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Ore Deposits of Central Montana

by

A. L. McGuinness

Mining 111A

INDEX

Introduction

Purpose of the report..... 1

Location of the area..... 1

Geologic history of the area..... 2

Structure of the area 3

Bearpaw Mountains 5

Castle Mountains 8

Judith Mountains 11

Little Belt Mountains 15

Neihart district 17

Barker District 25

Yogo District 26

Little Rockies 27

North Mocassin Mountains 32

Sweetgrass Hills 35

Summary and Conclusions 37

List of references 39

Introduction

Purpose of the report: This report is written as a term paper for Mining 111A, its purpose is to study the ore deposits of north-central Montana and attempt to show their structure and ore controls. As these districts are not usually ones of heavy mineralization, it was hoped that the controls for ore deposition would be plainer in these than in the districts in western Montana, where the heavy mineralization has clouded and covered the controls of ore deposition.

In this report I will take each mining district seperately, give its geologic structure, mineralization, and ore controls and also its principal mines. From these facts I will tryand classify the general ore controls of the region.

There will be no attempt made to study the whole regions structure or geologic history in great detail (except where applicable to the ore deposition of the mining districts).

Location of the area: The area discussed covers that region of Montana from just to the east of the Rocky Mtn front to 200 miles beyond it, and extending from the northern border of the state to about 40 miles from the Wyoming state line.

Geologic History of the region: The only exposures of archean rocks in the region are in the Little Belt Mtns, theyare composed of gneisses and intrusives, The Beltian formations are observed in the Little Belt and Castle Mtns but it is probable that some portion of these were deposited over a large area in central Montana.

Near the end of Beltian time, central Montana was uplifted and the pre cambrian se diments were deformed (the belt series was stripped off of a portion of the Little Belt Mtns), and erosion resulted in a base leveling of the area before the middle Cambrian sea, in which limestone and shale were deposited.

As central Montana was on the eastern edge of the mid-paleozoic trough, there were repeated oscillations of the sea and a noticeable difference in thickness of paleozoic beds in different portions of the area, The sea withdrew in ordivician and silurian time and in late silurian and in devonian time re-invaded the area and limestones and shales were again deposited. The sea remained and became more widespread in the carboniferous and the Madison ls and Quadrant sh and ss were deposited.

In late carboniferous time the sea with drew and land conditions prevailed thruout permian and triassic time. Toward the middle jurassic the seas again invaded the area and the Ellis ls and Morrison fm were laid down.

G Geologic history of the region: cont'd

During the cretaceous a succession of withdrawal and invasion of the sea took place but during early late cretaceous time central Montana was about on the center of the cretaceous trough and a great thickness of sediments were deposited.

Accompanying and following the uplift of the Rockies, which took place at the end of the cretaceous , the uplift of central Montana took place, the strong folding of the region is definitly post cretaceous and probably in the most part late eocene.

The tertiary intrusives and extrusives of the area are of eocene age (post cretaceous and pre mioceme) and the ore deposits all are clearly post intrusive.

Structure of the region: The region studied lies east of where the main front range looses its linear character and breaks up into a number of minor ranges, and, to the east, a number of local uplifts and short detached ranges .

The region is the dying out place of the waves of deformation which began on the Pacific coast in the upper jurassic and were not active in central Montana until late or post cretaceous time. Lindgren states that the region is also the "end"of the igneous intrusion and metallization which accompanied the waves of intrusion, these culminated

Structure of the region - cont'd

in the alkali province found in this area.

All the mining districts studied are closely related to igneous intrusion which, with the possible exception of The Judith and N. Mocassin Mtns, came up along zones of weakness in anticlinal arches, broad domes of the weak "hinge" zone on the sides of domal uplift, therefore all are closely associated with uplifts.

Most of the intrusives are laccolithic in form although there are many stock, sills and dikes associated with these. A great majority of these laccoliths probably floored on the pre cambrian schists, gneisses and beltian sediments. The domes south east of the Little Belt Mtns and Porcupine Dome are belived to be of laccolithic origin.

The area north of the Lake Basin fault zone and south of the Blood Ck syncline is belived by W. T. Thom to be the surface representation of the faulting and movement of the deeper seated rocks as blocks, thereby producing the strongly marked assymmetric anticlines and parallel fault systems. He also states that the laccolithic groups of this area (probably the N. Mocassin and Judith Mtns) were probably formed by magmas rising along the fundamental faults and upwardprojections of these planes of weakness.

Bearpaw Mountains

The Bearpaw Mountains consist of the dissected remains of a group of volcanoes of tertiary age. The igneous rocks are both intrusive and extrusive, The extrusives, mostly leucite basaltic tuffs, breccias and flows, make up the m major portions of the rocks of the district. The intrusives occur as dikes, sills, small lacoliths, stocks and volcanic necks; they consist of mica trachyte, quartz porphyry, syenites, tinguaite porphyry, and shonkinite.

The sediments in the mountains proper consist mainly of Cretaceous shales and sandstones, with some tertiary sandstones and shales. The sediments surrounding the larger intrusives have been contact metamorphosed to slates, quartzites, and marbles.

Structure: The principal part of the Bearpaw Mtns. constitutes a subsided area in which there are both normal and thrust faults. The sedimentary formations beneath the volcanics have the structure of a low, broad, dome, the axis of which runs east-west through the mountains. The sediments dip away from the dome on an angle of 10 to 30 degrees.

In the surrounding plains for a distance of 30 miles, around the mountains, the regionally flat lying cretaceous strata are buckeled into a series of long narrow folds, concentric with the mountains , most of these are disrupted by strike thrust faults. The field evidence clearly indicates that these features are related to the mountains

and have resulted from a horizontal shove that was transmitted from these mountains. However there is a great and wide difference of opinion as to the nature and origin of this shove and I will not try to list these as it is outside of the scope of this report.

Ore Deposits: The principal mineral prospects are located on the periphery of old volcanic necks and stocks within the zone of altered sediments. The mineralization occurs along shearzones, joints, and small fractures that are in part due to the intrusion of the igneous mass. The mineralization is also usually associated with dikes or sills which cut both the sediments and the igneous rocks.

The ores consist principally of sulfides, namely, argentiferous galena, pyrite, sphalerite , chalcopyrite, pyrrhotite, arsenopyrite, and quartz and barite. The veins range from small seams to widths of 20 feet (average width being one foot). The veins carrying the greater values tend to have a NW trend.

Mines of the district:

Bears Paw Mine

The ore body occurs near the margin of an intrusive mass of syenite porphry, the gangue of the ore body is the brecciated and altered porphry, the country rock is shale. The mine shaft has been sunk on a dike of shonkinite which cuts both the porphry and the nearby sediments. The vein strikes N40E. Hand sorted ore runs 50 oz of silver and 50-60% lead per ton.

Mines of the district - cont'd

Copper Gulch Group

Ore occurs in the metamorphosed rim of a stock, the ore is found along fractures and shear zones in a dike of syenite porphyry, the ore shows post-mineral movement on the ore fissure.

Edison Claim

Claim consists of a small pit sunk on a vein of barite and calcite along a brecciated zone in a highly micaceous gray dike, the brecciated zone contains small pieces of m metamorphosed limestone. Ore is said to average $6.90 a ton in lead and silver.

Edith M. Claim

Ore occurs in a calcite -quartz vein of which the hanging wall is a dike and the footwall is a metamorphosed impure limestone. Ore carries 8.33% Cu, $10.80 of Au and 14 oz of Ag per ton.

Black Diamond and Rex Claims

Both occur in dark basic dikes and are probably magmatic in origin. The Black Diamond vein consists of magnetite, apatite and augite, while the Rex vein is composed of pyrite, pyrrhotite, chalcopyrite , and augite.

Castle Mountain Mining District

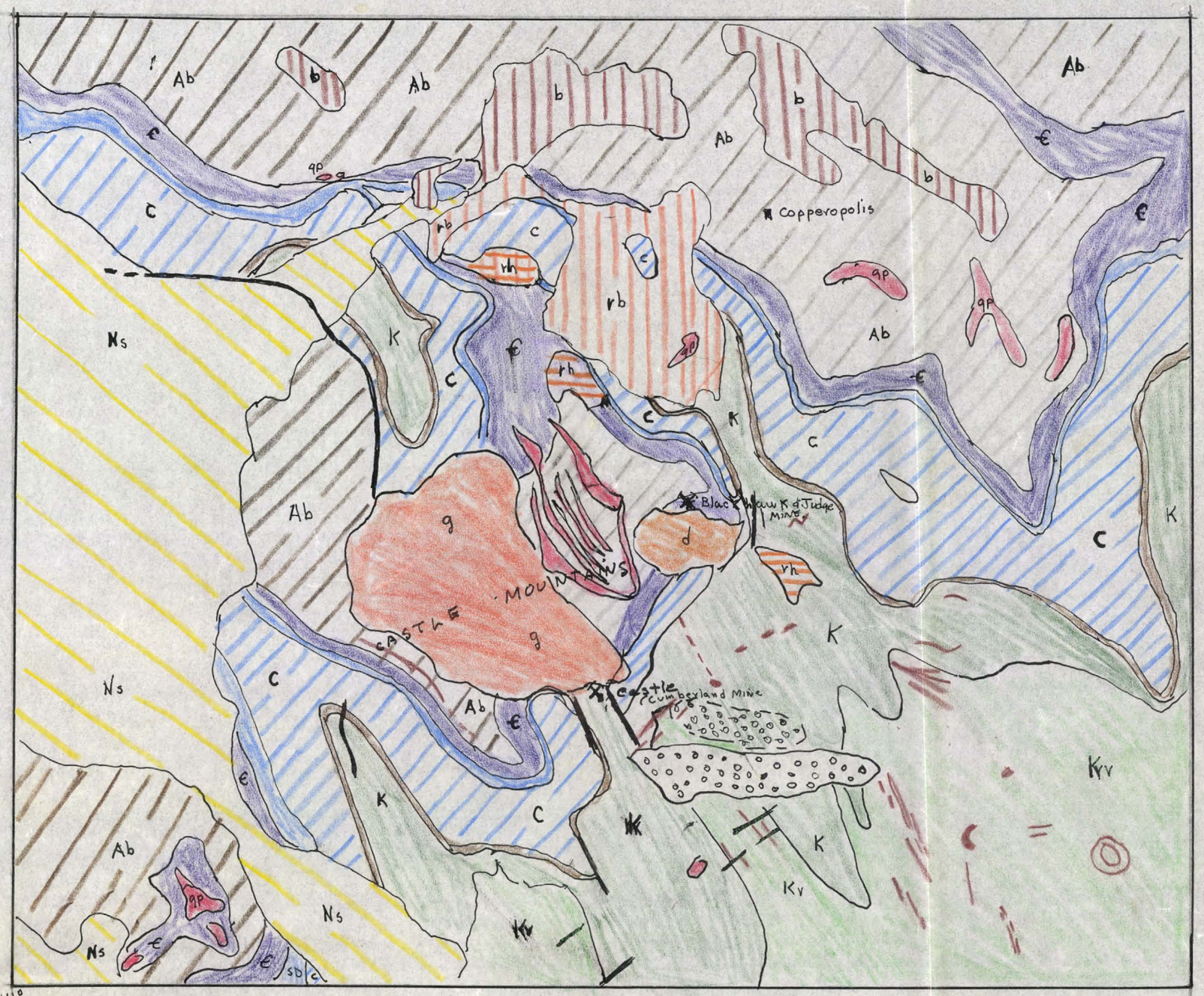
($3,000,000 production)

Castle mountain is an old dissected volcano of granite porphry laid bare by erosion that has not yet entirely removed the surface extrusives. It is probably of laccolithic form. Extrusives are prevalant to the north of the mountain and consist of rhyolitic breccias, tuffs,,and flows, and flows of basalts. There are also several small intrusions of quartz porphyry and diorite.

The sediments of the district range from Algonkian to Miocene in age, their total thickness being approximately 13,100 ft.(+). Broken down by ages theiformations thicknesses are:-

Algonkian (Beltian)	3,000
Cambrian (limestone)	2,475
Silurian (Jefferson ls.).....	715
Devonian (3 Forks sh.).....	145
Carboniferous	
Quadrent sh. &ss.	600
Madison ls.	1,200
Jurassic (Ellis ls and sh, ss.)..	690
Cretaceous (sh,ss, ls, ect).....	7,000
Miocene (lake beds)	

Structure: In its general structure Castle Mtn. is a part of the great anticlinal folds of the belt ranges. Castle Mtn. lies between two anticlines trending northwest and plunging to the southeast. The anticline forming



GEOLOGICAL MAP OF CASTLE MOUNTAIN DISTRICT

Scale: 1.2" = 1 mile.

Geol. by W.H. WEED.

Structure - cont'd

the eastern part of the mountain is a lateral offshoot of the Little Belt anticline, the second of the two larger anticlines is cut off by the granite intrusion of Elk Pk. and forms the west side of Castle Mtn. This fold is one of the plications which form the southwest end of the Big Belt anticline. The doming of the beds by the laccolithic intrusion has been superimposed on these previous features.

Ore Deposits : In this district ore occurs only in the sedimentary rocks which have been altered by contact metamorphism of the bosses of granite porphyry. The only valuable ore is in the limestone at the contact with the porphry or as ore bodies some distance from the igneous rocks. Small important ore bodies occur in decayed basic dikes and there are also some ore traces in the beltian shales.

The ore consists of galena and its oxidation products together with chalcopyrite, pyrite , and oxidized minerals. The gangue is usually silicous jasper passing occassionaly into quartz. The galena is silver bearing.

The ore solutions probably came up the contact between the sediments and the intrusive masses.

Mines of the district:

Cumberland Mine

This mine was the greatest producer in the district, it consisted of one large ore body which had the shape of a pod -shaped mass, roughly ellipitical in cross section, and dipping 60 degrees towards the intrusive near it. The ore body was roughly confined to the bedding of the limestone in which it occured - ore passed into a narrow zone of pyrite vein matter lying between a porphyry dike and the limestone at the 500 ft level.

Great Eastern

Ore occured on contact between white crystalline limestone (brecciated) and porphyry.

The other mines and prospects of the district are of like occurence, i.e. ore on the contact of the ls with porphry. The only one that is different is the Little May &Tip Top in which the ore (not workable) occured in a decomposed minette dike.

Copperopolis

This small district is not associated with the foregoing mines. The ores here consist of veins of quartz and calcite with copper sulfides occuring in the beltian shales; W. H. Weed belives these veins to be of Cambrian age as they do not pass upward into the overlying formations. At the time this report was written (1896) only prospect work was done in this district, although in later years some production was reported.

Judith Mountains

The Judith Mountains are composed of six principal laccoliths of acidic, granite, and syenite porphyry. Five of the laccoliths are below the paleozoic and one is above, they a re both symmetric and asymmetric. There are also numbers of smaller laccoliths which grade out laterly into sheets. No evidence has been seen which would tend to support the view that the mountains owe their elevation to any general folding of the strata, or that the strata lower than those lifted on the backs of the laccoliths are in any other than a undisturbed position.

The total exposed thickness of the sediments in the area is about 2,700 ft, the sediments range from Cambrian to Upper Cretaceous. The thickness of various formations are:-

Algonkian	absent
Cambrian (sh,ls, ls cg).....	500'
Silurian-Devonian.....	400
Lower Carboniferous (ls).....	700
Jurassic (Ellis ls &sh).....	184
Cretaceous (sh, ss,).....	900

Ore Deposits:- The Judith Mtn. ores are mainly gold ores, however a little argentiferous galena has been found. The ores consist of country rock inpregnated with quartz and flourite, although the gold now occurs in its free

Ore Deposits -cont'd

state, it probably orginally was a telluride. There is only a small amount of lead of copper sulfides present.

Ore deposition in the Judith Mtns can be classified as follows:-

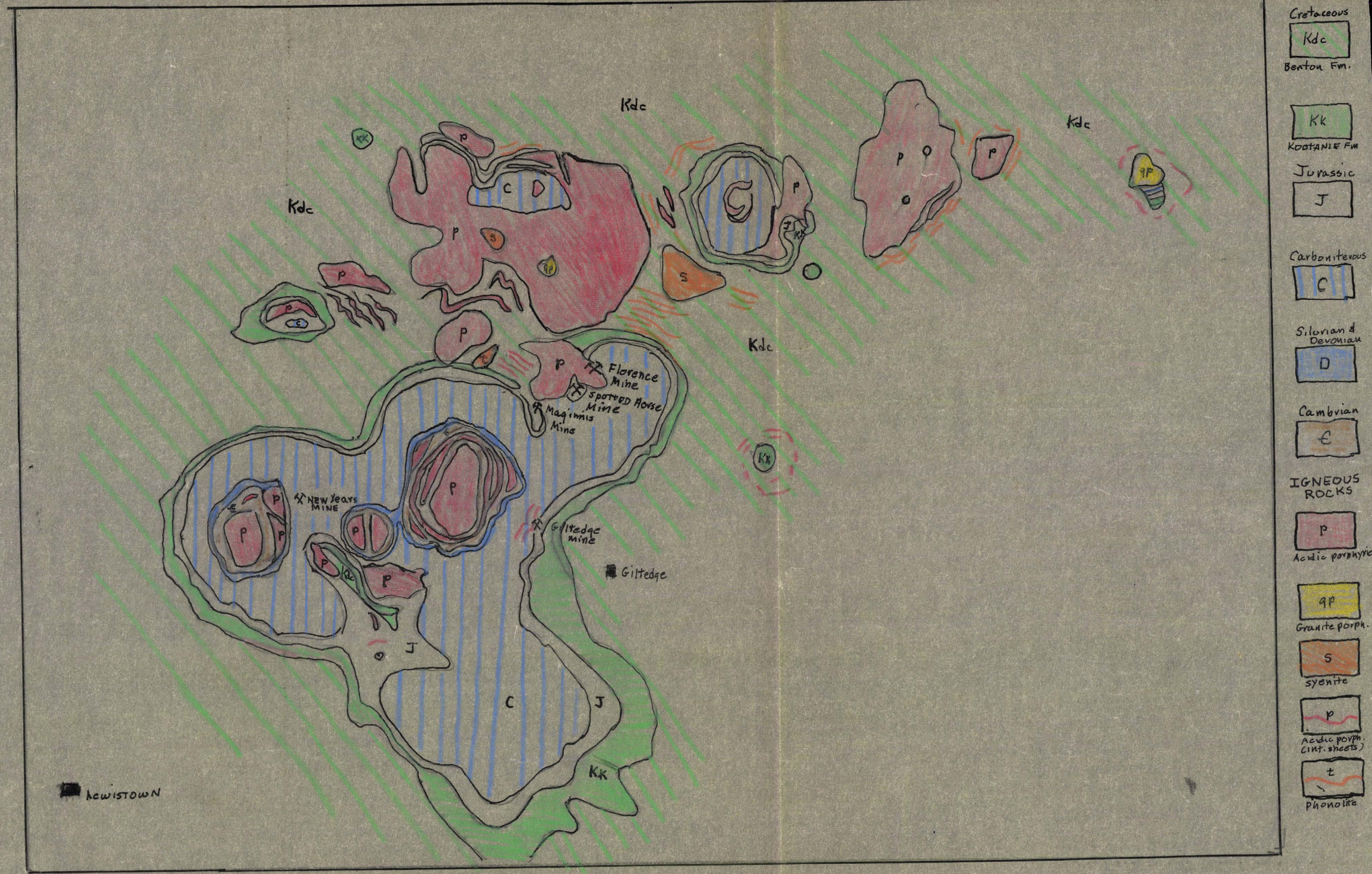
(1) Ore deposits in fissures in porphyry pipes.

(2) " " along contacts of phonolite dikes

(3) " " in the limestone at the contact of a irregular intruded mass of igneous rock or beneath intruded sheets of porphyry.

The first and second classes are of relatively small importance. The third class is by far the most important and productive, the Spotted Horse, Maginnis, and Giltedge properties are of this type.

In the third class ores, faults are found near the site of mineralization but it is belived that the brecciation of the limestone would furnish the available channels(?). The brecciated ores show clearly that there was movement after the cooling of the igneous intrusion, the ores were probably derived from the eruptive rocks at greater depths. The mode of deposition of the ore is probably mostly a replacement of limestone, the ore shoots occur as small bodies in the coarse crystalline limestone darkened by organic matter, not in the shalely of impure limestone. The association of gold and flourite seems to be an intimate one- as a rule the amount of gold



GEOLOGIC MAP OF JUDITH MOUNTAINS

by W.H. Weed & L.V. Pirsson

Scale: 1" = 2 miles

Ore Deposits - cont'd

present is found to increase with the proportion of fluorite. The ore is quite similar to that of Cripple or Creek.

Mines of the district

Maginnis Mine

Ore body is crushed of brecciated limestone recemented by silica and purple fluorite. The ore is localized on an irregular porphyry-limestone contact, the porphry having torn up and penetrated the beds in wedge like masses, the contact dips steeply in towards the porphyry. Ore averagess about $20 per ton.

Spotted Horse Mine

This mine is the major producer in the district. Ore body at or near contact of massive bedded white limestone with the intrusive mass of gold hill porphyry, ore occurs wholly in the limestone as a breccia of limestone and porphry fragments and occurs where the porphry projects into the limestone in jagged masses. Average value of the ore is $17 per ton.

Mines of the district -cont'd

Florence Mine

A small rich gold mine , ore occurs along the contact of limestone and a lesser porphyry intrusion.

Gilt-edge Mine

Ore body occurs at the lower contact of an intrusive sheet of porphyry with the soft limestone overlying the massive carboniferous limestone. The beds are tilted dipping away from the mountain at a 30 degree angle. The ore body is a crushed broken limestone and porphyry, the ore occuring chiefly in the limestone. Ore body is from 2 - 40 ft thick, ore averages $10 per ton.

New Years Mine

Ore located on contacts of porphyry sheets and limestone, the main ore body lies on the underside of an intruded sheet of porphyry in the brecciated limestone (some porphyry fragments in ore). Ore averages $14 per ton.

Little Belt Mountains

The Little Belt Mountains form a part of the eastern front of the Rocky Mtn region, they are structurally connected with Castle Mtn on the south and through it with the end of the Big Belt range. They are formed by a broad "V" shaped uplift pointing eastward which disappears beneath the plains at Judith Gap but continues eastward and reappears in the dome uplift of the Big Snowy Mtns.

Although connected with the general mountain folding, the Little Belt fold is practically a unit, it is a broad relatively low anticline having aflat top and steep sides. The southern border is formed by a secondary fold pitching eastward and passing into a fault which outlines the margin of the uplift father west. With the exception of this one fault, no others were formed in the area except those due to laccolithic uplift. On the north and south of the mtns are troughs of deposition in which great masses of sediments were deposited.

W. H. Weed attributes the uplift to lateral compression.

All the minor doming and faulting which are observed at all the larger mountain masses in the range are due to igneous intrusion which accompanied and were collary to the range uplift and locally modified it. These intrusions occur as dikes and sheets and the larger ones as laccoliths, plugs, and "bysmaliths".

These intrusions occur along the northern border of the uplift, most of them being situated on its northern limit or monocline. They also only occur where the great thickness of Beltian rocks is missing.

None of the laccoliths are simple and dome shaped, all the masses show at least a short arc on one side, along which the strata are broken and the igneous rock has risen to a higher horizon along the fractured edge of the beds.

There are three mining districts in the Little Belt mountains, namely Neihart, Barker and Yogo. I will take each district seperately and discuss its ores deposits, mineralization, ect.

The thickness of the sediments in the region total 8,000ft plus (not including the pre-beltian gneisses and schists or the beltian rocks (which are only present in the southwest corner of the mountains)). The sediments range from pre-beltian (Neihart quartzite) to the cretaceous, and while individual thicknesses of the formations were not compiled, the rocks are mainly limestones, shales and sands. The limestones dominate up to the cretaceous where a great thickness of cretaceous sh and sands are encountered.

GEOLOGICAL MAP OF LITTLE BELT MTN. REGION

BY W.H. WEED & L.V. PRISSON (1898)

Scale: 1" = 2 miles

Neihart Mining District (17,000,000 production)

General nature of the ores: The ores of the Neihart district are all silver bearing and a large proportion of them are silver-lead ores, in one or two mines gold forms an important constituent. Zinc is present in all the ores, especially those high in lead, copper is often present as well as arsenic and antimony. Schafer divides the ore deposits of the district into three zones, they are:

Zone 1 - Ores of the Silver Dyke, Minute Man, Whippoorwill, Savage and Double X. Chalcopyrite and tetrahedrite areimportant constituents,they have a siliceous gangue and the ratio of base metal to precious metal is so high they must be considered as low grade ores.

Zone 2 - Ores of the Florence, Evening Star, London, Mountain Chief, Queen-Galt, O'Brien, Moulton, Ingersoll, Rock Creek Lizzie,Broadwater, Blackbird, and other deposits on the Neihart slope. They are distinguished by a high lead-zinc content,Carbonates and barite gangue, and important silver with little gold.

Neihart Mining Dist. - cont'd

Zone 3 - Ores of the Big 7, Benton, Ripple, Corucopia, and IXL-Eureka. They are highly siliceous, contain little or no zinc and lead, no copper, and a high silver and gold content.

Schafer considers the ores of this district as not being formed at very great depths (less than 5,000 ft below the existing surface). He states that in following the ore down Zone 3 changes into that of Zone 2, which in turn changes to that of Zone 1.

The veins occur in a narrow area adjacent to Neihart and traverse the gneiss and various igneous rocks found there. The veins are confined mostly to the gneiss and schists of archean age and in a few places the overlying quartzite. The ores occur in normal fissure veins , whose character and strike vary with the different rocks traversed. All fill well defined fissures except in the porphry, where the rock is shattered for a considerable width.

In general the vein fissures strike between N15 W and N45E. In the immediate vicinity of Neihart the veins form a system of two sets: one having a strike of N10E and the other a strike of N30-50E. As the fissures vary in strike along their length, a bend of the fracture to the right produces an opening, ~~and~~ in the north -south set and a

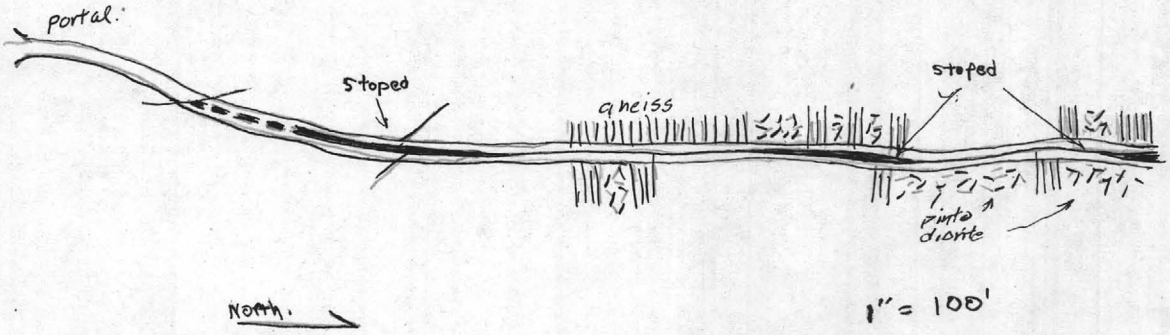
Neihart Mining Dist. - cont'd.

deflection to the left produces an opening in the northeast set. The openings produced in this manner receive the bulk of the ore deposition. North-south splits from northeast veins are frequently well mineralized near the junction with the main vein. Weed attributes the fissure system to compression along a line of pre-existing weakness but Schafer says the fissures are related to the domal uplift that produced the Little Belt Mtns.

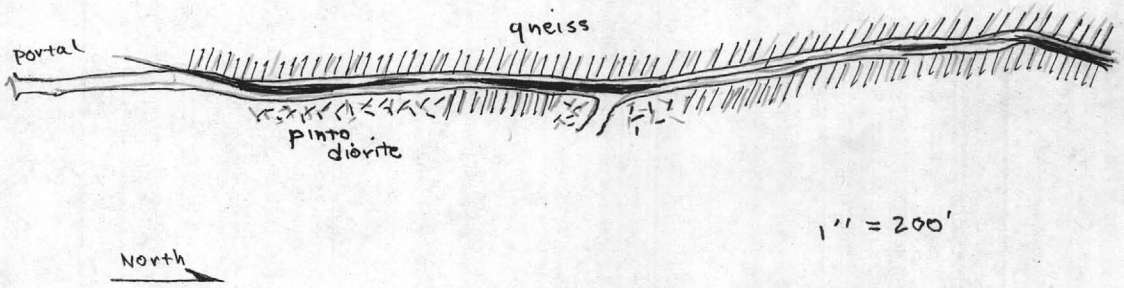
The ore streaks are very constant but the values are bunchy, the veins are usually productive in the red and grey gneisses which evidently have the optimum brittleness for permability of soultions (in the quartzite and porphry the rock is too brittle and just stringers and disseminated bunches of ore occur).

The veins of the district show good banded structure with the vugs common in the center of the vein. Wall rock alteration varies with the rock from a few inches to several feet.

Ores were deposited by hot ascending solutions; mainly in open cavities with some metasomatic replacement, the ore solutions coming from close underlying igneous bodies. Order of ore deposition is; quartz, sphalerite and pyrite, galena, pyrite and quartz, sphalerite, white quartz, polybasite and pyrargyrite.



Lower adit of the Ingersoll Mine showing ore occuring at the left hand deflections in the vein.



Adit level of the Rock Creek Mine showing ore at the left hand deflections of the vein.

Neihart Mining Dist. - cont'd

Mines of the District

Queen Mine
(production -$437,560)

Vein varies from 1-5 ft in width, strikes N20-30E, dips 80E, ore comes from kidney shaped masses scattered thru the vein filling. Ore consists of galena, sphalerite, pyrite, little chalcopyrite, ruby silver minerals and quartz, ankerite and barite as gangue.

Galt Mine

Four parallel veins in a light feldspathic gneiss, veins strike N20E. Ore shoots occur at left hand deflection of a north-south fissure, pay streak varies from 1-5 ft in width, ore consists of galena and sphalerite in a gangue offcarbonates with the silver minerals.

Florence Mine

Vein occupies a well defined fissure, varies from 4-6 feet in width and strikes NE. The primary ore shoot pitches 60 southand is limited on the south by a fault, within this shoot the ore carried several hundred ounces of silver. The ore minerals were pyrite, galena, sphalerite, polybasite, proustite, tetrahedrite, barite, ankerite, and quartz.

Neihart Mining Dist. - cont'd

Broadwater Mine
(production - $5,000,000)

Vein has a northwest course cutting gneiss and pinto diorite with an upward extension into the Neihart quartzite. Vein is 5-6 ft wide with white quartz spotted with sulfides the rest of the vein matter being altered country rock. Ore usually close to walls (usually the footwall), veins scatter when they go into the quartzite.

Moulton Mine
(production - $1,500000)

Vein has a strike of N40E and dips 80-90W, best ore occurs in shoots caused by the intersection of the vein with bands of feldspathic gneiss. Vein varies from 3-7 ft and consists mainly of decomposed country rock sprinkeled with sulfides. Silver minerals are pearcite and proustite, they occurs with galena, sphalerite, some chalcopyrite, and barite, ankerite, and quartz as gangue.

Mountain Chief Mine

Vein cuts the pinto diorite but the ore shoot occurs at the intersection of the pinto diorite and the feldspathic gneiss (?). Very high grade secondary ore was encountered.

Silver Belt Mine
(production - $250,000)

Vein lies in the pinto diorite not far from its contact with the gneiss.

Neihart Mining Dist. - cont'd

Harily Mine
(production - $766,837)

Veins occur in red gneiss, width varies from a few inches to several feet, strike is N10E and dip is 50W, vein is a filled fissure vein with sharp walls. Ore usually occupies the whole vein, minerals are galena, sphalerite, polybasite, proustite, and pyrite in a gangue of quartz, ankerite, and barite.

Rock Creek Mine

The main vein varies from one to three ft wide with occasional shoots of sulfide, trend is N10W and dip is 70-90W, wall rocks are pinto diorite, gneisses, and amphibolite.

Evening Star Mine

Vein lies in the granite gneiss and the pinto diorite, in the diorite it is irregular and narrow while in the gneiss it is wider and nearly straight. Ore bodies occur along left-hand deflections in the northeast trend.

Silver Dyke Mine

Orebody occurs at a junction of a number of dikes of quartz porphry and granite porphyry, ore body is elliptical 400 ft wide by 600 ft long, ore occurs in the interticies between the breccia fragments, ore minerals are pyrite, chalcopyrite, sphalerite, galena, and tetrahedrite.

Neihart Mining Dist - cont'd

Hegener Group

Number of veins on the property - Vilipa, Copper Queen, and Baker, all strike north-south to northwest, main ore minerals arechalcopyrite, tetrahedrite, sphalerite, galen a, and native silver.

Mackey Creek Mines

Much of the ore occurs in the snow creek porphyry, clear cut veins are rare and large low grade disseminations are common. Some distinct veins occur along the contact of porphyry with gneiss of schist (Whippoorwill and Double X).

Big 7 Mine
(production - $1,000,000+)

Vein cuts pinto diorite, gneiss, and Snow Creek Porphyry, varies from 2 ft in width in the diorite to 6 ft in the gneiss, ore usually occus near the walls of the vein, ore minerals are pyrite, galena, sphalerite, proustite, and pearcite, veins strike northwest.

Benton Mine

Vein crosses pinto diorite and gneiss, vein matter is a decomposed gneiss, vein is 3-6 ft in width, values are cheifly in gold with some silver.

Barker Mining District

The ores of this district all are mainly argentiferous galena. The ore deposits may be divided into two classes:

1. Ore as veins in the Hughsville syenite.
   (Barker, Edwards & Wright, Mines)
2. Ore in limestone along contact planes between limestone and porphyry.
   (May & Edna & carter, Moulton, Tiger Mines)

Mines of the district

Barker Mine

Vein in the Hughsville syenite near a contact with granite porphyry, was a good producer.

Wright & Edwards

Old and good producer, vein is a fissure in the Hughsville syenite which follows in part the contact with a trap dike, vein is 3 ft wide and runs NW-SE.

May & Edna & Carter

Workings are in carboniferous limestone, ore occurs in chambers or bunches.

Moulton, Tiger & T.W.

Ore occurs in folded and crumpled limestone and has porphyry on one wall. The Tiger ore occurs in lenticular bodies 3-6 ft wide and pinches out rapidly with depth into low grade pyrite.

Yogo Mining District

Generally low grade deposits too small to work, the deposits occur in the altered limestone at or near the contact with the rocks of the Yogo stock or the sheets and dikes connected with it. The ores at Yoge which have been worked occur beneath intrusive sheets of porphyry, the ore being a replacement of the limestone and in part an impregnation of the limestone itself.

Similar deposits to those of Yogo occur at the Running Wolf District, but they are too, are small and very irregular.

Little Rockies

The Little Rockies are formed by a single domed shaped uplift having a core of crystalline schists which has been intruded by a thick body of porphyry (laccolithic). The overlying beds dip outward from the central axis of the mountains and are composed of :-

Cambrian (quartzite, sh, ls,)..... 575'

Devonian ls

Carboniferous white ls

Jurassic ls and cretaceous sh and ss,(these do not occur in the mountain group proper).

The porphyry in the central area of the mountains belongs to a large single body of syenite porphyry and closely related rocks, this mass is nearly circular and about 6 mi in diameter. This porphry forms the country rock for the most important ore deposits. The porphyry intrusions of the marginal summits such as Crown Butte, Indian Butte, ect appear to be small laccolithic bodies.

Ore deposits: The ore occurs as

1. Zones of fractured porphyry replaced and cemented by quartz and pyrite.
2. Replacement deposits in limestone near the intruding porphyry

The ore carries from 3-7 dollars in gold and about an ounce of silver per ton. The important ore deposits are in the porphyry and these fall into two groups:-

Zortman group- includes the Mint, Independant, and Alabama lodes

Landusky group - includes the Goldbug, August, and other lodes nearby.

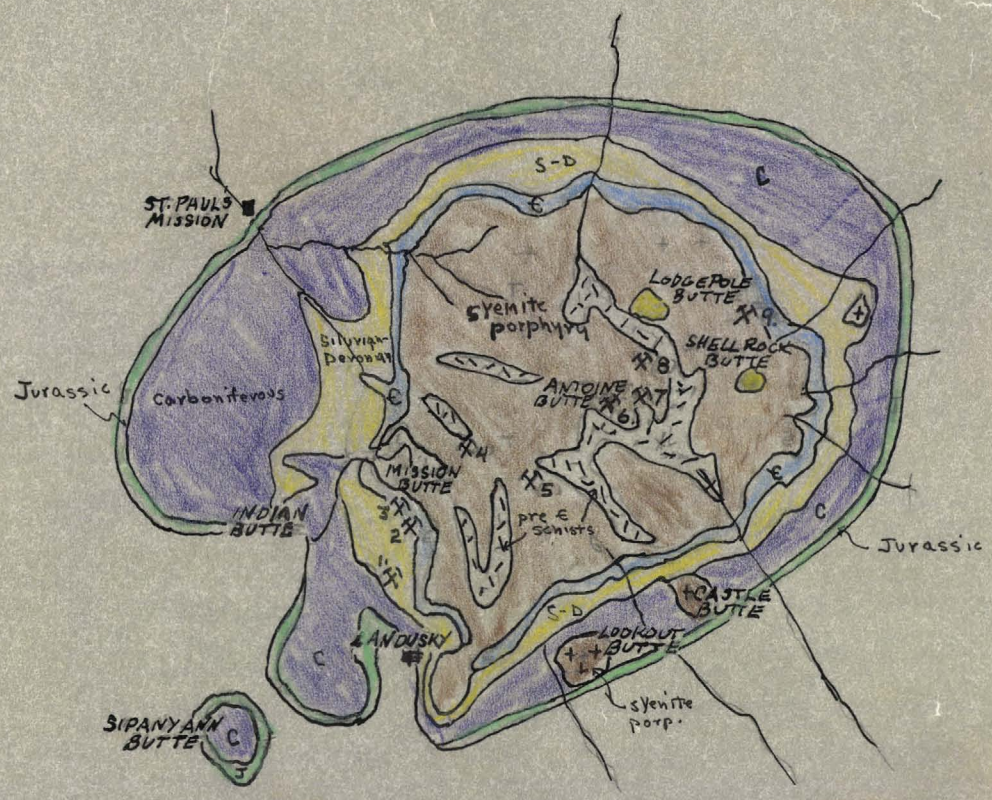
The movements which resulted in the opening of ore channels are of shearing and brecciation along fissured zones consisting of a number of small openings.

The lodes in porphyry vary in width from a few inches to 70 ft, the Mint and independant lodes were more than 50' wide and 200-300' long, the limits of these ore bodies are determined mostly only by assay.

In the Zortman district the lodes are fairly persistant and nearly all the lodes are cut by post mineral fissures, slickensided and grooved. This parallelism of lodes and shear planes indicates that the lodes are planes of weaknness.

The replacement deposits in limestone have not been developed sufficiently to determine their character other than that they occur near the contact of the limestone with the porphyry and that they are not "contact metamorphic" deposits, for the sediments are not noticably metamorphosed.

The minerals of the ores are gold and gold telluride, silver (probably with the gold), quartz, pyrite, purple fluorite (associated with the higher grade ores), and calcite.(abundant in the ls replacement deposits).



Geologic Map of the Little Rockies

Mines of the district

Mint Mine
(production - $350,000)

Country rock is porphyry and the lode is a zone of shattered, cemented, and replaced porphyry, average strike is N28W and dip vertical, ore runs $3-21 per ton in gold.

Independant Mine

Closely resembles the Mint and the two may be on the same lode. Lode in shear zone in porphyry, ore runs $6.50 per ton in gold.

Alabama Mine
(production - $200,000)

Ore in shear zone in porphyry, the ore being a brecciated porphyry, replaced and cemented by quartz, pyrite and other minerals. Strike of lode is N12W and dips about 87W, maximum width is 30 ft, assays run $3 - 18 in gold.

Pole Gulch Mine

The country rock is limestone dipping 15SE, the ore, running $3-4 in gold, is composed of soft and partly decomposed limestone with bunches of purple fluorite. At some places the ore deposits appear to follow the bedding and at other places cut accross the bedding.

M Mines of the district - cont'd

Beaver Creek Mine

Consists of a small body of limestone dipping 34NW and entirely surrounded by porphyry, the principle deposit is near the north contact of the limestone and the porphyry. The ore averages $5 per ton and consists of decomposed iron stained limestone and spongy brown silica.

Goldbug Mine

There are 5 gold bearing lodes on the property, the deposits are sheared and brecciated zones in porphyry and strike NE. At some places well defined slickensides form the sides of the lodes.

August Mine
(production - $32,000)

Deposits similar to the Goldbug, generaltrend is about N35E.

Ella C. Claim

Lode is in sheeted zone in porphyry which strikes N35-40E and carries up to $20 per ton in gold.

Susie Claim

Lode strikes NE, it is a brecciated zone in altered porphyry that has been recemented by iron oxide and quartz. Lode is said to carry $15 per ton in gold.

North Moccasin Mountains
(production $9,000,000)

The North Moccasin Mtns consist of a single dome shaped uplift, roughly symmetrical with local irregularities, resulting from a laccolithic of syenite porphyry. Large scale dip faulting is absent but radial faulting is prevalent.

Sediments exposed are approximately 6,000 ft thick and are made up of the following:-

Pre -cambrian	Not exposed
Cambrian (ls,sh, quartzite).....	1,000'
Devonian limestone.....	200
Mississippian(Madison ls).....	1,100
Pennsylvanian	100
Jurassic (sh,ss,ls).....	567
Cretaceous (ss,sh).....	2,450

Although some sulfide and oxide ore was shipped in 1914 from Bed Rock Ck in the northwest part of the mountains, the chief production of gold has come from the Kendall District which is southwest of the main mass of porphyry. The mines, allof the same character, in the district are the Kendall, Santiago, Barnes-King, and Horse shoe.

The ore mined was mainly in the limestone near the top of the Madison formation, but at the Kendall Mine some ore was mined in an altered portion of an outlying dike of porphyry and in the calcareous shale of the Quadrant and Ellis fm (Penn. &Jurassic). Ore deposition is reported

to be confined to a particular bitumenous and argillaceous horizon in the limestone , ore bodies were tabular in shape and irregular in outline, ore shoots dipped 20 -60 degrees near the surface but within 1,00 ft flattened out greatly in accordance with the dip of the strata.

The ore occurs near a large intrusive body but the ore occurs away from the contact of the main porphyry mass (sometimes up to 1/2 mile). The elongation of the ore bodies suggests control by fissuring and also the ore is associated with breccias distributed along the bedding planes, strongly suggestingbedding plane movement. Typical contact metamorphism of the limestone is noticeably absent.

The gold mined was in the native form with sulfides (except a little pyrite) noticably absent, the ore all was oxidized and the presence of purple flourite indicates that the gold may have been originally present as telluride. The gold was uauallyassociated with bitumen and averaged $5-9 a ton.

Blixt suggests that the deposition of the ores was by localized ascending dilute solutions, probably at shallow depth, long after the consolidation of the porphyry.

Mineralization in the other parts of the mountains is small and irregular but pyrite,chalcopyrite, sphalerite, argentiferous galena,and their oxidation products have been found.

Sweetgrass Hills

The Sweetgrass Hills consist of three buttes of laccolithic origin, namely West, Middle, and East Butte, lying in the center of a low broad anticlinal arch that runs parallel with the Rocky Mtn front.

West Butte is an especially large connected area of q quartz diorite porphry and two other principal outlying laccolithic masses.

Middle Butte is the conical erosion remnant of a large laccolith of augite diorite porphyry with radiating sills and dikes.

East Butte shows the largest uplift and brings to the surface the Madison ls (carboniferous), all the other intruded rocks are of jurassic and cretaceous age. It also is a large laccolith with smaller outlying masses around it, with a maze of sheets and dikes on its flanks. A few minette dikes occur in the region.

On the west side of middle butte, where the intrusives have penetrated the cretaceous shales a few prospect pits have been sunk, the ore being closely associated with a minette dike, pyrite, quartz, magnetite, and apatite were observed. The mineralization has penetrated the shales fb for a few feet from the dike, contact effedts were observed.

The most extensive contact effects were observed on the northern edge of East Butte, the outcrop was 40-50 ft ~~long~~ wide

and 700 ft long and occured on the contact of the marbelized limestone and the porphyry. Samples yielded 60% iron, specular hematite and magnetite were the chief components with some copper stains. Lime silicates were observed in the ore.

Although a shipment of silver lead ore was listed as shipped from "West Butte in this district (the Eurekast Mine) in "Mineral Res, for the U.S., 1908, no information could be found on it.

Gold Butte (East Butte) gold production came solely from placer operations.

Summary and Conclusions

The ore deposits of the region may be divided as to the metal content into two classes:

1. Silver-lead ores composed mainly of argentiferous galena with sphalerite, pyrite, and other sulfides and having a silica, cabbonate, barite, gangue (some of the silver occurs as the silver sulfides, halides, arsenides, ect).

2. Gold ores occuring with purple fluorite and pyrite, gold probably present orginally as telluride (similar to Cripple Creek).

The silver-lead ore may be futher divided into two classes as to occurence:

1. As replacement deposits and breccia filling in limestone along or near the contact with an intruded dike of body of porphyry. These deposits have been formed by the ore solutions coming up along the zone of weakness of the porphyry - ls contact and have replaced faverable and/or brecciated ls beds.

2. As ore is fissure veins in highly competent rock (gneiss, syenite, ect), ore deposits formed primarily by vein filling with some replacement. These ore bodies were formed whenethe fissures were open to the solutions, ie. structural control.

The gold ores also formed in two ways:

1. In ls at or near the contact with irregular masses of porphyry or beneath sheets of intruded porphyry (less often in the shear zones in the porphyry).

2. In ls quite a distance away from any intrusive porphyry , ore occurs along breccia in the bedding planes in the ls.

In the case of both above examples the ore solutions arose along pre-existing zones of weakness and deposited in breccia zones caused by pre mineral and post consolidation of porphyry movements.

The gold ore is belived to be of a later period and deposited by cooler and more dilute solutions than those causing the lead-silver ores. Also the gold is belived to be deposited at somewhat shallower depth than the lead - silver which is mesothermal.

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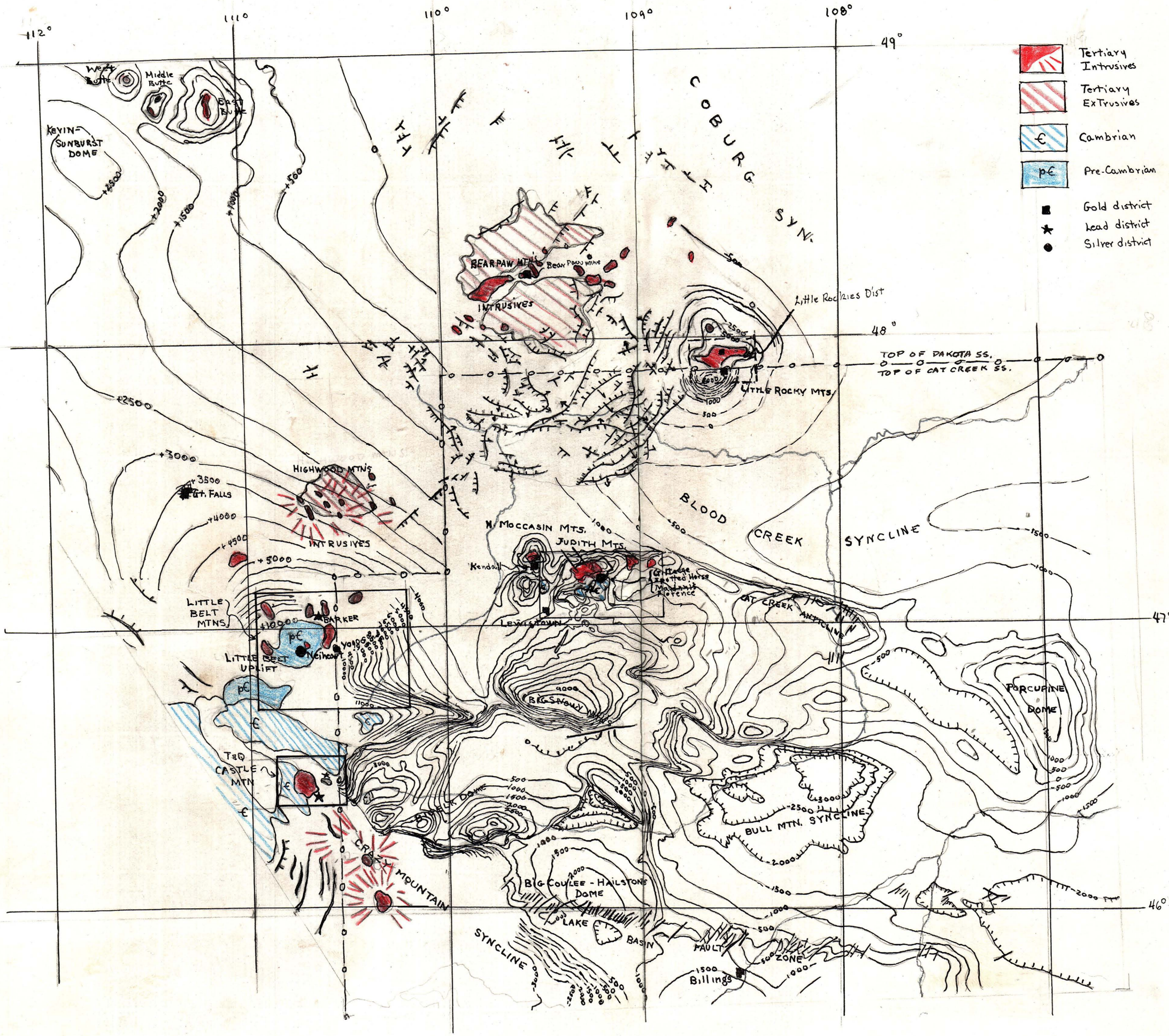

STRUCTURAL MAP OF NORTH-CENTRAL MONTANA

Scale: 1" = 17+ Miles

Compiled from A.A.P.G. Map of U.S. and Map by Thom in AAPG Vol 17.