting geology and the help of other students were indispensable.

The surface geology was mapped by members of the senior class, Montana School of Mines, in 1938, with plane table and telescopic alidade. Underground mapping was done by Mr. Harlan and the writer during January and February, 1939. All maps, diagrams, and photographs were also prepared by the writer.

**PHYSICAL GEOGRAPHY**

The Golden Sunlight Mine is in the northern part of the Cardwell mining district on the eastern slope of a small range that rises by a series of benches to an elevation of 7,200 at a point five miles east of the town of Whitehall in Jefferson County. The range, which runs 20 miles northward, is called Bull Mountain by the U.S. Geological Survey after local usage, but as there are other mountains
in Montana known by the same name, the location of this district should be noted carefully. Most of the mine property lies on steep eastern slopes cut by several intermittent streams, the topography lending itself very well to the inexpensive development and mining of the ore bodies through adits, no shafts being necessary. Drainage is eastward to the North Boulder River which flows into the Jefferson River a few miles southeast.

The mine is reached by a good road leading north from U. S. Highway No. 10 at a point five miles east of Whitehall. Two railroads, the Northern Pacific and the Chicago, Milwaukee, St. Paul and Pacific, have stations at Whitehall and Cardwell and at Piedmont and Jefferson Island respectively.
Precipitation is small, there being little snow and almost no rain except in the month of June. Temperatures range from \(-40^\circ\) to \(100^\circ\) Fahrenheit. Vegetation consists of ragged growths of juniper trees and sage brush on the lower slopes and firs and pines at higher elevations. The rigorous winter weather makes mining the shallow workings difficult. Very little water is encountered underground, an amount sufficient only for small scale mining, and further development may necessitate pumping water from the Jefferson River.

Fig. 1. Panorama view of east slope of Bull Mountain. The long switchbacks left of center connect the adits of the Sunlight group. Mineral Hill is outlined by trees and roads to the right and above center. Photo by Wayne Fenner.
The geologic history of the Golden Sunlight area is incomplete unless the history of adjacent areas is also considered. High uplift caused nearly all of the Paleozoics to be eroded away, obliterating the records of about 420 million years. The Paleozoics north of the mapped area, however, show that the column here was normal for southwestern Montana. This is not of great importance, however, because the absent strata have no connection with the ore bodies and intrusives.

The contact between the lowermost Belt beds and the Archaean rocks cannot be found, but it is safe to say that there is a basement complex of Archeozoic gneisses, probably the Pony and Cherry Creek series.

The Proterozoic era opened with the deposition of arkosic material from the nearby Pony granite gneiss. As this high area was worn down, the sands became finer and finally graded into shale. Continued leveling of the land mass brought further encroachment of the sea to deposit some limestone along with the fine argillite, and colloidal silica was included in some beds to form chert and bands of silicious shale. The total thickness of the beds is from 12,000 to 15,000 feet, and it is possible that there were additional upper beds of argillite and limestone that were eroded away during the post-Proterozoic interval. Although this interval may have eroded away some of the upper part of the formation, there was no angular displacement, the first Cambrian formation lying conformably upon the Belt.

As shown by the nearby section, all the Montana formations of the Paleozoic and Mesozoic eras were deposited and removed by the
early Tertiary uplift. It is certain that there were no violent earth movements or igneous activity during this time, but only gentle rising and sinking of the entire region.

The early Tertiary brought the structural movements and the igneous activity that were all-important in the present topography and ore deposits. The monzonite porphyry was intruded, block faulting raised the lower end of the range, and the resulting fissures were filled with quartz and pyrite. The granite aplite was then intruded and was accompanied by the gold-bearing pyrite and silica solutions which permeated the previously fracture shale. Final faulting and intrusion of the lamprophyre dikes took place late in the Tertiary and resulted in the movement of Mineral Hill and fracturing of the shale and monzonite in the hill. The large fault which limits the block on the north was also formed at this time.

Tertiary lakes surrounded the range but no gravels were found near the mines.

During Pleistocene times, the present topographic features were eroded into the upthrust block and, most important, the concentration of the gold by surface water continued. There is no evidence of glaciation.
SEDIMENTARY ROCKS

Sedimentary rocks of the northern Cardwell area include a great thickness of pre-Cambrian arkoses and shales of the Belt formation overlain by quartzite and limestone of Paleozoic age. Tertiary lake deposits and Quaternary alluvium surround the main range. The arkosic shales constitute the dominant formation in and around the mines, and the Paleozoic sediments lie about one half mile north of the mineralized area.

PROTEROZOIC FORMATIONS

The base of the Belt is composed of green, red, and grey arkoses, derived probably, from the pre-Beltian gneissic complex that now appears in the southern part of the Cardwell district and the Tobacco Root Mountains, and which is known as the Pony gneiss. Mineralogically and texturally, the arkose greatly resembles this complex series of rocks.

Overlying the coarse lower beds is a zone of finer grained arkosic sands, massive and grey in color, which is transitional to the uppermost beds of shale and argillite that make up most of the formation. The shale is tan throughout most of the area, but in places, narrow bands show strong silicification and are grey. This silicification was contemporaneous with the deposition or consolidation of the shale and is separate from the later silica which was injected with the gold bearing sulfides. Calcite also appears in some beds in grains from 1/100 to 1/10 millimeter.

In the transitional zone between the arkose and shale, there is a six inch band of black paper shale, exposed only in an adit on the southern edge of the area. This bed is peculiarly
folded and overturned while the beds immediately above and below are undisturbed.

Also between the shale and arkose, there is a bed of shale breccia, fragments of unaltered shale in a matrix of consolidated shale dust from which the iron has been leached and oxidized and colors the bed red. Neither of the last two described beds is important as compared to the bulk of the formation, but they are mentioned here only because of their peculiarities.

PALEOZOIC FORMATIONS

Cambrian sediments appear in the extreme northern part of the area described and are included only to show their relation to the underlying formation. Because they are not connected in any way with the ore deposits, it will be sufficient to mention that these formations are those usually found in the Paleozoic of southwestern Montana. Paleozoics covered the entire region prior to uplift and rapid erosion of the range.

CENOZOIC FORMATIONS

Bench gravels and silts of the Bozeman lake beds of Miocene age surround the entire southern end of Bull Mountain, covering the older formations. These gravels and silts were reworked during Pleistocene times, and talus material was washed outward from the mountain, but it is unlikely that additional material was introduced by glaciers.
c. Veinlet of redissolved pyrite and quartz. X nicols. X 80.
d. Granite aplite. X nicols. X 80.
e. Coalescing andesine twins in granite aplite. X nicols X 100.
f. Microperthite in granite aplite. X nicols. X 100.
IGNEOUS ROCKS

The sedimentary rocks of the area are intruded by numerous dikes, sills, and irregular masses of granitic rocks with minor amounts of more basic types. These intrusions are particularly plentiful in the area of the mines, and in places mineralization appears to be intimately associated with intrusive bodies. Superficially, many of these rocks appear the same, but close scrutiny reveals several rather definite types, some similar in mineral composition and others differing greatly.

MONZONITE PORPHYRY

The porphyritic phase of the monzonite intrusive which is found in the Bacorn and Ohio tunnels extends westward three quarters of a mile where it grades into granite aplite. A typical specimen showed the following mineralogic composition:

- Orthoclase: 20 per cent
- Andesine: 20
- Primary quartz: 1
- Cryptocrystalline groundmass: about 59 per cent

Megascopically, the rock shows yellowish phenocrysts of feldspar about 5 millimeters long set in a blue-grey, glassy groundmass. Pyrite, 1/2 to 10 millimeters in diameter, occurs disseminated throughout the whole mass, but the presence of this mineral is more noticeable on the east slopes of the range where the larger grains occur. Most feldspar crystals have been attacked by sericitization, and epidote, which gives further evidence of alteration, was observed in some thin sections. The largest extinction angles obtained from the plagioclase twins were 10° which would class it as oligoclase; zoning occurs, however, and since this is rarely seen in oligoclase or more acid plagioclase, it is probably andesine.
SYENITE PORPHYRY

In the zone which is transitional from the monzonite to the granite aplite, a syenitic phase of the main igneous body occurs. Megascopically, this does not differ from the monzonite porphyry, but microscopic examination shows that there is 60 per cent orthoclase and only 10 per cent plagioclase which here is definitely proved to be andesine. Other minerals are practically the same, and in addition, there is secondary chlorite pseudomorphing pyroxene crystals.

Where the syenite porphyry contacts the shale, there is brecciation and specimens were collected that contained small shale xenoliths.

Both of the above described rocks contain, in addition to the secondary pyrite, small veinlets of secondary silica. This, together with the general fracturing of the mass, was an important factor in the supergene enrichment of the ore bodies.

GRANITE APLITE

On the south and west sides of the mountain, a granite aplite occurs which has the following composition:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthoclase</td>
<td>60 per cent</td>
</tr>
<tr>
<td>Quartz</td>
<td>20</td>
</tr>
<tr>
<td>Oligoclase</td>
<td>10</td>
</tr>
<tr>
<td>Biotite, hornblende</td>
<td>10</td>
</tr>
<tr>
<td>Zircon and apatite</td>
<td>minute quantities</td>
</tr>
</tbody>
</table>

Sericitization was also observed in this intrusive, but secondary pyrite and silica, so prominent in the syenite and monzonite, are lacking. Grain size is uniform, about one millimeter. To the south, the aplite is yellowish and compact; to the west, where it occurs as a series of dikes, it greatly resembles the granite arkose. 
which forms prominent beds in the Belt formation. A feature of one specimen examined was the presence of microperthite and free albite.

**BASIC DIKES**

Basic dikes of several types, which cut all rocks, are prominent in the long adits. These rocks are grey or greenish black, fine grained and heavy, with phenocrysts of biotite and pyroxene, some being one centimeter long. With the microscope, large crystals of zoned pyroxene, augite, were identified, and also the minerals biotite and magnetite. The groundmass, though nearly isotropic, is believed to contain laths of labradorite and granules of pyroxene as well as microlites of other minerals. Most of these dikes are lamprophyres, those on the west side of the range being alnöites, and those on the east side, encountered in the mine workings, being spessartites.

Fig. 2. Large zoned crystal of augite in dike rock. X nicols. X 80.

Fig. 3. Alnöite dike rock. Black, biotite. Euhedral grey crystals, pyroxene. White, gypsum filled amygdals. X 1/2.
Fig. 4. Pyrite in smallest drill core fragment in Fig. 5. X 80.

Fig. 5. Drill cores. Upper left, pyritized argillite. Upper right, monzonite porphyry. Lower, silicified argillite with calcite. X 1/2

Fig. 6. Shale breccia. Fragments of shale in a matrix of oxidized, consolidated shale dust. X 1/2.

Fig. 7. Tiny fold in Belt shale. X 1/2.
STRUCTURE

The area is one in which faulting and intrusions have played an important part in the structure. The mountain seems to be an isolated fault block cut off on all sides by faulting. On the north, the fault is not topographically prominent because there are upper Paleozoic beds at equal elevation, but on the east, south, and west, steep scarps mark the movement. Vertical movement is especially noticeable on the west side where there is repetition of strata and on the east where the fault planes can be seen underground.

Thick gouge and slickensides are prominent features in the Sunlight workings where two stages of movement can be seen. The first period of faulting was early Tertiary, probably contemporaneous with igneous activity, and these were mineralized to make up the fissure veins of the district. The second set of faults is post-mineral and are themselves only slightly mineralized. These major faults in general strike north and south with the exception of the large one to the north where the strike is east-west. The displacement of Mineral Hill can also be placed in the second group.

Mineral Hill is oxidized to a depth of several hundred feet while the Sunlight vein shows superficial alteration to a depth of only 50 feet, showing that the hill was exposed to weathering for a much longer time, that is, it was very high as compared to the rest of the range. But the summit of Mineral Hill is now below the top of the Sunlight vein showing that this conical hill has settled or slid down off the top of the range to its present position. Bearing out this theory is the intensely fractured condition of the hill.
a. Bed of shale breccia in the field. Scale shown by pencil.

b. Fold in shale exposed in road cut. This fold was found in Sunlight tunnel No. 2 where it appeared as a symmetrical anticline about three feet high. The strike is N 35° W.

c. South end of Bull Mountain. The deep canyon to the left is cut into a shale-aplite contact. The conical hill is shale and the steep eastern face is a normal fault.

d. View from top of hill in (c). Sunlight tunnel No. 2 is in the foreground, and the dump of tunnel No. 3 may be seen at the foot of the hill.
the difference in the attitude of the Beltian beds here and in the main range behind, and also the topography which plainly shows that the movement here described has taken place.

Except for the areas near large faults, the sedimentary rocks have not been greatly disturbed. The regional strike of strata is N 15⁰ E and the dip is 17⁰ east. Near fault planes, the shale has been dragged into sharp folds, and in the Sunlight tunnel No. 2, a small anticline was noticed and traced to the surface where it appeared very plainly in a road cut. There are no true sills in the area, all intrusions being small stocks or dike-like.

While the major features, including the uplift of the mountain block, are controlled by faulting, contacts have also been important in shaping the topography. Nearly every large canyon has been cut along a contact. It is also believed that the Mineral Hill movement may have occurred along a weakened contact zone. Brecciation at contacts is also important in this deposit which owes its existence to fracturing.

**MINERALS**

In addition to the rock-forming minerals mentioned, the following minerals were observed in the veins.

- Calcite
- Chalcanthite
- Chalcopyrite
- Gold
- Gypsum
- Hematite
- Limonite
- Malachite
- Pyrite
- Pyrolusite
- Quartz
- Siderite

Minerals whose presence is inferred from chemical analysis are galena, sphalerite, sylvanite, and calaverite.
ORE BODIES

In general, commercial mineralization in the area consists of (1) a series of fissure veins, and (2) a disseminated deposit wherein Belt shales and Tertiary intrusive rocks have been pyritized. The vein system lies on the extreme southern end of the mountain and is controlled by north-south striking fissures. The disseminated deposits lie almost entirely within Mineral Hill. Early mining was carried on primarily in the veins of the area, but recent attention has been given to the development of the disseminated deposits. The intrusions have been important in fracturing the rocks and providing the channels for the introduction of the minerals as well as being closely related to the source of the mineralization. The prominent faults associated with mountain building were accompanied by minor fracture systems, both essential to the formation of the ore bodies.
Fig. 9. Sampling cut, one inch deep and six inches wide, in road cut through monzonite porphyry near Bacorn tunnel by A. O. Smith Corporation in 1936.

Fig. 10. Sampling trench over top of Mineral Hill. The shale here is colored red and is finely fractured.
a. Sunlight tunnel No. 1. The white dumps in the background show where the vein outcrops.

b. Surface plant at tunnel No. 2. Two portable compressors supply air for drilling. Water for drilling must be hauled up here.

c. Dumps and ore bin at portal of tunnel No. 3. The boiler in the foreground was part of the power plant installed by the American Development and Mining Company about 1905.

d. Outcrop of Buffalo lead marked by dumps where stopes cut through to the surface. The vein was mined in the 1890's and early 1900's.
Map of Golden Sunlight Workings

Scale: 1" = 200'

Belt Formation
Basic Dikes
Granite Apron
Mineralized Faults
Ore Zones

No. 3

No. 2

No. 1

House

Low, 2, 140
The north-south Sunlight "vein" (see PLATE I) is about eight feet wide and dips 75° east. Although continuous for some distance along the strike, it carries minable ore for only about 60 feet. Most of this shoot lies within the limits of the quartz-pyrite vein, but at each end there is a short spur leading into the wall rock parallel to the northeast fractures. Silica, bornite, chalcopyrite, and auriferous pyrite have been added in microscopic quantities, but the shoot shows no alteration, and assays are necessary to determine the ore limits. Away from the shoot, both the northeast and northwest fractures carry pyrite and quartz but no gold.

About 250 feet south of tunnel No. 3 of the Sunlight mine, the vein is offset by a well marked fault containing a little ore. Exploration by previous lessees has failed to locate the ore. Herbert W. Carver, now leasing the Sunlight vein from the A. O. Smith Corporation, plans to drive an inclined raise from No. 3 to intercept the faulted segment.

The shoot has been stoped from tunnel No. 3 to the surface, more than 500 feet, and is reported to have produced about $1,700,000 since 1890. The ore near the surface, a honeycombed mass enriched by loss or alteration of pyrite, was so light that special sacks five feet long were used to carry it down the hill.

The Buffalo vein outcrops on a hillside parallel to a creek and about 40 feet above it (see PLATE I). It has been stoped continuously for about one quarter mile on the strike and from the water table to the surface, a height of 20 to 60 feet. Both the remaining pillars and the wall rock have been intensely altered by surface water since mining, but the ore and waste picked off the dump are similar to Sunlight vein material.
The nearby shale-aplite contact has been important in the disposal of the lode, forming a line of weakness now cut into by a stream which has exposed the vein to rapid erosion. Except for this erosion, the pitch length probably would have been equal to the Sunlight vein.

The Telluride vein is similar to the Sunlight but the wallrock is aplite instead of shale. The ore is irregular, and the factors controlling its presence or absence are probably similar to those already mentioned. Martin Stepan and his brother of Butte are now leasing the property and during March and April, 1939, they have shipped about one hundred tons of gold ore to the smelter in Anaconda.

Past production of the area has come mostly from the Sunlight vein, but future operations will be almost entirely on Mineral Hill, a deposit that differs greatly from the Sunlight, Buffalo, and Telluride. Because of the future importance of Mineral Hill, it was
Map of Bacorn and Ohio Tunnels

Scale: 1 = 100

Monzonite
Belt Shale
Basic Dikes

Bacorn Tunnel
Fig. 12. Small glory hole in Mineral Hill on site of old Bacorn shaft. Only high grade is being mined now (1939) which accounts for the irregularity of the workings.

Fig. 13. Another view of the glory hole above. This photo was taken from inside a drift cut by the hole.
studied in some detail, the microscope being used to determine genesis of the ore body.

Both the shale and the monzonite, which form the country rock, were intensely fractured by faulting providing innumerable tiny channels for primary mineralizing solutions. Secondly, all these fractures were filled with microscopic veinlets of quartz and pyrite, the pyrite probably containing the gold. At this stage, there was developed a huge body of very low grade gold bearing rock. Further microscopic evidence points to the resolution of the gold, pyrite, and silica and redeposition in the zones where proved ore now occurs. The upper zone, including much of the rock that has been eroded, has been leached free of these minerals leaving the veinlets filled with sericite, epidote, some limonite, and rarely, a ragged, partially dissolved grain of pyrite. Manganese oxides are present and no doubt have effected the solution of the gold. Reprecipitation took place when the descending solutions mixed with the greater concentrations of sulfides at depth.

All these factors have resulted in an enriched zone centering at the Bacorn shaft and diminishing in value in all directions. Places favored by greater concentrations, such as contacts with fine fracturing, have been enriched more than average and are being mined as high grade. By a cheap large-scale method such as glory holes or block caving, most of the hill can be profitably mined.
PLATE IV

Generalized Section Through Mineral Hill

Generalized Section Through Sunlight Vein
a. Surface plant, office buildings, and living quarters for technical staff at foot of Mineral Hill.

b. Blocky monzonite porphyry in road cut near Bacorn tunnel.

c. Bedded shale exposed by mine operations on Mineral Hill.

d. Portal of Bacorn tunnel. The glory hole and Bacorn shaft are up the hill a short distance.
HISTORY OF THE PROPERTY

The Golden Sunlight group has been worked intermittently since the early 1890's when Anthony H. Hedley, who had worked and patented several claims in St. Paul's Gulch, discovered the leached outcrop of the Sunlight vein and located the Sunlight, Golden, and Last Chance claims. The Buffalo and Tulleride claims were located at about the same time. The Mineral Hill and Ohio claims were located in 1894 by the American Development and Mining Company. This company bought the Sunlight claims in 1900 and built a mill in 1905 but recovery was so low that the tailings were shipped to the smelter at a profit.

H. C. Bacorn took over the property in 1910, worked both the Mineral Hill and Sunlight deposits, and located more claims on Mineral Hill. After he left in the early 1920's, Dan Zink, Lot Borden, and Mike Mufly of Whitehall and Mr. Tidball of Butte leased the workings at various times until 1930 when H. W. Carver got the lease. During this time, 1920 to 1930, McKay, a grocer in Whitehall, and Wellcome, a lawyer, both deceased, acquired the entire property, one claim at a time, in payment of bills and fees. Carver leased from Frank Ball of Butte who had an option to buy the mines from Mrs. McKay and Mrs. Wellcome. The Anaconda Copper Mining Company examined Mineral Hill in 1935 but rejected it.

In 1936, the A. O. Smith Corporation of Milwaukee examined the working, sampled Mineral Hill by cutting trenches, and bought the 23 claims that now make up the entire property. These are the Golden, Sunlight, Last Chance, Tulleride, Somerville Placer, Foraker, Ohio, Mineral Hill, Macomber, Madge, Prairie, Astley, Buffalo, Star-
light, Hematite of Iron, Hillside, Moonlight, Lamplight, Red, White, aand Blue, Meteor, Lapear, Excelsior, and Lapear Millsite. This company now leases the Sunlight vein to H. W. Carver and the Telluride vein to Martin Stepan and his brother of Butte. The A. O. Smith Corporation operates three other mines similar to the Mineral Hill deposit, one in California and two in Colorado. About ten men are now working in the small glory hole and underground, only the richest zones being mined. With a 3000 ton mill and mining by block caving or glory holes, the total cost will be about one dollar per ton. The ore is being tested now but recovery is only 85 percent.

No exact figures on production are available, and estimates vary from one million to three million dollars. The most probable figures are $1,700,000 for the Sunlight vein and $600,000 from the Buffalo, Telluride, and Mineral Hill. The writer estimates that production in the next eight years will be $20,000,000, provided that the mill is built soon and operations start.
CONCLUSIONS

There are few mining districts in which the ore deposits have been so continuously benefitted by geologic events. Except for the erosion of the Buffalo vein, nearly every structural movement and igneous intrusion in the Tertiary period has resulted in the formation of ore or the enriching of ore already deposited.

Development of the Mineral Hill deposit will affect other mines in the district, especially those in St. Paul's Gulch, because their ores can be treated in the mill at a much lower cost than shipping and smelting. Perhaps these operations will arouse an interest in other large low-grade deposits in Montana.

The exact structure and stratigraphy of the Belt formation remain as an interesting and specialized problem.
GEOLOGIC MAP
OF THE
GOLDEN SUNLIGHT MINE AREA
SCALE: 1" = 500'
MONZONITE PORPHYRY
BELT SHALE, ARKOSE
APLITE
BASIC DIKES
CAMBRIAN SEDIMENTS
OXIDIZED AREA IN BELT SHALE
FROM MAPS BY M.S.M. STUDENTS, SEPT. 1938