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SUMMARY AND CONCLUSIONS

Alder Gulch was Montana's richest gold camp. The most reliable estimate of all-time total production places a value of at least $50 million on the placer gold taken there. According to Dana's Mineralogy, gold ore dug mainly from placers made Madison county the leading gold producing county in Montana mining history. Reputedly, the Lucas Bar placer, near the head of Alder Gulch, yielded $20 million in gold at a time when the price of gold was $16 an ounce. The Cemmilex Prospect is ideally situated to test the rocks which may well have supplied the Lucas Bar placer from a rich mother-lode deposit.

Plate 1 of this report is a photogeologic map. It shows that the subject area is an 11-mile square with the Cemmilex Prospect at its center. Precambrian rocks of the Proterozoic sequence are exposed over more than half the area, including the ground occupied by the Cemmilex Prospect. The eastern part of the area has great thicknesses of Mesozoic and Paleozoic sediments partially covered by Tertiary lava flows; and some Tertiary sediments are present in the northwest corner of the area. Because primary gold has been found here only in the Precambrian gneiss and schist rocks apparently mostly metasediments, that is to say, the oldest exposed formations, the younger formations had importance to the present study only as they could contribute to an interpretation of the geology of the older gold-bearing strata with which we are concerned at the Cemmilex Prospect. All rocks except the lavas have been severely faulted and folded.

Exploration of the upper part of Alder Gulch was given new life by the discovery, on aerial photographs, of several faults which intersect near the Cemmilex Prospect. These faults, numbered from 1 through

8 on Plate 2, culminate in a zone which seems to be a focal point of the effects of intense horizontal compression between a resistive bastion to the east and a dynamic force moving from the west. The Lucas Bar lies in the eastern and the Cemmilex Prospect in the western parts of this zone.

A study of the Tobacco Root mountains by R.R. Reid for the Montana Bureau of Mines, 1957, states categorically that metalliferous deposits are most likely to be discovered in this region on northwest trending faults. Alder Gulch being at the southern end of the Tobacco Roots, it was interesting to find that the Cemmilex "discovery" fault has a northwesterly trend, and to note also that the Brown's Gulch mining district, comprising at least ten mines, occupies the same fault. Owing to topographic barriers, however, none of the Brown's Gulch mining areas could have furnished the gold found in the Lucas Bar placer.

Plate 2 is a close-up view of the Cemmilex Prospect and was made to a scale permitting illustration of localized factors having to do with the ore geology. The plate is essentially in two parts: A plan view made by enlarging an original aerial photograph, and a series of five cross-sectional sketches of the prospect area. The sketches were made from minimal control, oversimplified but conforming to the country habits of Precambrian lithologic relations.

Cut number 1 was opened to test fault number 1 for possible ore mineral occurrences. When it was found that solid bedrock could not be reached at operating depths attainable by the earth-moving equipment then in use, cut no. 2 was opened on the same side of fault no. 1, but with no significant results. One specimen of rich copper ore was found in cut number 1, and nothing else of interest.

About this time, a new and intensive scrutiny of the aerial photographs revealed some very subtle traces of slump scars in the Cemmilex

area. Their arrangement and some springs emanating topographically lower immediately suggested a buried channel through which an ancient surface stream might have flowed while carrying gold to the Lucas Bar. Further photo work indicated that the slump scars trended along the easterly plunging nose of an anticline.

The next exploratory move was to dig cut number 3 in a place southwest of fault number 1 and nearly at right angles to the hypothetical, buried stream channel. That "phantom" stream is colored blue on the plan view of Plate 1. At a depth of about 80 feet greenish-colored bedrock with a weathered appearance and no visible stratification was unearthed in the cut. The top surface of this greenstone rock slopes toward the phantom stream channel, and is covered with a 3-inch layer of greenish clay which clearly is the decomposition product of the greenstone on which it lies.

The rock above the greenstone (see DB, Plate 2, a-a' and e-e'), where seen in the southeast wall of cut number 3, is composed of various lithologic types, all apparently metasediments. These strata dip easterly, leaving little room for doubt that the greenstone mass is structurally and lithologically anomalous to the enclosing rocks, and that the greenstone could have an intrusive relationship with them as though it were a weathered dike. While maintaining good member-to-member position, the whole mass of decayed rock on top of the greenstone is creeping down the steep slope toward Alder Creek, a process doubtless facilitated by the lubricating power of the greasy 3-inch layer of clay at the interface.

The next step in exploration involved sinking a shaft in the bottom of number 3 cut at a spot chosen, as far as possible, to intersect the

place where the bottom of the buried stream channel was postulated. This had the primary purpose of determining the existence or non-existence of the channel. If it was there, then any buried placer material, hopefully including gold, could be sampled and studied. Another objective was to check on the expected southwestward continuity of the greenstone body beyond where it is last seen in the floor of the cut.

The shaft reached a level 50 feet below the floor of the cut, with the result that it pretty well shows the presence of a debris-filled gully in bedrock and a likely habitat of an ancient stream. But, what is perhaps more important to the exploration picture, the last 10 feet of the shaft were in a blue clay (see BC, Plate 2, a-a') of a type said by an older miner of the region to be identical in appearance to the blue clay immediately overlying the placer gold of the Lucas Bar. It can be logically proposed, therefore, that the clays at both places came from one and the same source, namely, the greenstone rock formation of the Cemmilex Prospect. This strengthens the evidence that relates the Cemmilex area with the Lucas bar via the stream channel. The hypothetical lode source of the Lucas Bar placer gold might have been covered by semiconsolidated slump material brought down, for example, by an earthquake slide, leaving the lower reaches of the stream channel open long enough to have carried and deposited greenstone-derived clay on top of the placer gold already accumulated at the bar. It can be assumed just as logically that deposition of the Lucas Bar gold exhausted the primary lode source of the metal; or it is reasonable to say that a larger of small quantity of the metal than that taken from the Lucas Bar remains today in downfaulted blocks of rock in the Cemmilex area. (see fault blocks 1 and 2, and faults 1 and 2, Plate 2).

Recent severe winter weather forced suspension of shaft sinking before it was possible to reach the bottom of the clay layer and the bedrock below it. In order to continue testing the stream channel and the gold possibilities of any gravels that may be found in it, a churn drill will be brought in. Drilling promises a relatively inexpensive way to attain current exploration goals. Overthrusting on the west and underthrusting on the east (see faults 1, 2, 4, and 5, Plate 2) probably relieved the horizontal tectonic stresses active in Tertiary time. All such activity apparently ceased before the beginning of the Quaternary period. Because the gold-bearing gravels of the Virginia City-Alder Gulch region are Quaternary in age, the Lucas Bar placer gold was deposited after the end of Tertiary tectonism.

The extreme angularity and roughness of the nuggets taken from the Lucas Bar seem to prove that the gold didn't travel very far from its lode source. And if it came by way of a buried stream channel from the Cemmilex area, it traveled less than 7/8 of a mile from mother-lode to lower end of placer. At the Cemmilex Prospect the stream gradient would have been sufficiently steep to have carried off large cobbles and gold nuggets, which came to rest when they reached the much flatter gradient of Alder Creek at the Lucas Bar.

Detailed knowledge of a degree to permit reliance on petrology as an exploration guide is presently lacking. Statistically, the mineral assemblage identified in the Virginia City area is indicative of low temperature hydrothermal deposition and exomorphic metamorphism. The ratio of hydrothermal to exomorphic mineral occurence is on the order of

6 to 4. The prevalence of higher temperature hydrothermal minerals runs a fairly close third.

On a worldwide basis, important deposits of gold occur throughout the entire hydrothermal temperature range of deposition, and the same is true of primary copper ore, although the greatest copper deposits in western United States were generated in the upper middle range. Argentite, the most important primary ore mineral of silver, has been found in the Virginia City district. It commonly forms in the zone of lower middle temperatures. Considering gold, silver and copper, only the primary copper ores are ever found commercially in the contact metamorphic zone of ore deposition.

An important lithologic anomaly contributing to the favorability of the Cemmilex Prospect is the greenstone rock of cut number 3. Considerable chlorite is present, a mineral which, when formed hydrothermally, deposits at high temperatures. Chlorite may also be an alteration product of other minerals like the pyroxenes and amphiboles. The possible significance to the work at Cemmilex is that chloritic alteration might have taken place hand in hand with the introduction of metals like gold and copper in commercial quantities.

The specimen of rich ore-grade copper recovered from cut number 1 is somewhat weathered, showing that it reposed above the water table in the zone of oxidation for a time. However, since the bulk of this specimen's contents is primary and not secondary, it could be that gold occurs in proximity, since primary copper minerals are seldom found without some associated gold. On mineralogical and petrological grounds, the chances of finding commercial gold and copper ores are better here than the chances of making a silver discovery.

The greenstone rock body probably is a dike and it may be at least 500 feet wide. Such a dimension implies the association of metalliferous deposits, along with the greenstone, containing gold in quantities large enough to supply the rich metal of the Lucas Bar placer, and perhaps some of the other bonanza placers worked on the downstream side of the Lucas Bar. One must keep in mind, however, that the Cemmilex Prospect, while it has the encouraging signs of development potential indicating a good prospect, is not a mine. And remember that the gold of the elusive mother-lode is still where you find it.

REVIEW OF REFERENCES

SETTING

The subject area (covered by Plate 1) is approximately 11 miles square, with its center about 5 miles south of Virginia City. The Cemmilex Prospect is about 3/4 mile south-southwest of this center and near the crest of the western side of Alder Gulch.

Virginia City is reached via state highway 34 through Ennis, about 16 miles to the east-northeast, and through Twin Bridges, about 29 miles to the northwest. This restored ghost town, and present Madison county seat, is approximately 50 airline miles southwest of Bozeman, 33 airline miles east-northeast of Dillon and 56 miles southeast of Butte. Alder is about 10 road miles northwest on highway 34 and Sheridan about 20 road miles northwest on the same route. Highway 34 terminates at state highway 41 in Twin Bridges and state highway 287 in Ennis.

Alder Creek heads on the north face of Baldy Mountain about 1 mile south of the Cemmilex Prospect and empties into the Ruby River, a course of 19 or 20 miles. Summit, Virginia City, Nevada City and Adobe lie near

its banks. Alder Gulch is bounded on the east by the Jefferson Range, a southern appendage of the Tobacco Root Mountains. On the south is Baldy Mountain, formed at the merged north ends of the Gravelly and Greenhorn Ranges.

The upper reaches of Alder Gulch, including most of the subject area, display very rugged, timber-covered topography where accessibility, except by 4-wheel-drive vehicle, is difficult much of the year; the lower part displays considerable relief but comprises more rounded, grass-and sage-covered terrain.

Within a range of 42 miles and in an arc extending clockwise from west-southwest to north-northeast there were, as of 1959, seventeen named mining locations. The eighteenth such district lies about 11 miles southeast of the Cemmilex Prospect.

The U.S.G.S. Varney Quadrangle topographic map, 1949, shows within the subject area and also within the Virginia City-Fairweather district, fifteen named mines which are, from north to south: Prospect, Alameda, U.S. Grant, Winnetka, Oro Cache, Cornucopia, El Fleeta, Black Rock, Belle, Mountain Chief, Easton Pacific, Pacific, Bartlett, Marietta, General Shafter, Kearsarge and Garrison. The same map shows several other unnamed mines in the area. According to this source, the Brown's Gulch mining district, from the headwaters area of Brown's Creek to its juncture with Alder Creek, includes at least nine mines.

Older writings define the modern Virginia City-Fairweather district in terms of six subdistricts as follow: Junction and Nevada City, both

northwest of Virginia City; Highland, Pine Grove and Summit, spotted in that order south of Virginia City, and Brown's Gulch which extends from its headwaters west of Summit, the most productive part, to its mouth at Alder Creek, where considerable placering has been done.

The southeast corner of the Dillon quadrangle lies just northwest of the subject area. Older references list seven mining districts within its borders, namely: Fleecer Mountain, Siberia or German Gulch, Moose Creek, Highland, Melrose, Rabbit, and Vipond.

Slightly more than the eastern half of Plate 1, the subject area, lies within the southwestern corner of the area covered by the U.S.G.S. Three Forks Folio, No. 24.

GEOLOGY

Sedimentary Rocks.

Many thousands of feet of rocks, from Precambrian to Quaternary in age, have been deposited in this region, and many of them subsequently removed by erosion.

The oldest rocks in the region are of Archean age and, from some viewpoints, should include only those rocks wholly or chiefly of igneous origin. They are composed of gneiss and schist, highly metamorphosed.

Other Precambrian rocks, probably belonging to the Proterozoic Cherry Creek group or Pony series, are clearly of sedimentary origin. Many quartzitic and shaly or argillitic strata exist, often interlayered with schist, phyllite and other phases of moderately metamorphosed rocks. A pronounced unconformity likely exists at the base of the Proterozoic sequence. The highly disturbed condition of the Cherry Creek and Pony series indicates profound tectonic activity prior to deposition of the

Proterozoic Belt formation, indicating a probable intra-Proterozoic unconformity of considerable importance.

Presumably the earliest Cambrian rocks unconformably overlapped older rocks, but there is no clear evidence that the change from Proterozoic to Cambrian was not transitional. Indeed, it may be that in some cases, at least, parts of one system are included with the other.

The Cambrian, Devonian, Mississippian, Pennsylvanian, Permian, Triassic, Jurassic, Cretaceous, Tertiary and Quaternary periods are represented in the general region by a wide variety of sediment types which range into low grade metamorphic rocks such as quartzites, phyllites and argillites. Notably absent are rocks of Ordovician and Silurian age. Rocks of many lithologic types, varying in age from Archean to Cretaceous, have served as host rocks for mineral deposits. The entire section from the Cambrian into lower Tertiary presumably dips concordantly, indicating that, despite repeated and pronounced vertical crustal movements, there was little compressional distortion during that long span of time.

Gravels of Alder Gulch are considered to be Quaternary since they are continuous with known Quaternary deposits along the Ruby and Jefferson Rivers. They may, in the lower part of the gulch, rest upon a false bedrock formed from volcanic ash which is thought to be of Miocene or Pliocene age.

Metamorphic Rocks.

There are rocks in the region which formed both from dynamic and contact metamorphism. Certain mineral assemblages indicate both exomorphism and endomorphism. In the former, country rock is altered by the

intruding material, and, in the latter, the crystallization and composition of the intruding material are affected by contact with and assimilation of country rock.

Intense metamorphism occurred prior to deposition of the Proterozoic rocks and probably after deposition of the Cherry Creek group and Pony series, but prior to deposition of the Belt formation, though less profoundly in the latter case. A great deal of dynamic metamorphism must have occurred during the transition from Mesozoic to Cenozoic time; and contact metamorphism later in Tertiary time with emplacement of the Boulder Batholith.

Probably most of the contact metamorphism occurred with emplacement of the batholith and its many offshoots, and continued for some time as a result of later stage emanations from that great igneous body.

Metamorphism varies from high grade, as revealed by gneisses and schists containing garnet and actinolite, to low grade, as marked by quartzite and argillitic shale.

Igneous Rocks.

Dominating, and likely parental to all the intrusive igneous rocks of the region, is the granitoid Boulder Batholith of Tertiary age. The batholith was seemingly emplaced by a combination of faulting, thrust faulting, assimilation of country rock, and updoming.

Though the Virginia City-Alder Gulch area is not specifically mentioned in this connection, it is stated with respect to the Dillon quadrangle, that nearly all the mountains and mountain ranges in the region are underlain by segments of the Boulder Batholith. In the writer's view it is logical to presume the same to be true of the subject area. No proof is offered that all appendages of the batholith were emplaced simultaneously, even though they are all considered to be of Tertiary age.

Quartz monzonite is considered to be the predominant rock of the batholith, true granite being rare. Aplite dikes are common in the upper part of Brown's Gulch, and at Butte. Some of these are granite, but others, since they contain as much plagicoclase as orthoclase are classed as quartz monzonite aplite.

Around Virginia City there are considerable quantities of Recent and Tertiary basalt flows. In the same area are small patches of andesite volcanics containing phenocrysts of biotite and plagioclase in a matrix of the same minerals; also included are some magnetite, apatite and rock glass. Some of the unaltered plagioclase phenocrysts contain carbonate. A fine-grained trachytic basalt containing augite phenocrysts and very small serpentinized olivine phenocrysts of yellow to dark brown color also occur there.

North of the East Gallatin River and west of Dry Creek, the Flathead quartzite is downthrown in blocks along transverse faults, and sheets of igneous rock lie on the quartzites in the fault blocks.

During the Miocene or Pliocene epochs of Late Tertiary time, strong volcanic activity produced great quantities of volcanic ash and dust which rapidly collected in valleys to form a false bedrock along Alder Creek below the point where it leaves the gulch.

Structure.

During the Tertiary period, the Boulder Batholith was emplaced through the mechanisms of normal faulting, thrust faulting, updoming and assimilation of country rock. Thus, the present structure of the region doubtless owes the batholith for much of its origin. Whether or not the batholith and all of its appendages were emplaced simultaneously

is not known. Recent geologic work has defined an igneous body called the Tobacco Root Batholith, which covers an area in the northern part of the Tobacco Root range. This may or may not be an integral part of the Boulder Batholith.

Thick deposits of sediments attest to the forces which acted vertically. Folds and high angle reverse, or thrust faults, resulted from horizontal compression. The entire structural setting has been further complicated by the emplacement of dikes, sills and laccoliths, and the ejection of surface flow rocks.

The extreme structural complexity of the Cherry Creek group and Pony series marks a great epoch of folding and deep erosion prior to deposition of succeeding strata.

All formations from Cambrian to lower Eocene age dip essentially in concordance despite intermittent pulsations of uplift and subsidence. It is, therefore, concluded that no great compressional forces were active during that enormously long span of time. The great series of conformably dipping strata are tightly folded by forces that began to act about the end of Cretaceous time, and probably acted periodically and with diminishing intensity, to Recent time.

In the Three Forks area fold axes are variously oriented, probably as a result of independent centers of disturbance, and limbs are commonly overturned. Anticlines are often limited in horizontal extent and usually plunge sharply. Some strata are overturned southeastward, and like conditions have been observed in the Bridger, Madison and South Jefferson ranges. Synclines dip most steeply on the western, northwestern and northern limbs.

Three principal faults, striking about N50W, cross the Gallatin Range, and two of them extend across the Madison Range to the western part of the Three Forks area. There seems to have been conflict of opinion among earlier observers as to whether these faults are the normal or the thrust type.

North of the East Gallatin River and West of Dry Creek are several transverse faults along which blocks of Cambrian Flathead quartzite have been downdropped. Horizontal displacement is about 300 feet and vertical movement about 100 feet. One fault has been traced up into the Carboniferous, but most of them seem only to have affected the Cambrian strata. Wherever the downdropped blocks occur, a sheet of igneous rock rests on the quartzite.

MINERALOGY AND PETROGENESIS

The mining districts in the Dillon quadrangel are in or near the Boulder Batholith or its apophyses; the host rocks are limestone, sandstone, conglomerate, shale, quartzite, dolomitic limestone, gneiss and schist. The batholith is commonly termed granitic but the true composition is closer to that of a quartz monzonite. Some aplite dikes have the composition of granite but others are quartz monzonite.

Mineral suites found in the region indicate the occurrence of metamorphism, hydrothermal deposition and secondary deposition by circulating meteoric waters.

Two types of contact metamorphism are evident, (1) exomorphism in which certain constituents of an igneous magma escape into country rock to form an associated group of minerals, and (2) endomorphism in which an intruding magma partially or completely assimilates segments of country rock to form another generally associated suite of minerals.

Hydrothermally formed minerals fall gradationally into four groups, based on the temperatures at which different minerals crystallize. Rated from highest to lowest temperatures of deposition hydrothermal deposits are: (1) hypothermal, (2) mesothermal, (3) leptothermal, and (4) epithermal. Theoretically, hypothermal minerals form at greatest relative depth and epithermal at shallowest.

Secondary deposits involve minerals falling into two suites, oxides and sulfides. Oxides form above the water table and sulfides within and below it. The constituents of these suites of minerals are dissolved by meteoric water and carried downward to be redeposited in the oxide and sulfide zones.

Minerals and their associated metals found in the Virginia City and Dillon Districts are as follow:

Actinolite	Calcite	Fluorite	Microcline
Anorthoclase	Cerargyrite (silver)	Galena (lead, silver)	Molybdenite (molybdenum)
Apatite	Cerussite (lead)	Garnet	Montanite
Argentite (silver)	Chalcopyrite (copper)	Gold, native	Muscovite
Arsenopyrite (arsenic)	Chalcanthite (copper)	Graphite	Nagyagite (lead-silver telluride)
Asbestos	Chalcocite (copper)	Gypsum	Opal
Atacamite	Chlorite	Hematite (iron)	Orthoclase
Augite	Chrysocolla (copper)	Hornblende	Paragonite
Axinite	Copper, native	Hubnerite (tungsten)	Plagioclase
Azurite (copper)	Corundum	Kaolinite	Polybasite
Barite	Cuprite (copper)	Limonite (iron)	Proustite (silver)
Biotite	Diopside	Magnetite (iron)	Pyrargyrite (silver)
Bornite (copper)	Dolomite	Malachite (copper)	Pyrite
Bromyrite	Ecdemite	Melaconite Melanterite	Pyrolusite (manganese)
Calamine (zinc)	Epidote		

Pyromorphite (lead)	Silver, native	Stromeyerite (silver, copper)	Tridymite
Pyrrhotite (nickel)	Smithsonite (zinc)	Sylvanite (gold-silver telluride)	Vanadinite (vanadium, lead)
Quartz	Sphalerite (zinc)	Tetradymite	Wulfenite (lead)
Sericite	Stephanite (silver)	Tetrahedrite (copper, silver)	Zircon
Serpentine	Rutile	Titanite	Zoisite
Siderite (iron)	Stibnite (antimony)	Tourmaline	

Of all the minerals identified exclusively in the Virginia City area, or in that area and also in the Dillon area, but never exclusively in the Dillon area, those generated by leptothermal-epithermal agencies or exomorphism are clearly the dominant suites. The ratio of those embracing the two hydrothermal classes to those of exomorphic genesis is on the order of 6 to 4.

More minerals have been identified in the Dillon area than in the Virginia City area, and, when the Dillon assemblage is given slightly more statistical weight, minerals characteristic of the oxide zone, and habitually formed considerably nearer the surface than hydrothermal or exomorphic minerals, attain some prominence. The following proportion then obtains. Leptothermal-epithermal: exomorphic: oxidational:: 44 : 30 : 26. If we assume that oxides were found in greater abundance simply because of their easier accessibility, and if we disregard them, the ratio of leptothermal-epithermal to exomorphic minerals is again 6 to 4, and hypothermal-mesothermal types third. So, one can postulate that lower temperature hydrothermal ore deposits are dominant and those of exomorphic origin fairly close beneath.

The silver sulfide ARGENTITE (called silver glance), most likely to be of leptothermal genesis, is the greatest single primary source of

silver. It has been identified in the Virginia City district but not in the Dillon quadrangle.

ECONOMIC GEOLOGY

General.

The primary source of the placer gold deposits in the Virginia City district has not been satisfactorily determined, though quartz veins were the source of some of the earliest gold taken from Alder Gulch. In Brown's Gulch the ores have been found only in a quartz monzonite aplite rock that is intrusive into gneiss and schist. Elsewhere in the region the ores occur in ancient gneissic rocks closely associated with igneous intrusions. This brings up the question as to whether or not the Virginia City ores are associated with some part of the Boulder Batholith. Clearly, they are not genetically related to Tertiary flows of basic rock, which are younger than the ores.

Minerals formed from cold solutions, which chiefly descend from the ground surface, belong to two classes, namely, those formed under conditions of oxidation and those deposited under deoxidization. Certain minerals are characteristic of the oxidized zone, which lies above the ground water level. Minerals found in the zone of sulphide enrichment directly below the oxidized zone and within or below ground water level arise from deoxidation. Native gold, silver, carbonates of zinc, lead and copper, oxides of iron, vanadium and other metals are diagnostic of the oxide zone. The zone of sulphide enrichment is characterized by native gold and sulphides of silver, copper, lead, and zinc.

In Alder Gulch placer gold was mined along a 15 mile stretch of stream sands and gravels. About three miles of gravel were worked by large dredges. The gold varied in coarseness and the average size of gold

particles increased toward the head of the gulch. The best authorities state conservatively that about $50,000,000 worth of gold was recovered from Alder Gulch placers.

Gold was discovered in 1863 near Virginia City by panning stream gravel, and, within one year afterward, gold-bearing quartz veins had been discovered and mining development on them begun. As early as 1866, mills were treating quartzose ores from the vein or lode mines at Summit in Alder Gulch, and by 1871 there were at least 8 mills working near Virginia City.

Summit District, Brown's Gulch and upper Alder Gulch

In the Summit area, the largest producing mines were the Oro Cache and the Kearsarge. The Oro Cache is about a half mile from Summit in Spring Gulch. Its ore vein is about 4 feet wide, strikes N10E and dips about 65W. Sulphide ore was encountered at a depth of about 100 feet. Reportedly, the mine yielded about $400,000 worth of gold in the years between 1864 and 1880. Like most of the gold-lode mines in the region, the Oro Cache has been inactive for many years.

The Kearsarge mine had large bodies of ore in one vein and a parallel system of lenses. The ore-enclosing rock is gneiss and schist which strikes about N30E and dips 60NW, with the ore veins conforming in a general way to the attitude of the schistosity. Both veins and ore bodies are composed largely of crushed feldspar clay, abundant quartz, and subordinate amounts of cholorite, calcite and gold-bearing pyrite, as coarse native metal, and less commonly, as gold tellurides.

Some other mines at Summit, all of which carried gold exclusively, are the Keystone, Lucas, Polar Star, Excelsior, and Nelson.

At the U.S. Grant mine, about a half mile upstream from Virginia City, a tunnel at the concentrating mill level penetrated about 200 feet of decomposed basaltic rock before entering the gneiss. Pyrite, chalcopyrite, and galena were found in quartz veins and stringers, especially the latter. One vein was 2 feet wide, had strike of N45E and dipped about 45NW. Much of the developed ore was oxidized and enriched by minerals deposited from surface waters.

A fissure vein was traceable for about 600 feet on the surface at the Winnetka mine, located 3 miles upstream from Virginia City. The vein carried equal quantities by weight of gold and silver. Quartz, pyrite, and telluride occurred with a little chalcopyrite, malachite, pyrargyrite, sphalerite, and galena. Strike is about due east and dip is about 45S. At one place in the mine the vein is faulted off.

In Brown's Gulch two claims had two ore shoots on the same vein of quartz monzonite aplite rock. On the Pacific claim, the vein was not productive below a depth of about 300 feet. Gold, free silver, and silver sulphides were present in a mixture of quartz and iron oxides.

PRESENT EVALUATION

PLATE 1, Photogeology

The Cemmilex Prospect area occupies only a very small portion of the subject area. One may, therefore, wonder why an area this size was photogeologically mapped. There are two principal reasons.

First, when working with vegetation-covered Precambrian rocks which have been severely deformed it is necessary to view such features as faults and structural dip for considerable distances to lend reasonable verification to their existence. The same is true of subtly expressed vegetational patterns which may be indicative of mineralization.

Second, very commonly, clues bearing importantly on a highly localized area but not detectable there can be discovered in the surrounding terrain and used, by projection, to help clarify the local problems.

The anticlinal nose shown on the Plan View of Plate 2 tends to be verified by the long anticline beginning in sec. 7, T7S, R3W. In the restricted area of the Plan View faults 1 and 6 would be only mildly suspected on the basis of topography, and the others would not even be suspected at all. Their linear extent on Plate 1 affords considerable reason to believe in their existence though they are shown as inferred. The other faults, once discovered in the surrounding environs, could then be mapped with reasonable assurance into the local area. Truncation of the outcrop patterns of sedimentary beds in secs. 10, 11 and 14, T8S, R3W offer the strongest evidence of thrust faulting, and their continuing traces indicate that the Cemmilex Prospect area was affected by them.

The regional synclinal axis of Paleozoic and Mesozoic folded rocks beginning at least as far south as sec. 12, T8S, R3W, and extending northward in recurving fashion at least to sec. 32, T6S, R2W is a dominant feature in the area. Its configuration and overturned western limb indicate that the limit of the rocks' capacity to absorb horizontal compression by folding was reached and the remaining foreshortening required by compression was accomplished through the rupturing mechanisms of thrust and shear faulting.

Since the Tertiary lavas were not concordantly folded in the syncline we can conclude that the major folding predated their deposition. The gentle northeasterly dip of the Tertiary lavas suggests that compression, with greatly diminished intensity, continued until after the lavas were deposited. The diminishing of force affecting the younger rocks may have resulted from the force-absorbing thrust fault mechanism to the west. Therefore the thrust faulting likely continued into, or was renewed in, Tertiary time.

As part of the rupture mechanism, shearing may have occurred along the two parallel faults extending from sec. 35, T6S, R4W and sec. 33, T6S, R3W into sec. 1 T7S, R3W. Concurrent shearing likely occurred in the Cemmilex Prospect area. With relaxation of tension gravity faulting along the shear planes definitely downdropped Tertiary sediments against Precambrian metasediments in the northwestern corner of the map. Definite normal faulting that cut Tertiary lavas also occurred in sec. 36, T6S, R3W. They trend almost perpendicular to the two long, east-west faults noted above, and though penetrating Tertiary rocks are probably the older, since one of them, and others on the same trend, are offset by the east-west faults.

Faults of at least three ages, and at least two periods of folding are discernible in the subject area. The younger of those events were apparently intermingled with emplacement of the Boulder Batholith, considered to be Tertiary in age. Whether the Boulder Batholith was forcefully emplaced and caused the structural features, or was permissibly emplaced as a result of structure caused by other orogenic forces, cannot be ascertained.

At any rate the area was greatly disturbed during the Laramide orogeny, when mineralization may have begun, and then continued well into Tertiary time.

Cursory field observation indicates that the rocks assigned to the Archean on Plate 1 are more likely to be Proterozoic. Archean rocks may, however, be exposed where streams are most deeply incised, particularly across anticlines.

PLATE 2, Local Plan View and Cross Sections

This illustration is in two parts, (1) a plan view made by enlarging part of an aerial photograph to three times the original, and (2) a

series of 5 cross sectional sketches lettered a-a' through e-e' and drawn at twice the scale of the plan view, where the lines of section are shown in red.

The plan view is intended to show the logic of believing that the greenstone body (E in cut 3, colored green) is ideally situated to have fed placer gold to the Lucas Bar. The cross sections are to replace hundreds of words needed to explain clearly what, based on very limited control, the subsurface conditions may be.

Two apparent faults were early discovered on aerial photographs. They are numbered 1 and 2. Fault 1 is most clearly defined and can be called the Cemmilex Prospect "discovery" fault, as trenching, which led to discovery of the greenstone body (E in cut 3), was initiated on its trace. Faults 1 & 2 are now believed to be the result of underthrusting. Faults 4 and 5 are thought to be the overthrust type. Faults 3 and 8 are believed to be shear, or tear, faults which contributed to relief of horizontal stress in such a way that over and under thrusting occurred in blocks rather than continuous sheets. Most movement was horizontal but some dip-slip movement likely occurred also. Relative movement was probably eastward and downward on the north sides of the shear faults.

At least some of the gold taken from the Lucas Bar presumably traveled only a few hundred feet prior to deposition in the placer. Topography eliminates the possibility of a source to the north, east or southeast; and placer gold in the Lucas Bar could not have derived from other mining areas to the northwest. Exhaustive prospection to the southwest has revealed no source. Considering this, the short distance the gold was transported, and the topographic process of elimination the remaining possibility is to the west.

The greenstone body is exposed to a depth of approximately 3 feet in cut No. 3. It is distinctly in angular discordance with the overlying, partially decayed strata. The surface of the greenstone slopes noticeably to the southwest and the overlying metasediments dip eastward in accordance with the anticlinal nose shown in the southern part of fault block 1. There is a persistant 3-inch layer of greenish-gray clay on top of the greenstone. It is obviously a weathering product of the greenstone and has good lubricating qualities. The clay grades into very soft greenstone which gradually hardens downward. Chlorite is probably the greatest constituent of the greenstone but some ruby-colored streaks can be seen in the unit, no change in crystalline character being evident with the color change.

Due to its softness a stream could easily cut a channel in the greenstone where exposed in the core of an anticlinal nose. Intense scrutiny of the aerial photographs revealed some U-shaped lineations indicative of rock creep. They are near the mountain peak (A, Plan View) where the slope is very steep. Springs emanating farther down the mountain indicate a subsurface flow of water. The creep scars, springs, lubricating quality of the clay on top of the greenstone, and the decaying condition of the superjacent metasediments add up to the possibility of a fossil stream channel as postulated at H, Plan View. A deep gully may have been incised in the soft greenstone during a period of exceedingly heavy rain in the Pleistocene epoch. Subsequent weathering of the greenstone surface produced the lubricating green clay which induced rock creep into the gully and down the mountain. Owing to the steep slope, a minor earthquake could have triggered the movement.

Such a "phantom" stream, unthought of in previous prospection, is ideally situated topographically and horizontally to have carried gold

into the Lucas Bar. The change from the high gradient of a stream flowing down the mountain side to the much lower gradient of Alder Creek occurs at about the 7460 foot contour. Thus the maximum distance the Lucas Bar nuggets would have been transported before reaching the upper end of the placer is less than 5/8 mile.

Not only does the shaft (O, Plan View and Cross Section a-a') tend to substantiate a buried stream channel but it suggests a deep and abrupt gully. It is down some 50 feet and has not reached solid bedrock. It was sunk to test the continuity of the southwesterly slope of the top of the greenstone, as cut No. 3 could not be bulldozed deeper without a cave-in.

Some ten feet or more of a slippery, tenaceous, blue clay have been penetrated in the bottom of the shaft. One miner helping to sink the shaft also worked on the Lucas Bar and he says the clay is identical to a layer immediately overlying the gold-bearing gravel in the placer.

Irregularities, or "riffles", on the bottom of a stream channel will sluice out gold nuggets and heavy pebbles. Assuming a buried stream channel exists as postulated, one can surmise further that in the deepest part there would be a more or less continuous layer of blue clay immediately overlying any sluiced, gold-bearing gravel. Sections d-d' and e-e' were drawn respectively subparallel and parallel to a postulated greenstone dike (stippled, F, Plan View) occupying the core of an anticline, and into which the stream cut its channel. If, (1) the fossil stream channel can be proven, and (2) bottom-sluiced placer material can be found in it, there is sound reason to believe that the lode which supplied the Lucas Bar is nearby.

One must account for the fact that gold deposition apparently ceased prior to deposition of the superjacent clay layer in the Lucas Bar. It is possible that only a certain horizon of the greenstone weathered into the

clay, and that the gold bearing zone was immediately above it. This would indicate that the near-surface gold has been eroded away.

On the other hand, creep may have commenced high on the mountain and moved down far enough to bury the lode and cut off the gold supply, but not far enough to cut off the clay supply which then continued to be carried from the lower reaches of the stream and deposited as a seal over the Lucas Bar.

Fault block 2 may be thrust under fault block 3 and block 1 under block 2. Thus considerable primary gold may be preserved beneath the upper plates. And there is no reason to believe that its depth is too great for profitable mining. As an example, d-d' is drawn with the eastern end just north of the wall of the hypothetical dike; if the lode horizon is horizontally equal to the top of unit 4 of the country rock, it would be approximately 80 feet beneath the surface along the line of section. Only core drilling will suffice to test the subsurface in this respect.

Sections a-a', b-b' and c-c' are drawn at right angles to the strike of the postulated greenstone dike. Control is so sparse that they must be considered imaginary, and close scrutiny will reveal certain disparties. The movement arrows on fault 1 of section a-a' represent a glaring error discovered too late for cartographic correction; they show the movement opposite to the way it is believed to be. Section a-a' depicts a clean-walled dike, b-b' a moderately clean-walled dike and c-c' an irregular intrusive mass retaining some characteristics of a dike.

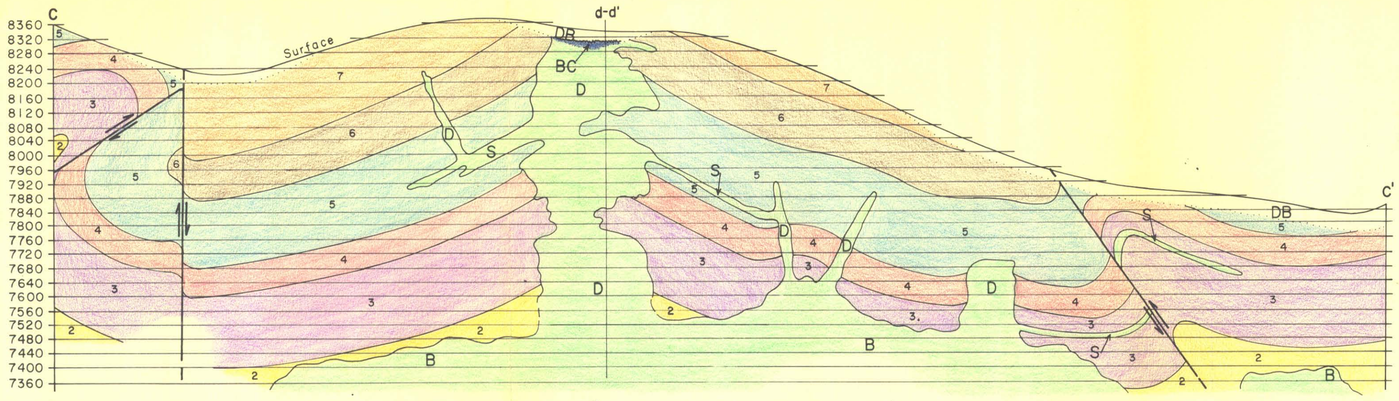
The slightly mineralized "sill" (G, Plan View) is known to exist; d-d' illustrates that the hypothetical greenstone dike may be parental to it, and also how one may account structurally for its outcrop.

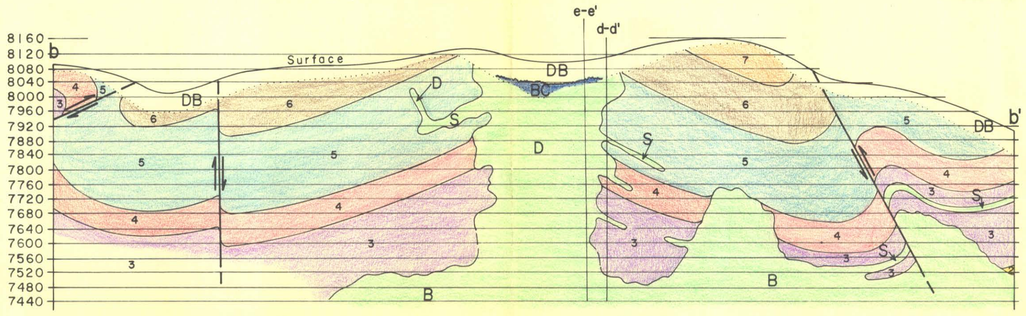
Regardless of the innumerable possibilities surrounding the Lucas Bar placer gold and the lode that furnished it, if the phantom stream chan-

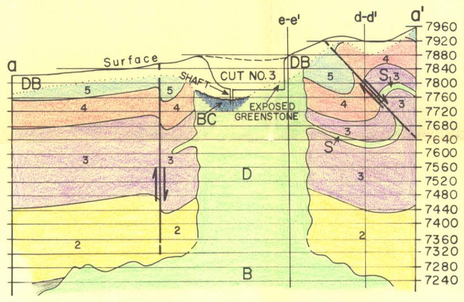
nel does in fact exist, the implication of an intimate relationship is clear. Furthermore, if some placer gold is found preserved on the stream bed it is proof that the source of supply is very nearby, and probably not exhausted. If such is not found the source of supply in the exposed part of fault block 1 may be exhausted, but even so other parts of a lode may exist at mineable depths beneath fault blocks 2 and 3.

W. W. Shisler

W. W. Shisler
Geologist





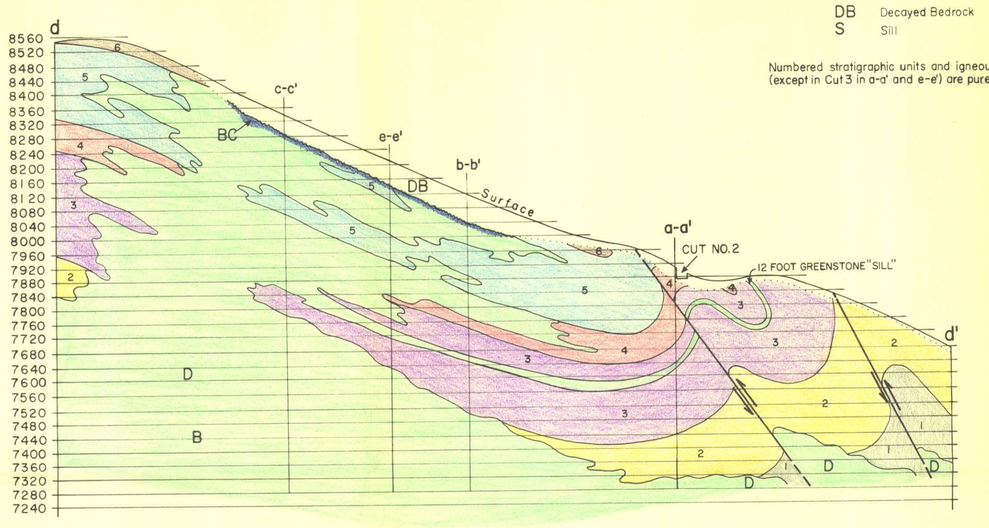


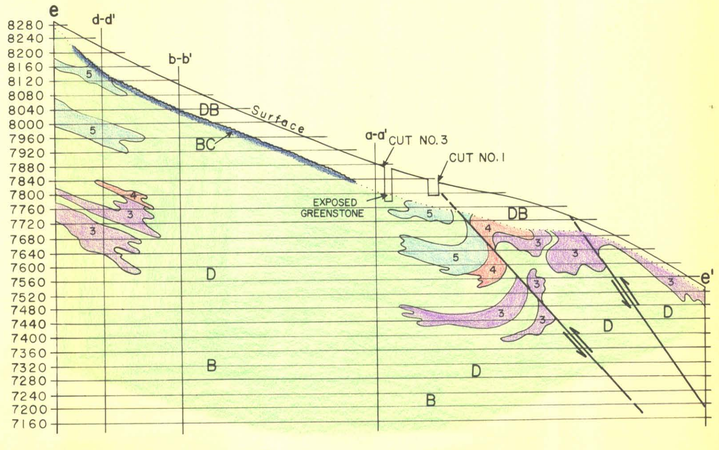
CROSS SECTION LEGEND

Approximate Vertical and Horizontal Scale 1/10 inch = 27 feet

- B Batholith
- BC Blue Clay
- D Dike
- DB Decayed Bedrock
- S Sill

Numbered stratigraphic units and igneous features (except in Cut 3 in a-a' and e-e') are purely illustrative





PLAN VIEW LEGEND

- A Slump scars
- B First cut
- C Second cut
- D Third cut
- E Greenstone "dike" exposed on S.E. side of third cut
- F Trend of possible greenstone "dike"
- G Mineralized greenstone unit about 12 feet thick, possible "sill"
- H Possible slump-filled drainage channel
- J Possible high angle reverse or underthrust faults, points on side of upper plate
- K Possible overthrust faults, points on side of upper plate
- L Possible horizontal movement along shear faults
- M Possible anticlinal axis
- N Lucas Bar
- O Shaft
- P Dip and strike
- Q Springs
- R Present drainage channels
- S Topographic contours
- T Unclassified possible faults
- U Road or trail visible on photograph

Plan View

Approximate Scale 1/10 inch = 54 feet

Contour Interval 40 feet

0 500 1000 1500 2000 Feet

0 1/4 1/2 Mile

APPROXIMATE TRUE NORTH

CROSS SECTIONS through the [redacted] PROSPECT

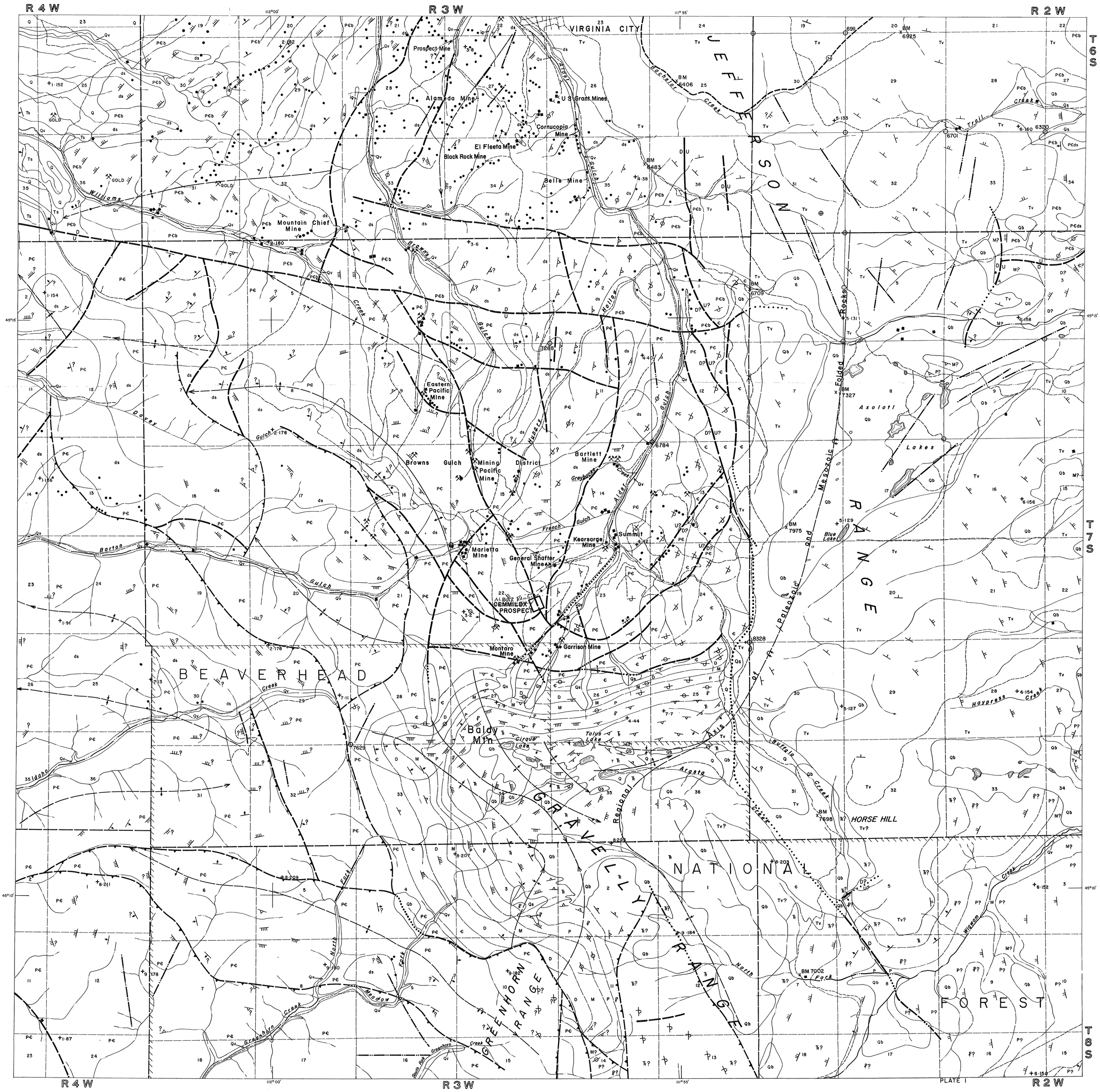
Alder Ventures

SEC. 22, T 7 S, R 3 W, MADISON CO., MONTANA

PREPARED BY

SHISLER GEOLOGICAL ASSOCIATES · MINNEAPOLIS, MINNESOTA

October, 1961



CENOZOIC

QUATERNARY

Q — Undefined surficial material

Qb — Slump; includes undeteriorated bedrock which may appear to be in place from local observation.

Qs — Slump; soil with segments of bedrock more deteriorated than in Qb.

Qv — Valley bottom alluvium; mainly gravel, may include placer gold.

TERTIARY

Ts — Mostly poorly consolidated clay, silt, sand and gravel with possible tuff, lignite, bentonite and lava. Mainly deposited as stream and fan alluvium, but some deposited in lakes.

MESOZOIC

TRIASSIC

TR — DINWOODY and THAYNES formations and other Triassic units including the CHUGWATER of Triassic and Permian age. Conglomerate, sandstone, shale and impure limestone.

PALEOZOIC

PERMIAN

P̄ — PHOSPHORIA formation (mainly). Chert, limestone, sandstone, shale and quartzite with phosphate rock mostly at base.

PENNSYLVANIAN

P — QUADRANT quartzite with limestone and other strata of Pennsylvanian age.

MISSISSIPPIAN

M — MADISON group, limestone, in part probably dolomitic, sandy or cherty.

DEVONIAN

D — THREEFORKS formation and JEFFERSON limestone. Former mainly carbonaceous and calcareous shale. Includes other unnamed units of Devonian age.

CAMBRIAN

Є — Undefined but probably FLATHEAD quartzite; mainly quartzite varying to sandstone. May be overlain by FLATHEAD shale. The two may in places be separated by a layer of eruptive rocks. In places rests on Belt series and in others on Precambrian schists and gneisses. In places may include Precambrian units and in others may be partly included with Precambrian.

PRECAMBRIAN

PROTEROZOIC ?

PЄb — Possible BELT rocks; gneiss and schist with included conglomerate, sandstone, limestone and quartzite.

ARCHEOZOIC

PЄ — Probably ARCHEAN; predominantly gneiss and schist thought to have formed from very ancient igneous rocks.

IGNEOUS ROCKS

THOUGHT TO BE OF EARLY TERTIARY AGE
Probably of Boulder Batholith Parentage

Tv — Flows of latite, quartz latite andesite and basalt with associated pyroclastics and intercalated sediments. May include some pre-Tertiary volcanics.

ds — Rocks invaded by dikes and sills, too numerous for individual mapping. Light-toned on photos. Aplitic intrusions are known in the upper reaches of Brown's Gulch.

ig — Apparent etrusive bodies large enough to be mapped individually. Darker-toned on photos than ds. Noted only in PЄb

PHOTO-INTERPRETED DIP AND STRIKE OF SEDIMENTARY BEDS, LAVA FLOWS OR OTHER PLANE-FORMING SURFACE OF CONTINUITY SUCH AS GNEISSIC BANDING.

- Dip 1° to 3°
- Dip 3° to 10°
- Dip 10° to 25°
- Dip 25° to 45°
- Dip 45° to vertical
- Vertical
- Overturned
- Flat
- Amount of dip indiscernible

APPROXIMATE SURFACE TRACES OF FOLD AXES

ANTICLINE: Plunging to right; overturned at left with arrows pointing in direction of dip of overturned limb

SYNCLINE: Overturned at left with arrows pointing in direction of dip of overturned limb

FAULTS

NORMAL

THRUST OR HIGH ANGLE REVERSE
Points on side of upper plate

ALIGNMENT: Topographic or vegetational, may or may not reflect faulting

Faults, contacts and axes are solid where definite, long dash where location is uncertain and short dash where inferred. Faults are dotted where covered by Quaternary or other younger material.

STREAM CHANNELS — LAKE

BM 6772 — BENCH MARK AND ELEVATION

5946 — INDICATED SECTION CORNER WITH ELEVATION

SECTION LINE

TOWNSHIP LINE

Section and township lines dashed where location is approximate.

NATIONAL FOREST BOUNDARY

PROSPECT — MINE TUNNEL ENTRANCE

SCAR — BUILDING

MINE

MAIN ROAD

SECONDARY ROAD OR TRAIL

6·15 — PHOTO CENTER LINE NUMBER AND PHOTO NUMBER

PHOTOGEOLOGIC INTERPRETATION MAP

OF AN AREA IN

MADISON COUNTY, MONTANA

PREPARED BY

SHISLER GEOLOGICAL ASSOCIATES · MINNEAPOLIS, MINNESOTA

June 1961

Approximately 3 1/4 inches equal 1 mile

0 — 1½ — 2 Miles
0 — 5000 — 10000 Feet

Approximately 1/10 inch equals 160 feet

TRUE NORTH — MAGNETIC NORTH

Mean declination, 1961