General Geology and Mines of Northwestern Montana

Robert L. Sandvig

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GENERAL GEOLOGY AND MINES
OF NORTHEASTERN MONTANA

by

Robert L. Sandvig

MONTANA SCHOOL OF MINES LIBRARY
BUTTE

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 15, 1947
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INTRODUCTION

Certainly one of the most primitive regions in the United States, the northwestern five counties of Montana cover a forested area of over 4000 square miles and support a population of about 54,700 persons. It is a land of Alpine mountain peaks and scenic valleys. Much of it is unexplored.

Industries are agriculture, grazing, lumbering, and in a small way, mining. Also, by no means unimportant to the people's livelihood is the income derived from sportsmen and tourists who seek the pleasant summer climate and outdoor recreation of the Flathead area.

In 1937 and 1938, eleven months were spent by the writer as an employee of the Viking Mining Company near the crest of the Cabinet Range between Libby and Trout Creek. From observation of the mining activity in the area, and because of the high proportion of prospectors in the Libby district, it was concluded that the mineral wealth of the area should be further investigated. The prospector's tales lend credulity to the existence of many veins, hence, this problem is a step toward finding out if such tales are fact of fiction.

Without even preliminary inquiry, it is assumed that to gain final conclusions on the problem, about twelve summer months
would be required in the field. So the scope of this thesis is confined largely to library research, and it is submitted to the geology department of Montana School of Mines as a requirement for the Bachelor of Science degree in Geological Engineering.

From September, 1946, to May, 1947, all available information that has been published to this date concerning geology and mining in Flathead, Lake, Lincoln, Mineral, and Sanders counties was sought out, evaluated, and condensed into summaries and maps. To this, information gained by the writer through experience in the field has been added.

LOCATION AND ACCESSIBILITY

The five counties discussed in this paper compose the northernmost and westernmost counties in Montana. On the eastern boundary is Glacier National Park and the Continental Divide; on the southern boundary are Missoula and Powell counties; Idaho lies on the southwestern and western side; and the Canadian border lies along the northern edge. The region is on the Pacific Ocean side of the Rocky Mountains. Three major rivers, the Clark Fork, the Flathead, and the Kootenai drain this area into the Columbia River.

United States Highways No. 10, a branch No. 10A, and No. 2 are transcontinental routes which pass through the region easterly and westerly, while United States Highway No. 93 crosses north to south from Canada to Missoula. Numerous state, county, and United States Forest Service roads connect the small communities and outlying districts. However, there are many townships through
which no road passes. Forest trails, however, make all areas accessible by saddle horse or foot travel.

Three major transcontinental railroads, the Great Northern, Northern Pacific, and Chicago, Milwaukee, St. Paul, and Pacific, pass through northwestern Montana. The former goes through Whitefish and Libby, the Northern Pacific follows the Clark Fork River, and the later follows up St. Regis valley through Superior and Saltese.

CLIMATE AND VEGETATION

Winters last from four to six months in this very mountainous region, and snow depths range from three feet to fourteen feet. Summer months provide only comfortably warm weather, and the summer nights are cold. Rainfall in this region is higher than in any other part of Montana, ranging fourteen to thirty inches per year.

Conifers cover all of the area, even growing in groves on the level Flathead valley floor. White pine, yellow pine, Ponderosa, tamarack, fir, spruce, with aspen and cottonwood on the creek bottoms, are to be found in every township. Grass is not abundant, being confined to stream bottoms and open parks. Since almost all of the region has been scourged by forest fires in the last fifty years, brush, saplings, and deadfalls prevail everywhere. Thousands of acres of lush huckleberry bushes are found on the slopes and ridge tops. Hundreds of gallons of berries are canned in Kalispell.

Crops in Flathead valley and other valleys are hay, wheat, sugar beets, and garden seeds, while apple and cherry orchards are rapidly expanding.
EARLY HISTORY

Soon after the return of Lewis and Clark to civilization in 1805, adventurous agents of the fur companies fanned out into all the river valleys of the Northwest. However, it is rare when a record of their explorations can be found. But Alexander Henry and David Thompson descended the Kootenai from Canada in 1806, crossing the Cabinet mountains and going down the Clark Fork to Lake Pend Oreille. Thompson was an astronomer and scientist; his accounts are accurate and of considerable historical value. He established trading posts on Lake Pend Oreille and at Thompson Falls.

Following the trappers came the Jesuits to establish missions at St. Mary's in the Bitterroot valley, and in the Coeur d'Alene valley. Hostile Indians forced St. Mary's to be abandoned in 1850, but the next year, St. Ignatius' mission was established in the Flathead valley where the present community of that name is now situated.

Army engineers came into the Clark Fork country in 1853 searching for the most feasible route for a railroad to the Pacific. Under the leadership of Lt. John Mullan, the expedition travelled from Missoula down the Clark Fork River to where it enters Lake Pend Oreille a few miles west of the Montana-Idaho boundry. The next year they explored the St. Regis and Coeur d'Alene valleys and discovered Mullan pass between St. Regis and the Coeur d'Alene settlements.

Gold was discovered by early prospectors on Libby Creek in
1867, but hostile Indians killed several of their number, and so prevented them from producing from their placer discoveries. In 1869, gold was discovered on Cedar Creek in Mineral county, and production from Cedar Creek gravels continues today. However, until 1883, when the Northern Pacific railroad was completed, prospecting, hunting, and trapping with scattered agricultural endeavors were the only industries in northwestern Montana pursued by white men.

With the completion of the railroad, extensive prospecting resulted in the opening of more than a score of gold and silver mines. Settlements were established, and the current day industries of lumbering, horticulture, and ranching expanded rapidly. Nevertheless, roads did not penetrate into the mountain regions until the thirties, so only the valleys served by railroads were systematically explored or exploited. Mining ventures prior to the building of U. S. Forest Service roads were forced to operate at abnormally high transportation costs. After building of these roads, depression and war hindered the development of the mineral potentialities that are known to exist. Consequently, the history of mining in the five counties under study is at this time just beginning.

Hydro-electric power development of importance has been made by the Montana Power Company at Thompson Falls and Polson. The U. S. Geological Survey has made numerous surveys of the large rivers in search of damsites, and again, the history of power is only beginning.
MOUNTAINS AND RIVERS OF NORTHWESTERN MONTANA

PLATE I
The mountain ranges of northwestern Montana belong to the Rocky Mountain system. The Flathead range is actually part of the main range of the Rockies. However, each of the different ranges has distinctive individuality, being wholly or partly surrounded by major depressions. Separating the Flathead range from the Swan range is the South Fork of Flathead River which forms a broad valley. Between the Mission and Swan ranges lies the Swan river valley.

Roughly from Missoula through Kalispell and trending on northward into Canada is a great depression commonly called the Flathead valley, but in geologic literature it is called the Rocky Mountain trench. Between the Idaho border and the Purcell and Cabinet ranges is the Purcell trench which parallels the Rocky Mountain trench. Cutting these trenches diagonally is the Clark Fork valley, which by virtue of its breaching several mountain ranges is called a trench, although structurally not strictly so. The valley of the St. Regis river is likewise a major depression. From the accompanying map, it can be observed that alternating northwestward and southeastward trending ranges and valleys form the mountain and depression system prevalent throughout this part of the Rocky Mountain system.

Peaks of the Flathead, Swan, Mission, and Bitterroot ranges exceed 10,000 feet, while the other ranges reach 8000 feet on major peaks. Flathead valley has an elevation of 3100 feet.
The most distinctive geologic feature of this region is the preponderance of partly metamorphosed pre-Cambrian sediments. It is certain that their thickness exceeds 40,000 feet in both the Thompson Falls area and the Kalispell area. Quartzite, argillite, siliceous limestone, and argillaceous shale with gradations of the four are the rock types. Belonging to the upper Proterozoic period, they have been classified and named the Belt series.

Evidence exists that deposition of this great volume of sediments continued uninterrupted into the Cambrian. Also, isolated remnants of Paleozoic and Mesozoic rocks have been found with fossils to establish their age. Therefore, before Laramide time, when orogeny commenced, this region was receiving sediments on top of the pre-Cambrian series. Some evidence of the basal complex underlying the great Belt series is found in Idaho on the western side of the Purcell trench.

Both uplift and compressive forces from the west functioned during the Laramide orogeny, starting possibly as early as Jurassic time. Since the entire Belt series is of hard, competent beds, folding is not complex; however, faulting is exceedingly extensive and complex. Bedding-plane faults, en echelon faults (local), great faults of thrust and overthrust nature, and normal faults with immense displacement have made the regional geology a problem that will require decades of study to solve. Most remarkable is the great eastward moving overthrust which has a displacement that may be as great as 120 miles.
Erosion following the first orogenic activity has removed most of the Paleozoic and Mesozoic sediments. Glaciation has affected practically all of the area, and most of the valley fill and trench sediments are a result of glacier working. Uplift during the Tertiary period is certain, as bench gravels of both lake and morain type are found abundantly and identified as of Tertiary age.

Igneous activity has been widespread, but it is relatively minor in magnitude when compared with other Rocky Mountain regions to the south and east. Pre-Cambrian sills of metadiorite similar to the great Purcell sills of the Belt series in British Columbia are quantitively related in Lincoln county. Dikes and stocks of every rock type are found throughout the five counties under study, and some extrusive bodies are known. Individual igneous bodies are discussed in detail subsequently in this report.

History of Geological Exploration

The Belt rocks were first subdivided by G. M. Dawson in 1875 and assigned to the Paleozoic. In 1899, C. D. Wolcott made the first satisfactory subdivision of this group of rocks, and he identified them as Proterozoic by pre-Cambrian algae which he found in some of the beds. In 1902, Bailey Willis published the Glacier Park section and correlated the Altyn of that section with the Newland of the Belt section of his predecessors. Wolcott correlated all of the Belt series in 1906 after making a reconnaissance of the Lewis and Clark, Swan, and Mission ranges.
In 1909, F. C. Calkins with F. L. Ransome and D. F. MacDonald published the findings of their reconnaissance through the Coeur d'Alene, Clark Fork, St. Regis, and Kootenai drainage areas. In the Phillipsburg area, Calkins established a five way division of the Belts which in Montana geological circles is accepted as standard. The division from bottom upward is Neihart, Frichard, Ravalli, Newland, and Spokane groups of formations, and it was published in 1915. In 1912, R. A. Daly published sections of the Belt series along the 49th parallel.

The Montana Bureau of Mines and Geology commenced a survey of western Montana in 1921, the party being composed of G. S. Lambert, Arthur Bevan, and C. H. Clapp. Summer work was carried on, and in 1923, Roy Wilson joined the party. From 1924 to 1928, the work was carried on in an unsystematic manner, but in 1929, the Lewis and Clark range was studied in greater detail. Dr. Clapp with C. F. Deiss surveyed a section from Missoula to Helena in 1930, and they prepared their final paper for the Montana Bureau of Mines and Geology, also presenting it to the Geological Society of America in December, 1931.

The next year, Dr. Russell Gibson commenced a thorough study and survey of the Libby Quadrangle. Unfortunately, his map is not yet published. However, in 1944, the U. S. Geological Survey prepared a geological map of Montana in conjunction with the Montana Bureau of Mines and Geology, but the Belt formations are grouped together into a three way division. Information about country rock in small mine reports indicates that the 1944 map of Montana is not adequate for an accurate study of northwestern geology.
Correlation of Sediments

Early geological explorers in northwestern Montana recognized distinct divisions of the Belt series. Calkins separated distinct formations in Lincoln, Mineral, and Sanders counties, whereas Daly established a stratigraph column along the 49th parallel. Previous to their exploration, the U. S. Geological Survey had established a column for the Belt mountains in Cascade county. It remained for Clapp and Deiss to correlate the entire series on the basis of lithology and paleontology.

Not found in the five counties discussed in this thesis is the basal Niehart formation with a basal quartzite formed from a quartz rich conglomerate. Arkosic sandstone grades up into argillite and fine-grained quartzite.

Prevalent throughout northwestern Montana, particularly on the crests of anticlines, is the great Prichard formation which ranges from 8000 feet to 12,000 feet in thickness. It is remarkably uniform in lithologic character throughout, consisting of sericitic and argillaceous quartzite which weathers to a rusty color. Its base is not exposed at any place in this region.

The Ravalli group consists of three distinct divisions, but the names of these formations conflict. On the west, they are named the St. Regis, Revett, and Burke formations; whereas on the east, around Glacier Park, they are named Grinnel, Appekunny, and Altyn formations. Ravalli rocks are exposed more than any other group in the region.
The basal formation of the Ravalli group is the Burke (Altyn) formation. It is a gray sandstone essentially, but not uniformly. At the top, it grades into the typical quartzite of the Revett ( Appekunny formation; whereas, at its base, the beds are gradational into typical Prichard rock. Variations of strata include sandy argillite and siliceous limestone, with the upper part in the eastern sector grading into ferruginous and argillaceous sandstone. Its thickness is usually found to be from 2000 to 7000 feet.

Massive white quartzite and gray argillaceous quartzite prevail as the constituents of the middle member of the Ravalli group. It is usually called Revett quartzite, but in some sections it is designated as the Appekunny formation. Its thickness ranges from 1000 to 10,000 feet. The upper member of the Ravalli group is characterized by its multicolored shale beds. Some quartzite is found at its base, but red, green, and gray sandy shale, green argillite, and thin-bedded slightly-calcareous gray shale are found interbedded throughout most of its exposed areas. In Glacier Park, it was named the Grinnell formation, but in most areas, it is known as the St. Regis formation. Its thickness ranges from 1000 to 3000 feet.

Midway in the Belt deposition cycle, limestone was laid down in thicknesses ranging from 10,000 to over 20,000 feet. This limestone is generally called the Wallace group, but its designation may be the Wallace formation, Newland formation, Siyeh group, or Siyeh formation. In the western area, it is preferably called the Wallace formation, but where subdivision is desirable, it
should be divided into the Helena, Spokane, and Newland formations.
The Newland is the basal member, consisting of calcareous dolomite fine-grained, thin-bedded, green sericitic slate, blue and white banded argillite, impure bluish or greenish feruginous and dolomitic limestone, and white-weathering calcareous quartzite. Variations are gradational, and limestones appearing dark on fresh fracture weather to a buff color. Algae are found to be abundant.

The middle member is typically exposed near Helena, but it is named the Spokane formation from the Spokane Hills east of Helena. At its base are found red, green, and gray argillites and quartzites, but these beds grade into gray and gray-green dolomitic and sideritic limestone. The Helena formation, at the top of the group, is thin-bedded, siliceous and argillaceous limestone, calcareous argillite, and pure limestone with calcite veinlets. Cryptozoans are abundant.

Topping the Belt series is the Missoula group, but its subdivisions have not been published at this time. However, in the west it is called the Striped Peak formation. Colorful shale beds are its distinguishing characteristic. Gray, green, purple, red, and varying shades of these colors are to be found in the shale, argillite, sandstone, quartzite, limestone, sandy shale, argillaceous and calcareous quartzite, and ferruginous dolomitic limestone. Thin-bedded shales are typical. It ranges from 3700 to over 10,000 feet in thickness, with algae found in the carbonate beds. Belt observers have noted that Cambrian beds were deposited conformably on the Missoula group in certain localities, and some evidence exists that the depositional cycle was uninterrupted.
**GEOLOGICAL SECTION - SALTESE DISTRICT**

(U.S.G.S. Bull 450)

Belt Series, Upper Proterozoic

<table>
<thead>
<tr>
<th>Formation</th>
<th>Approximate Thickness</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRIPED PEAK</td>
<td>1000'</td>
<td>Greenish-gray and blue to purple shallow water sandstones and shales</td>
</tr>
<tr>
<td>NEWLAND</td>
<td>4000'</td>
<td>Blue shale or argillite</td>
</tr>
<tr>
<td>(WALLACE OR SIYEH)</td>
<td></td>
<td>Apple-green shale</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blue shale or argillite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thin-bedded greenish calcareous shale with blue and white argillaceous strata of sandstone and quartzite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Apple-green shale</td>
</tr>
<tr>
<td>ST. REGIS</td>
<td>1200'</td>
<td>Indurated shale and quartzitic sandstone with purple and green tints</td>
</tr>
<tr>
<td>REVETT QUARTZITE</td>
<td>1200'</td>
<td>Thick-bedded greenish sericitic quartzite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thick-bedded quartzite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Glassey quartzite</td>
</tr>
<tr>
<td>BURKE</td>
<td>2000'</td>
<td>Thick-bedded sericitic quartzite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Greenish-gray flaggy quartzite or siliceous shale made soft by sericite and mica</td>
</tr>
</tbody>
</table>
Region Around Saltese

(Condensed from U.S.G.S. bulletin 450 by F. C. Calkins and E. L. Jones in 1912.)

In 1912, F. C. Calkins and E. L. Jones revised some of their earlier work in the Coeur d'Alene mining district of Idaho, then they moved eastward across the Idaho-Montana border and examined many prospects in the area surrounding Saltese on St. Regis River in western Mineral county.

This area had long been a scene of mine exploration, but no steadily productive mine had been developed. Therefore, other than the paper in 1912, almost nothing on this area has been published.

The mountains seldom exceed 6,500 feet in height, but the region's topography is rugged with narrow and intricately branched valleys. South of Saltese, the creeks lead up to the Bitterroot crest, whereas the Coeur d'Alene range is the highland on the north.

At the time of Calkins' and Jones' field work, the great fire of 1910 had demuded the dense forest, but at the present, second growth timber covers all of the area.

As in all of northwestern Montana, the Belt series are the overwhelmingly dominant rocks. However, metamorphism is not as greatly advanced as in some other areas of the Belt. Tertiary gravels form patches on the lowland floors, but their economic importance is negative, since they conceal the rocks underneath, which may be metalliferous.
Igneous rocks are not abundant, but the great Wishards sill of diabase is prominent at the crest of the Bitterroots. It extends for many miles along the divide in the middle member of the Newland formation, and its thickness ranges from 400 to 550 feet. Since it was folded and faulted with the Newland, intrusion must have taken place before the orogeny. Petrology of the sill is not unique, but it is rather typically diabase. The black band of its outcrop can be seen for miles, as vegetation is very scant along it. Minor lamprophyres and other diabase sills are noted in the Coeur d'Alenes and the Saltese district.

The most remarkable tectonic feature of the region is the great Osburn fault zone which has determined the St. Regis and Clark Fork valleys from Mullan pass through Missoula. South of the fault zone, the structure appears to be a southwestern flank on an anticline.

Packer Creek Area

Minea and prospects of the Packer Creek area are located along fissure veins of the same character as in the Mullan, Idaho, district. Galena is the predominant ore mineral, although argentiferous tetrahedrite and chalcopyrite occur with it in a gangue of quartz and siderite. Silver tenor is high, and gold values are appreciable. A one-foot vein of barite is known near the Bryan mine. The Last Chance mine has reported a net profit of $200,000 from shipping ore. Not in the Packer Creek group, but related, the Silver Cable mine has shipped ore running
11 percent zinc and 24 percent lead. All are related to the Osburn fault zone.

Copper Area South of Saltese

Well defined, nearly-vertical fissure veins of siderite containing chalcopyrite and pyrite are found south of Saltese. They were opened up prior to 1912 by early day prospectors. Calkins suggests relationship of these to the Wishard sill. Two major normal faults strike northwestward in this area, but little is known of their displacement or degree of mineralization. However, the Newland formation is exposed exclusively from the Bitterroot divide down to the St. Regis valley, where its contact is made with the Ravalli group below it. Since the Newland beds trend northwestward in strike, and dip steeply southwestward, as do the underlying beds of the Ravalli group, they are no doubt the flank of a great anticline of late Cretaceous development. This is not an unbroken anticline, because hundreds of minor faults of every description the textbooks afford have broken it into blocks which lie in disarray. Faults of several hundred feet of displacement abound, and they are neither mapped nor named. Deposition of pyrite and copper bearing minerals does, however, take place in them.
The Osburn Fault

(Condensed from volume 32 of Journal of Geology by Joseph B. Umpleby in 1934.)

The Osburn fault, long recognized as an earth fracture of major importance, extends from Spokane, Washington, through the Coeur d'Alene district, and eastward along the trend of the great valley of the St. Regis River and Clark Fork River beyond Missoula to the Continental Divide. Umpleby studied and mapped it in detail for 30 miles along its course through the Coeur d'Alene mining district.

Numerous mine workings and prospects have crossed or have been sunk into the fault, affording an excellent opportunity to study it in detail. In general, there is a central mass of gouge a few feet wide, with numerous parallel gouge seams both in the hanging wall and in the foot wall. Thus it must be considered a complex fracture of many planes of movement distributed through a zone locally 100 to 200 feet wide. The main fault plane in every exposure examined dips between 60° and 70° south. Locally, igneous material, principally lamprophyrie, follows the fault zone, indicating that it existed as a zone of weakness during the period of magmatic activity in the region. In places, such igneous material is crushed by later movement along the fault.

Apparent vertical displacement caused by the Osburn fault is widely different in different places, ranging from less than 1000 feet to more than 10,000 feet, but after allowing for such
great vertical displacements, it is impossible to fit the opposite sides together into anything like a regular arrangement. Anticlines are opposite synclines; major north-south faults are cut off abruptly; and cross-folds that might explain the great differences in apparent displacement are lacking. These difficulties lead O. H. Hershey to make a detailed study of the problem, and a certain purple bed in the Burke formation on the south side of the fault was sought for and found on the north side of the fault about 12 miles to the east. Further correlations of minor structures confirmed this great horizontal displacement, also suggesting that horizontal displacement may be as great as 16 miles.

Structural features of the Coeur d'Alene and St. Regis valley region may be grouped by age. First came folding along a northeast-southwest axis; secondly came faulting along north-south axes; and thirdly came faulting and folding along northwest axes. The third orogenic trend includes the Osburn fault, and with its contemporaries, it is in part older than the ore deposits, in part younger than the ore deposits, and in part of the same age. Normal and reverse faults occurred in both the second and third periods of diastrophic activity.

The Osburn fault has not been found to be cut by any other faults, so it is believed to be an uninterrupted earth fracture. There is evidence, however, of recurrent movements along it. Where cut off by the Osburn fault, intersecting faults show drag phenomena on a tremendous scale. Mineralization persisted throughout much of the general period of faulting, but ore deposition
principally accompanied the faults of reverse displacement. These also were recurrent, and they have been shown to have less gouge than the faults of normal type, a fact believed to be due to re-adjustments in an underlying magma. Thus it appears that ore deposition, which is thought to be younger than the granite and older than its lamprophyre derivatives, accompanied stages of particular activity within a magma underlying the region, and it connects this activity with movements along the Osburn fault.

The age limits of the Osburn fault may perhaps be narrowed by consideration of the intrusive rocks. Much of the movement along the fault accompanied mineralization in the Coeur d'Alene and Mineral county region at a time when an underlying magma was giving off lamprophyre dikes, and some of these dikes, crushed by later movement, follow the fault plane. The age of these intrusives can not be determined from local evidence, but they represent the same general period of intrusive activity as that of the central Idaho batholith. This great batholith has been assigned to the late Cretaceous or early Eocene, therefore it seems reasonable to assign the Osburn fault to late Cretaceous or early Eocene.

It must be pointed out by the writer of this thesis that the Osburn fault is concealed by valley fill along most of its hypothetical course in Montana. However, structure and strata do not conform north and south of the deduced course of the fault, and it is quite reasonable to assume that the great valley represents a zone of major faulting.
**LIBBY QUADRANGLE**

*(G.S.A. Bull. Vol. 52)*

**Belt Series, Upper Proterozoic**

<table>
<thead>
<tr>
<th>Formation</th>
<th>Thickness</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STRIPED PEAK</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UPPER</td>
<td>6000'</td>
<td>Gray to greenish-gray shale and argillite; thin-bedded gray sandstone; ferruginous magnesian limestone</td>
</tr>
<tr>
<td>LOWER</td>
<td>2000'</td>
<td>Dark-red to purplish ferruginous sandstone and quartzite; red sandy shale; minor algal dolomitic limestone</td>
</tr>
<tr>
<td><strong>WALLACE (SIYEH OR NEWLAND)</strong></td>
<td>16,000'</td>
<td>Gray to greenish-gray sandy argillite; gray, greenish-gray and brownish sandstone; gray to buff, thinly bedded soft shale; deep red, ferruginous sandstone and sandy shale; gray to white dolomitic limestone, in part algal. Shale, argillite, and sandstones are in part calcareous and dolomitic.</td>
</tr>
<tr>
<td><strong>ST. REGIS</strong></td>
<td>1700'</td>
<td>Thin-bedded sandy, slightly calcareous shale and argillite</td>
</tr>
<tr>
<td><strong>RAVALLI GROUP</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REVETT QUARTZITE</td>
<td>1200'</td>
<td>Even-grained, gray to white quartzite and quartzitic sandstone</td>
</tr>
<tr>
<td><strong>BURKE</strong></td>
<td>7000'</td>
<td>Dark-gray, sandy shale</td>
</tr>
<tr>
<td><strong>PRICHARD</strong></td>
<td>9700'</td>
<td>Dark-gray sandy argillite which weathers brown; some beds are slightly calcareous. Minor amounts of light-colored sandstone and quartzite that become more abundant near the top.</td>
</tr>
</tbody>
</table>
Lincoln County

All of the four great sedimentary groups of the Belt series are exposed in Lincoln county. In general, they have been folded into great symmetrical folds which may plunge gently to the north in certain areas, and which may plunge gently to the south in other areas. One of the most notable structural characteristics besides the great folds are the numerous longitudinal normal faults which can be traced all of the way across the county from north to south.

From viewing the large geological map, it can be seen that in the northwest corner is a great anticline which plunges across the Canadian boundary. At its crest is exposed the Prichard formation, and cropping out all around that area is the Ravalli group. Like in textbook illustrations, the Wallace group appears on the flanks. The big fault, which runs from the boundary at Range 32, has cut off the eastern flank of the anticline and there displaced the Striped Peak formation at least seven miles. South of Libby, the Snowshoe fault bisects the anticline down its axial plane. This great fault is very nearly vertical, and its vertical displacement is at least 10,000 feet. Prichard beds are again well exposed on the eastern side of the fault, and aside from one transverse fault of notable displacement, the overlying formations crop out in normal sequence to illustrate the anticline. The eastern flank of this anticline extends distinctly southward to the Osburn fault. It also forms the Cabinet mountain range.

From Libby to the north and south, the Striped Peak formation
marks the trough of a syncline, and reports of Paleozoic rocks occurring in it have been received from engineers residing in Lincoln county. When Russell Gibson's quadrangle map is published, the location of these Paleozoic formations will be known.

From the trough of the syncline eastward, outcroppings of the underlying groups again appear, and it is obvious that the folding is reversed into another anticline. About 20 miles east of Libby, the crest of this anticline is found in a wide exposure of the Prichard formation, again with the beds nearly horizontal. North of that area, the Ravalli group has not been eroded enough to expose the underlying Prichard. Instead, it blankets the crest of the anticline for many square miles, but another great normal fault which has been mapped from the Hog Heaven district for 50 miles northward cuts off the eastern flank of the anticline.

West of the Snowshoe fault, in the Purcell trench, the Lenia fault of 15,000 feet vertical displacement parallels the two great longitudinal normal faults to the east. However, faulting in this area is more complex than east of the Cabinet anticlinal axis.

Throughout Lincoln county, monor faults of both horizontal displacement and vertical displacement of tens to thousands of feet exist, but they are vastly too abundant to be mapped up to this time. The immense thickness of the Belt series is such that faults which do not have displacement measurable in miles do not modify the regional structure very much. It is a certainty that rocks of such hard constitution as the Belt series cannot be subjected to such enormous compressive force as produced the folding without
rupturing and slipping along the bedding planes, and further, producing thrust faults. In the bedding-plane faults, normal faults, and thrusts, mineral deposits are found.

Monzonite and Related Rocks of the Libby Quadrangle


Igneous bodies described in this paper were examined in 1929, 1931, 1932, and 1934 in the course of mapping the Libby Quadrangle by the authors for the United States Geological Survey. The map has not been published at this time, however.

In addition to several small stocks which have penetrated the great thickness of the Belt sediments, dikes, sills, and flows of several rock types are known. Conformable with the bedding at a few horizons are sills of dark-colored, fine-grained to medium-grained rocks which have been much altered, but which were originally similar in composition to diorite and are here called metadiorite. They range from 10 to 800 feet in thickness. No large sills crop out near the stocks, and their areal distribution is in no way related to the stocks. They decrease in number and thickness toward the south. These sills are correlated with the Purcell sills of British Columbia, and are therefore believed to be pre-Cambrian in age.

The sedimentary rocks and their included sills have been folded into large open anticlines and synclines that trend north-northwest, and plunge at low angles in the same direction. The
axial planes of the folds are commonly inclined eastward.

The largest intrusive mass in the quadrangle is found underly-
ing the valley of Dry Creek and parts of the valleys of several
other creeks on the west side of the high range between Lake Creek
and Libby Creek. It covers 20.5 square miles. Except at the
western border where it is bounded by the Dry Creek fault, its
contact cuts across the strike of the strata and dips steeply out-
ward from its center. Known as the Dry Creek stock, it is composed
of a rather light-gray medium-grained rock whose mineral composition
conforms in part to that of granodiorite, and in part to that of
quartz monzonite. Foliation is present, and becomes more and more
pronounced as the fault is approached. Feldspar, quartz, and biotite
are the chief megascopic constituents. Andesine is more abundant
than potash feldspar. Hornblende is found near the contacts; apatite,
silicon, and magnetite are evenly distributed; and sphene, tourmaline,
and pyrite are present in a few specimens.

Across the ridge where drainage is to the east, is a satellite
stock on Granite Creek. Being a little lower in potash feldspar
than the larger body, it is, strictly speaking, a granodiorite.
Another satellite south of the Dry Creek stock, and along the Dry
Creek fault, is found on Payne Creek. However, it is composed of
two distinct rock types. The older was originally a quartz diorite,
but it has been amphibolized, hence it is called metadiorite. Cut-
ting the metadiorite is a small body of quartz monzonite. The meta-
diorite resembles the pre-Cambrian Purcell sills, whereas the quartz
monzonite is clearly related to the Dry Creek body.
Metamorphism of the Dry Creek and Payne Creek stocks has taken place along the fault by rising solutions. A normal fault, the Dry Creek fault dips westward at an angle ranging from 45° to 60°. There is evidence that at an earlier period in its history the fault was a thrust, the western block having ridden up and over the eastern. This is deduced from the fact that the foliation in the stocks parallels the fault. Furthermore, the sedimentary rocks are crumpled and schistose in a zone as much as three-quarters of a mile wide along the east side. In his study of the Idaho batholith, to which these stocks may be related, Ross also found that the granitic rocks were intruded later than the major part of the folding, but possibly before thrust faulting had ceased. Evidence around these stocks points to the same idea.

On Hayes Ridge south of Dry Creek is a small stock with an exposed area of only about one-half square mile. It is composed of quartz monzonite similar to that of the stock on Dry Creek, but one difference is the presence of three to five per cent of muscovite, a feature unusual in quartz monzonite. Two types of rock, differing only in grain size, have been noted in the stock, but they are intermingled in such a way that they cannot be mapped separately.

The small area of porphyritic quartz monzonite exposed on Parmenter Creek is believed to be the top of a stock. It cuts across the sediments, and it has metamorphosed them similarly to the contact zones of the stocks mentioned previously.

About sixteen miles north of Libby, a stock of porphyritic syenite crops out on Bobtail Creek. Its texture is notable for the marked parallelism of the large orthoclase grains which average one
centimeters in length, and attain a maximum length of nine centimeters. Ferromagnesian segregations, in which the chief minerals are pyroxene and amphibole with accessory magnetite, sphene, and other minerals, are present; but they are rarely as much as 50 feet in the greatest dimension.

Most of the large or persistent dikes in the Libby quadrangle are in the northwestern part, north and south of Callahan Creek, west of the Lenia fault, and north of Keeler Creek. A few dikes in the neighborhood of Callahan Creek are within four miles of a granodiorite stock, and within ten miles of a granodiorite batholith, both of which are in Idaho.

The largest mine in the Libby quadrangle, the Snowstorm, and many prospects on Grouse Mountain, as well as the area immediately north and south of Callahan Creek, are in metadiorite dikes. This area consists of the greatest known concentration of metalliferous deposits in the quadrangle. In view of this fact, and of the proximity to the granodiorite plutonic intrusives in Idaho, it may be that a stock not yet revealed by erosion or by mining underlies the Callahan Creek-Grouse Mountain area.

Most of the dikes remote from the stocks are concentrated in the Snowstorm and Grouse Mountain area. They cut the Prichard formation and to a lesser extent the Ravalli formation. Commonly dark-colored, richer in ferromagnesian minerals than in plagioclase, coarse, even-grained, and exhibiting various degrees of alteration, they are called metadiorites. A felsic intrusive on Grouse Mountain
is latite porphyry, and it ranges from three feet to fourteen feet in thickness. In some places it is a sill, but elsewhere, it distinctly cuts across strata of the Prichard; and in the Iron Mask mine, it cuts a metadiorite dike. Similar small dikes were seen in the Ravalli rocks on Ross Creek. All the porphyry dikes seen are barren of metalliferous veins.

The age of the stocks and closely related intrusives of the Libby quadrangle cannot be determined from evidence in the quadrangle. The rocks are very similar, however, to the outlying granodiorite stocks of the Nelson and Idaho batholiths. It is reasonable to infer that the age of the Libby stocks is close to that of the batholiths in Idaho. Argument on these ages places the Libby quadrangle intrusives somewhere from Jurassic to late Cretaceous, although most geologists favor placing them in Late Cretaceous or early Tertiary.

**Amphibolization of Sills and Dikes in the Libby Quadrangle**

(Condensed from *American Mineralogist*, volume 32, number 5, by Russell Gibson and W. F. Jenks, 1938.)

Numerous mafic sills, a few dikes, and one stock, which are intrusive in the Belt rocks in the Libby quadrangle, show widespread amphibolization similar to that observed in the pre-Cambrian Purcell sills of British Columbia and Northern Idaho. The Montana sills are the same age as the Purcell intrusives, whereas the dikes and stocks are regarded as late Mesozoic. The amphibolization of both groups of intrusives is believed to have been caused by hydro-
thermal solutions which were derived from and followed quartz monzonite, granodiorite, and similar intrusives that invaded the Belt rocks of northern Idaho and northwestern Montana, probably in the late Mesozoic. The ore deposits in these areas also are genetically related to the granodiorite and quartz monzonite.

The sills range in thickness from 10 inches to 800 feet, and they are found only in the Frichard, Ravalli, and Wallace formations. At this time, about 40 have been counted. Probably diorite originally, the term of metadiorite is applied to the altered rock now found. The unaltered sill rock was principally hornblende and plagioclase, often porphyritic with plagioclase and hornblende phenocrysts.

Hydrothermal alteration has replaced hornblende and plagioclase with biotite, chlorite, sericite, epidote, and pyrite, often completely. However, it is believed that pyroxene was a major constituent of the originally intruded rock, but the hornblende was produced by earlier amphibolization, and the hornblende subsequently replaced. Little contact metamorphism is found on the sill contacts, but biotite and pyrite occur on the sill margins in the sedimentary rocks. The greatest hydrothermal evidence is notable around mines.

Metadiorite dikes which cut across the sediments and sills are numbered as about 10, with the greatest 140 feet thick. They are later than the folding, and metallization frequently occurs with their hydrothermal alteration.
Vermiculite of the Rainey Creek District

(Condensed from U.S.G.S. bulletin 805B by J. T. Pardee and E. S. Larson.)

Vermiculite is mined by the Universal Zonolite Insulation Company from a stock in T. 31 N., R. 30 W., about seven miles northeast of Libby on Rainey Creek. Surface outcroppings of the stock are two thirds coarse-grained pyroxenite composed of pyroxene, biotite, and flourine-rich apatite assaying 0.12 per cent $V_2O_3$ from overall samples. The other third of the outcropping rock is a coarse-grained syenite containing nepheline and some muscovite of secondary origin.

Hydrothermal solutions have greatly metamorphosed the primary minerals of the stock. Biotite has been altered to vermiculite, and mining grade of rock contains from 30 per cent to 84 per cent vermiculite. Much of the pyroxene has been altered to amphibole asbestos, white mica, aegirite, aegirite-diopside, and fiberous amphiboles. However, only the vermiculite is at present commercial.

The pyroxenite is soft, dark-green, friable, and differentiated into masses of unmixed pyroxene and unmixed biotite, the latter being altered to vermiculite. Apatite ranges from 7 per cent to 10 per cent of the overall composition. Microcline and microperthite are found to be about 15 per cent of the whole, with accessories being magnetite, ilmenite, titanite, and garnet as found in thin-section study.

The large crystals of potassium feldspar in the syenite body
have ceramic potentialities. The rock appears nearly white, but iron stains are usually found on weathered surfaces. Accessory minerals observed in thin-sections are minor hornblende, fluorite, apatite, titanite, rutile, biotite, and garnet.

In the course of hydrothermal action, numerous quartz veins were deposited in the pyroxenite. They contain chalcopyrite, galena, sphalerite, fluorite, strontianite, and celestite, though not in commercial quantities.

Beyond the margin of the stock, in the Belt rocks, quartz-latite dikes of an early age are found. They are medium-grained, greenish-gray with streaks and bunches of dark minerals. Microperthite, pyroxene, and titanite were identified by thin-section study.

A very coarse-grained syenite dike of perthite and dikes of pyroxenite were intruded into the main stock at a later time. Also, south of the stock is another dike of fine-grained to very coarse-grained syenite containing albite, nepheline, orthoclase, and microcline.

Roy W. Goranson, writing in the American Mineralogist, volume 12, number 1, 1927, states that hydrothermal alteration of syenite caused aegirite needles to replace perthite, the length of the needles being up to one centimeter, and they are less than one millimeter thick.
Geology of the Northern Pacific Route

(Condensed from U.S.G.S. bulletin 611 by Marius R. Campbell)

U. S. Geological Survey bulletin 611 is a guidebook for travellers on the Northern Pacific trains, and it provides much geological information that is not readily obtainable in printed form. The information below is composed of specific observations of geological features that are very well correlated with the geographic locations along that route. Following Clark Fork River, an observer sees the stratigraphic section of much of the Belt series on the canyon walls.

At Arlee, just north of the Lake-Missoula county line, the route passes through the broad valley of the Jocko River. The mountain walls of the valley are quartzite and argillite of the Prichard formation. From Dixon, where the Jocko and Flathead come together, the Mission Range is prominently visible, and the author observes its remarkably straight western front, pointing to the fact that the Missions are a great block of the earth's crust raised and tilted to the east which was broken away from the block underlying the broad flatlands of the Flathead valley.

Down the Flathead, at Perma, the great sills which were intruded between the beds of the Prichard formation are conspicuous. They are diorite, being folded with the inclosing beds. Below Perma, the canyon is deep and narrow, and its walls are very precipitous. The dark outline of the sills describes the great anticline into which the Prichard beds have been folded.
From Perma to Thompson Falls, the Belt series has been folded into a great anticline and syncline. This central zone of relatively unfaulted structure extends northward in a belt 100 miles long. On either side of it, east and west, the folded Belts have been severely faulted. Just east of Thompson Falls, the Northern Pacific crosses the great fault that comes out of the Cabinets, and from there westward, faulting becomes more intense and complex.

Clark Fork River, below Thompson Falls, passes through a youthful valley which might properly be called a canyon. Only the Wallace limestones and argillites are to be seen. They have been so broken up by faulting that a tourist sees little of typical geological structure.

![Diagram of geological structure](image.png)

*figure 1.*

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### Belt Series, Upper Proterozoic

<table>
<thead>
<tr>
<th>Formation</th>
<th>Approximate Thickness</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRIPED PEAK</td>
<td>3700'</td>
<td>Gray, greenish, and red shale and quartzite; algal dolomite and limestone</td>
</tr>
<tr>
<td>WALLACE (SIYEH OR NEWLAND)</td>
<td>10,000'</td>
<td>Gray and gray-green argillite; shale; shaley sandstone; quartzite; dark gray dolomitic limestone</td>
</tr>
<tr>
<td>ST. REGIS</td>
<td>1000' to 1700'</td>
<td>Red, green, and gray sandy shale; some quartzite near base</td>
</tr>
<tr>
<td>REVETT QUARTZITE</td>
<td>1200'</td>
<td>Massive white quartzite and gray argillaceous sandstone and quartzite</td>
</tr>
<tr>
<td>BURKE</td>
<td>2800'</td>
<td>Gray sandstone; sandy argillite; quartzite which grades into Revett type quartzite above and Prichard shale and argillite below</td>
</tr>
<tr>
<td>PRICHARD</td>
<td>7800'</td>
<td>Dark gray thin bedded sandy argillite which weathers rusty brown; Interbedded gray sandstones occur near the top.</td>
</tr>
</tbody>
</table>
Middle Cambrian Fossils Near Noxon, Montana

(Condensed from paper by Ian Campbell, Robert P. Sharp, and Hoyt Rodney Gale in American Journal of Science, Volume 34, 1937.)

Fossils of middle Cambrian age occur in a prominent cut on U. S. Highway No. 10A in Section 26, T. 27 N., R. 34 W., on the north side of Clark Fork River eleven miles west of Noxon. The rocks are a dark, fissile shale, and the fossils are in well rounded concretions. The shale is petroliferous. Since it lies within the Hope fault zone, and on top of the Ravalli quartzite, the writers deduce that this Cambrian body is a downdropped block in the fault zone.

Fossils are Oryctocephalus reynoldsi, Tonkinella stephensis, Agnostus, and the brachiopod Micromita panula.

In this article, the authors postulate that the Hope fault is a steep southward dipping normal fault. Its throw is estimated to be from 10,000 to 15,000 feet.

The nearest known fossil locality is on Swamp Creek in the Libby quadrangle. However, the Swamp Creek fossils are similar in age only, but the species named above are common in British Columbia where they occur in middle Cambrian strata.
Hog Heaven District
Flathead County

(Condensed from Montana Bureau of Mines and Geology Memoir No. 17 by Philip J. Shenon and A. V. Taylor, Jr.)

Next to the Jack Waite mine in Sanders County, the Anaconda Copper Mining Company's Flathead Mine in the Hog Heaven district has the largest record of profits of any mine considered in this thesis. It was discovered in 1913, but it lay idle until lessees discovered the main ore body in 1928. Since then, the A. C. M. Co. has shipped high grade ore more or less continuously. Values are chiefly silver.

High grade silver sulphides occur in an igneous body surrounded by rocks of the Ravalli group on the east, south, west and northwest with the rocks of the Wallace group on the north and northeast. Both groups lie horizontally for the most part, although maximum dips of $5^\circ$ have been noted. The igneous complex is five miles long and from one-quarter mile to one mile wide, with numerous satellite stocks and dikes in the sediments surrounding it.

The igneous body consists of both fragmental and porphyritic latite, andesite flows, and trachyte which contains beds of conglomerate. Inclusions of the Belt sediments are found in the intrusive masses. To complicate the complexity, much hydrothermal replacement, exsolution, and alteration have taken place within the mass. Both intrusive and extrusive porphyry have been diagnosed. Large crystals of sanidine and plagioclase are found, and their characteristic twinning is excellent. Micro-phenocrysts of
biotite and magnetite occur in the microcrystalline ground mass. Solutions have removed many of the phenocrysts, and the cavities are left open or filled by subsequent hydrothermal products, some being valuable. Generally the alteration of the feldspar phenocrysts has been to alunite and clay minerals. Of particular significance in the intensely mineralized zone, the latite is altered to iron-rich beidellite, locally called "fumerole mud". With the alunite, clay minerals, and fumerole mud are long tabular barite crystals which were deposited by hydrothermal solutions. While these solutions caused general silification, rarely are quartz fillings or veins produced. In one type of altered rock, the alunite is associated with an exceedingly fine-grained quartz. Ore occurs in the intrusive latite in cellular pockets.

All of the evidence of epithermal, or possible telethermal deposition exists in the Flathead mine. After the solidification of the intrusive porphyritic latite, thermal solutions, representing a late stage of the igneous activity, in places ascended along the most accessible openings, particularly along intersections of fractures trending approximately north and east. The first solutions that coursed through the rocks probably contained a relatively high concentration of sulphuric acid, as the early formation of abundant quartz with pyrite represents a rather complete degree of wall-rock alteration. During or soon after this mineralization, stresses within the rocks were relieved by the formation of fractures, which were later healed by younger quartz, barite, alunite, and sulphides. The barite was probably formed through the agency of
acidsolutions at a relatively higher temperature than the alunite and beidellite. As the temperature dropped, and as the solutions became progressively less strongly acid, the alunite and beidellite were formed. When the solutions became still cooler and alkaline in character, probably as a result of reactions of the acid solutions with the wall rocks, the sulphides were deposited. Textures indicate that hypogene sulphides were deposited an an overlapping series, if not contemporaneously.

Argentiferous galena occurs in cellular masses ranging from the size of a pecan nut to the size of a small watermelon. Microscopic study of these cells show distinctly minute channels through which the solutions migrated, from which replacement fronts moved in all directions to deposit the silver-rich galena in a residual matrix of quartz. (See below.) Supergene argentite has in places replaced the galena. In addition, the multitude of cavities in the greatly altered latite contain pinhead sized crystals of lead and silver sulphides in considerable numbers. Matildite is the most significant hypogene silver mineral, being simultaneous and intergrown with galena. Argentite is supergene, by far the most abundant supergene mineral in the mine, and it replaces most of the other sulphides. Enargite is present in small amounts, and is probably the first of the hypogene sulphides after pyrite.
Gangue minerals are principally quartz, barite, clay minerals, and alunite. Some jarosite is associated with the alunite. Oxidation products are anglesite, a yellow powder containing lead, antimony, and bismuth oxides, melanterite, siderotil, some malachite, and sparingly, manganese oxides. Cerargyrite is possibly present in the oxidized zone.

Ore extraction for shipping to the smelter has been from a shallow zone 400 feet long, 150 feet wide, and only 100 feet deep. The shape of the ore deposit may be compared with a molar tooth, tapering out at the end of the root. High grade concentrations of cellular pockets occur irregularly, and no regular pattern of the ore structure exists. The high grade ore must be sought out. No doubt, supergene enrichment has been the major factor in making the deposit so favorable economically. Extension in depth is a problem that has not been determined at this time.

**Ole Mine**

The Ole Mine is about a mile directly west of the Flathead Mine. It consists of a 450 foot tunnel through the mountain, an adit which cut 30 feet of latite porphyry similar to that in the Flathead Mine, and a 15 foot winze in the adit. The 15 foot adit bottomed in Belt argillite, but values are reported in gold, silver, and lead. On the surface, the porphyry appears to be a dike, although evidence that it may be lava also exists. In favor of its nature as an intrusive, however is the hornfels halo in the contacting sediments.
Flathead County

Flathead county is an area of greater geological complexity than any other in northwestern Montana. Its topography ranges by extremes, the western half being relatively flat, and the eastern half being a land of alpine mountains so rugged that the area is not only uninhabited, but relatively unexplored. Through the center of the county, the flat valley floor and Flathead Lake mark the Rocky Mountain trench.

The Hog Heaven district lies in a line of low ridges which are structurally formed by the simple folding of the Belt series. Although modified by the great normal faults, the valley may be considered a synclinal trough. From the axis of the great anticline on which the Ravalli group is so extensively exposed, an eastward coursing traverse will cross the eastward dipping Wallace group on the western fringes of the valley fill, and on the east side of the valley, a broad band of westward dipping sediments crop out which belong to the Missoula group.

However, the syncline is the last of the symmetrical folds that extend from Libby to Kalispell. The eastern border of the valley is a gigantic fault scarp, straight as a ruled line, and it has thrown up the towering Mission range as a 7000 foot barrier. The Mission and Swan faults are ruptures of the earth's crust of extraordinary extent. From the regional geologic map, it can be seen that they are normal longitudinal faults of the same fault family as the Snowshoe fault in Lincoln county. Vertical displacement on the Mission fault is from 7000 to 10,000 feet, and the
horizontal movement is measured in miles. The great rock mass of the Mission range has been hoisted up to form rugged peaks over 10,000 feet above sea level on the eastern side.

Much of the Swan fault is covered by valley fill north of Flathead Lake, but its measured and deduced length is known to exceed 100 miles. Like the Mission fault, its eastern scarp forms a great range of peaks. This is known as the Swan range.

Parallel to the Swan fault, and closely related to it in all respects, is the Flathead fault. Its resulting Flathead range ranks right with the Mission and Swan ranges for height and rugged feature. East of the Flathead range is the backbone of the Rocky Mountain system, locally called the Lewis range.

Undoubtedly, the Mission, Swan, and Flathead faults are related to the Lewis overthrusting. Some geologists have estimated that the Belt series have been thrust over the Cretaceous plains of Central Montana for a distance of over 100 miles. The Lewis range illustrates the effects of the tremendous forces from the west that accomplished the great overthrust movement. In the Lewis range, bands of Mesozoic and Paleozoic strata stand up almost vertically. First yielding of these upper strata was crumpling and folding. Then faulting broke them up farther, and the present vertical position is the result of "sled runner" reaction.

Near the 49th parallel on the North Fork of the Flathead River, an area of Paleozoic rocks, chiefly limestone, occurs. Nothing has been published on them, and information concerning their existence comes from Dr. E. S. Perry.
PLACER MINING OPERATIONS IN WESTERN MONTANA

(Condensed from Mining World, volume 34, by J. P. Rowe.)

Most of the placer mines of Flathead county are located south of the Great Northern railroad, and in the southwestern part of the county. Placer mining has been more or less active on Libby Creek since 1880. Claims have been worked near the source of Libby Creek, and the Libby Placer Mining Company operates several near the junction of Libby and Howard Creeks. Tributaries of Libby Creek have also been the source of placer gold, namely Ramsey, Poorman, Bear, and Fisher Creeks.

The contour of the country generally has been fashioned by the action of glaciers, and most of the streams have giant boulders in their beds. Some of these boulders weigh hundreds of tons. The deposits are variable in grade, some being very high, and others being almost barren. Near the source of Libby Creek, values of 80 and 90 cents per yard have been recovered, while downstream several miles, the gold drops down to around 20 cents per yard.

In most of the placers on Libby Creek, no true bedrock is reached; but a hard conglomerate, known locally as "false bedrock", is the horizon where excavation stops. Libby Creek and its tributaries furnish plenty of water for summer work, and the largest and longest ditches with the most pretentious hydraulic placer in this locality is operated by the Libby Placer Mining Company. This company had two ditches in 1910, one from Libby Creek with a 50 foot head, and the other from Ramsay Creek with a head of 100 feet.
This hydraulic installation is strong enough to tear down the gravel banks and run the material through the flume.

Rowe reports in 1910 that there are several claims between Libby and Libby Creek. Some of these have many miles of ditches, and they have also reported profits. Though this is an old placer district, it has never been developed properly. Therefore, the production from this county is not as large as the deposits themselves really warrant. At that time, the Libby Placer Mining Company planned to build a dredge on lower Libby Creek, where it had several miles of splendid dredging ground.

The Fisher Creek placers were worked quite extensively, but when the area was incorporated into a forest reserve, the validity of the claims was contested and production brought to a halt.

The Cedar Creek Placers

These placers were discovered in 1869, and they have been worked almost continuously ever since. In the early days, this creek boasted a population upward of 10,000. The La Crasse brothers, until about 1910, owned and operated the ground near the head of Cedar Creek about 15 miles from Iron Mountain, and theirs is the only property that was being worked in 1910. It is estimated that from $9,000,000 to $10,000,000 in gold were taken from Cedar Creek between 1870 and 1910.

The Kansas City Commercial Company owned 570 acres on Cedar Creek in 1910, and at that time, it was operating a 100,000 cubic yard dredge. They were working ground that produced 25 cents per
cubic yard, and to operate the dredge, they had an electric power plant.

**Recent Summary**

In 1932, Frederick C. Gilbert wrote an article on the placers in Western Montana which appeared in Mining Truth, volume 17, number 4. Benches of lake gravels and glacial till are found throughout the valleys of the mountainous area. Reconcentration of the gold from these benches has been a major factor in making valuable placer deposits. An area 30 feet by 80 feet and only 3 feet deep near Trout Creek produced $3000 in 1873, and the extensive workings of these rich deposits has been estimated at $2,000,000. Gravels ran from 25 cents to 3 dollars per yard. However, the early day miners meticulously worked the stream bottoms, so very little commercial gravel remains.

The writer observed several sluice box placers in operation on Vermillion Creek in 1937. They were typical of the workings along the streams in California, which are numbered in the hundreds in areas of that state where bonanza gravels have been worked out. Such operations are called snipping, and the miners who do the work are called snippers. Western Montana placers are snipping operations, but they are small in numbers at this time compared with those in California. However, should the price of gold be increased and/or very low cost mining equipment be developed for handling very large tonnages, millions of dollars worth of gold are emplaced in the bench gravels and glacial moraines of the five counties in western Montana.
The property of the Iron Mountain Tunnel Company is located about three miles northwest of Superior on the Chicago, Milwaukee, St. Paul, and Pacific railroad. It was discovered around 1880, and the claims were worked by Holter and Hauser of Helena, taking out some very rich lead-silver ore between 1884 and 1886. It is reported that the richest ore was in the vadose zone, and that some shipments ran as high as 600 ounces of silver per ton. A shaft was sunk to 1800 feet with ore encountered all the way down. For access to the upper workings, four adits were driven to tap the vein.

Country rock at the Iron Mountain mine is shale and quartzite, probably of the Striped Peak formation, which strikes northeast and dips steeply to the southwest. F. C. Calkins classed it as the Wallace formation, and J. P. Rowe suggests that it might be the St. Regis formation. However, this writer notes that the mine is situated on the Osburn fault at the junction of all three of these formations.

Mineralization has taken place in a fractured zone, typical of all of the mines along the Osburn fault, by metasomatic replacement. Several parallel veins occur, and their width varies from a few inches to several feet. However, only one vein has been extensively worked. Its width varies from 6 feet to 22 feet, and high grade ore shoots have been the source of the mine's profits. Ore shipments in 1897 averaged 43.5 ounces of silver, 23.5 per cent lead, and 12.5 per cent zinc.
JACK WAITE MINE

(Condensed from Mining Congress Journal, volume 17, by John R. Turner.)

Half in Idaho and half in Sanders county, the Jack Waite mine is one of the richest producers in the entire history of northwestern Montana. Entrance to the workings is made through a long adit from the Idaho side.

A well defined fissure in the Prichard formation is the site of ore emplacement. Two definite periods of mineralization are in evidence, and possibly more took place, but the ore body appears to be two separate veins following the same fissure. These are known as the Montana vein and the Idaho vein.

In 1932, when this article was written, the fissure had been developed for 5000 feet along its strike, and plenty of ore was showing in the face then. Ore occurs in shoots from a few inches to 20 feet wide, and where mineralization did not take place, the fissure filling is gouge. The vein strikes N 55° W and dips 50° SW.

Fine-grained, pure galena is the chief ore mineral, although minor sphalerite, pyrite, and chalcopyrite occur in the vein. In the high grade ore shoots, the galena is in massive bodies without impurities of any consequence. Consequently, it is mined clean and shipped directly to the smelter. Where the ore is not so rich, it is milled and concentrated by flotation.
GOLD QUARTZ MINING IN WESTERN MONTANA

(Condensed from Mining World, volume 34, by J. P. Rowe.)

The Sylvanite district is situated in the northwestern part of the state in the Loop mountains on the Yaak River 25 miles northwest of Troy. There are two fairly well known properties in this district, the Victor and Keystone. The vein passing through these properties is in pre-Cambrian quartzite, and it is filled with white quartz containing free gold.

The Keystone group was operated by the Lincoln Gold Mining Company which employed 25 men. It was worked through two tunnels, 700 and 900 feet long. In 1909, a mill with 200 tons capacity was constructed, and a 2400 foot tram was used to convey the ore to the mill. Development at that time had not reached below the oxidized zone, and the gold is found in the quartz with residual iron oxide.

An 800 foot adit opens the Victor ore body, and considerable ore was shipped from it. Pyrite, carrying gold, along with some copper and silver values, composes the commercial mineral in the quartz vein.

North of Libby and a few miles east of the Mooyie River, the Buckhorn mine had been supplying a ten-stamp mill for six years. Its ore is free-milling, and the vein is in Prichard quartzite.

About 1 1/2 miles south of Plains, the Clark's Fork Gold Mining Company exploited five veins which carry free-milling gold, gold tellurides, and gold bearing pyrite. The veins vary in width from a few inches to 20 feet, and those found in the diabase
and diorite sills are true fissure veins, but those found in the
Frichard rocks are bedding-plane veins. Mineralization took place
after the cooling of the intrusives.

These veins are nearly parallel, with a north and south strike.
They dip to the west at angles from $50^\circ$ to $60^\circ$. Many assays were
made from samples taken at various places, and the average value of
all the ore blocked out was $30$ to $40$ per ton. Vein lengths are
from 5000 to 6000 feet along the strike.

On Prospect Creek near Thompson Falls, several properties
were being developed in 1910. Of these, the Rosebud near the
mouth of Rosebud Creek was the most promising. Bedding-plane
veins of quartz in the Frichard sediments occur at that mine.

On Vermillion Creek, the Gold Hill Mining Company operated
a mill about four miles north of Trout Creek. This operation was
carried on in a porphyry dike on the margin of the diorite stock
that crops out over several square miles near the mouth of Ver-
million Creek. Values of $8.50$ per ton were reported for average
mill feed.

Three miles from Trout Creek, the Eplin property reported
the discovery of copper ore, and the Trout Creek Development
Company exploited the contact metamorphic zone along the stock
nine miles from Trout Creek. Granite is the intrusive at that
property.
GOLD QUARTZ VEINS SOUTH OF LIBBY

(Condensed from Circular 7, U.S.G.S., by Russell Gibson.)

On the high ridges and peaks of the Cabinet range northeast of its water shed, and the boundary between Lincoln and Sanders counties, white quartz veins crop out in abundance. Quartz float can be found on almost any slope or creek bottom, and "colors" can be obtained in a gold pan by crushing and panning this float. Most of it, though, comes from veinlets in the Belt sediment's bedding-planes. However, some of the veinlets have been discovered in widths which warranted exploration and exploitation. A few small producers have reported notable profits.

In these producers, mining was conducted on veins of from a few inches to six feet in width. Sulphide minerals, chiefly pyrite and galena, seldom exceed 5 per cent of the vein, and small amounts of sphalerite, chalcopyrite, pyrrhotite, arsenopyrite, tetrahedrite, and scheelite are present. Oxidation is shallow, and both oxidized and sulphide zones contain gold in free-milling form. Step faults of small displacement have cut most of these veins, and prior to their development, bedding-plane faulting produced shearing effects on the quartz with subsequent replacement of the quartz by sulphides and gold to produce a ribbon structure.

The backbone of the Cabinets in this area is the ice and water-chisled remains of Belt sediments which compose a great anticline. Hence, since in the gold quartz area, the beds lie flat on the crest of the anticline or dip moderately to the northeast.
Because Gibson notes that most of the veins are in the Prichard formation, which is the lowermost of the Belt series exposed here, it is likely that the mineralizing solutions did not come from any near-surface source. However, the great vertical Snowshoe fault bisects the anticline parallel with its axial plane, and while the fault has been mineralized, the younger beds on the west side of the fault have not been mineralized.

Glaciation on the northeast slope of the Cabinets has deposited till to a considerable thickness along Libby Creek which flows over flat valley-land extending from the mountain canyons to Libby, a distance of about 15 miles. Reworking of these gravels by the streams has resulted in small but lucrative placers, and gold values are also concentrated in individual beds within the till. This basin of till is 12 miles wide, from 100 to several hundred feet thick, and heavily timbered. Occasional nuggets range from pea size to finger-tip size, and frequently they have quartz fragments still adhering to them.

Intrusive rocks on the western side of the Cabinets consist of small stocks of apparently Mesozoic age, and they are quartz monzonite, granodiorite, and syenite. Also, dark-colored greenish granular dikes occur in that area. The intrusives are not within the area of the gold-quartz veins. However, in the Prichard formation with the gold-quartz veins, sills of greatly altered granodiorite and diorite are somewhat abundant. These sills range from 3 feet thick at the Viking mine to 1000 feet thick elsewhere. Their age is in question, and it is possible that their origin may date back to pre-Cambrian time. They are known in two instances to contain gold.
Lead-zinc-silver deposits occur in this area, but do not belong to the gold-quartz type of veins. As at the Snowshoe mine, these deposits are found associated with the great normal faults that cut the area.

Ore Occurrence

The gold-quartz veins in the area south of Libby are commonly parallel to and between the beds of the Prichard formation, although some have been found in the Wallace formation. In certain cases, they cut across the beds at a low angle; and some distinctly cross-cutting veins change their course and become bedding-plane veins. They may pinch and swell within short distances, or one vein may split into two or more branches that fray out into the country rock. Other veins come in above or below a pinched vein; or, if one vein splits into several, the intervening country rock may be mineralized. Where the veins are not parallel to the bedding, they commonly cut across at low angles and invariably have a steeper dip than the beds, whether the beds are comparatively horizontal or not. It is said that in the vicinity of the Little Annie mine, where there are both flat bedding-plane veins and steeply dipping crosscutting veins, those veins parallel to bedding are much richer than the crosscutting veins.

Native gold is coarse enough to be seen easily in ores from four of the largest producers, although fine gold and scheelite in others lends strongly to evidence for hypothermal conditions of deposition as well. All the criteria of metasomatic replacement prevails, however, and gold appears to be concentrated in ore
shoots that contain abundant sulphides or have contained them. Shearing along the quartz planes took place after, and probably during, the quartz deposition; and in brecciated quartz zones, values are high. At the Viking mine, this movement along the vein must have taken place several times, because the quartz is banded and ribboned. Pyrite disseminations are abundant in the footwall quartzite as much as four feet from the vein.

Many stages of replacement are in evidence. Gold and sulphides have replaced quartz and then fine-grained quartz has again replaced the metallic minerals. Sericite is present in all the veins, but is presumed to be residual after the minerals of the sedimentary bed were replaced. Pyrite, pyrrhotite, and sphalerite are early minerals followed by galena and chalcopyrite. Gold is either free in the quartz or at the margins of grains of sphalerite, galena, pyrite, or pyrrhotite where it has replaced the sulphide. Gold which has replaced sulphides is smooth and dark yellow. The grains are irregular in shape, long and wirelike, or lenticular. Where gold has replaced sphalerite, it may exhibit straight edges, conforming to the sphalerite cleavage. In oxidized zones, the gold is gnarled, rough, or spongelike. Assays run from only a trace of gold to 25 ounces per ton.
Mines and Prospects

**Betty Mae**: six claims at the head of Goat Creek
Prichard formation; sandstone and sandy shale
Strata nearly horizontal or dipping slightly northwestward
Narrow vein
Pyrrhotite, sphalerite, chalcopyrite, and galena, in quartz
Development consists of six shallow openings.

**Blue Bird and Maybe**: west side of Hoodoo Creek
Wallace formation; greenish and gray shales that strike N80°E and dip 34°SE
Mineralization in shear zone dipping 78°SW and striking N50°W
Vein width 2 feet, length 1500 feet
Quartz, gold, chalcopyrite, and galena, averaging $2 per ton overall
Development consists of several shallow open cuts.

**Diamond John**: north side of Libby Creek above Howard Creek
Prichard formation; brownish-gray sandstone and bluish-gray shale
Dip slightly westward from horizontal
Two veins 3 feet apart showing 16 inches of quartz each
Sulphides have all been oxidized leaving limonite gossan
Development consists of 60-foot adit.

**Fisher Creek or Branagan Mine**: six patented lode claims and two patented placer claims 2 miles above the junction of Bramlet Creek and West Fisher River
Prichard formation; gray sericitic sandstone and shale; gentle eastward dip
Vein widths are from 2 feet to 4 feet, but stopes have been to 10 feet. Crosscutting veinlets and parallel veins are common, and underground workings have opened the veins for 500 feet. Quartz, gold that is visible in specimens, pyrite, galena, pyrrhotite, chalcopyrite, sphalerite, and oxides.

Development consists of 5 adits 200 to 500 feet long, and a stope area of about 50,000 square feet in the plane of the vein. Total production is estimated at $300,000.

Golden West Mining Company, Little Annie Mine: West Fisher River near headwaters

Prichard formation; sandstone and thinly laminated sandy shale dipping gently to the northwest

Vein widths range from a few inches to 4 feet and are of over 1000 feet in length, but pinching and swelling unceasingly. Quartz, pyrite, sphalerite, galena, and gold.

Development consists of 300 feet of crosscuts and drifts.

Production of 39 tons yielding 3.874 ounces of gold and 1.05 ounces of silver per ton is reported.

Golden West Mining Company, New Mine: West Fisher River near Little Annie mine

Prichard formation; sandstone and shale similar to that at the Little Annie mine.

Veins range in width from a few inches to 2 feet.

Assay of an average sample showed 2 ounces of gold per ton.

Development consists of an adit of short length.
Libby Prospect: two claims on south side of West Fisher River one mile west of the Branagan mine

Prichard formation; gray sericitic sandstone and sericitic shale

Vein widths range from a few inches to over 2 feet.

Quartz, galena, cerusite, anglesite, pyromorphite, and limonite

Development consists of five short adits up to 100 feet long.

"Dike" on Libby Creek; between Howard Creek and Libby Creek falls

Ravalli group; buff, hard quartzitic sandstone dipping 44° NE

Beds have been mineralized by small irregular quartz veins which contained a little sulphide before oxidation. These quartz veins are from microscopic dimensions to a few inches wide.

Mineralized zone is 300 feet thick along the stream course, and placer mining has been carried on downstream from it.

Midas Mine: one mile southeast of Howard Lake on the county road

Wallace formation; calcareous shale some beds of which are paper thin, sandy shales or sandstones, and banded and contorted limestone; beds dip 40° to 60° NE and strike N20° to 30° W.

Veins range from a few inches to 6 feet in width and strike with the bedding.

Quartz, scheelite, carbonates, scant galena and tetrahedrite, and native gold which can be seen with a hand lens associated with malachite, scheelite, and limonite. Gold is gnarled and wirelike.

Development consists of 300 feet of drifts, crosscuts, and raises with stopes. Modern mining machinery, hoist, and a plant of 75 ton capacity employing flotation are on the property.

Production exceeds $59,000
Montezuma group: six claims on the north side of West Fisher River just below the mouth of Standard Creek

Wallace formation; calcareous shale, sandstone, and dolomite, all buff colored and dipping 40° to 50°NE

Bedding-plane veins from a few inches to 20 inches wide which in some places dip more steeply than the bedding-planes.

Quartz, tetrahedrite, galena, pyrite, and chalcopyrite

Development consists of open cuts and short adits; the longest is 385 feet.

Mustang group: four claims on the south side of Standard Creek

Prichard formation; shaly sandstone and sandy shale striking N30°W and dipping 30°NE

Closely spaced bedding-plane veins from 7 to 18 inches thick in the adit and 30 inches at the surface; banded and sheeted into ribbon structure

Quartz with scant pyrite and galena; much pyrrhotite is found in the beds near the veins. One hand specimen assayed 1.49 ounces in gold and 2.11 ounces of silver per ton.

Development consists of an adit 300 feet long.

Olsen and Switzer group: eight claims on Bramlet Creek

Prichard formation; bluish-gray to gray shale, nearly horizontal

Several quartz veins between bedding and from 6 to 48 inches thick

Quartz, galena, pyrrhotite, sphalerite, chalcopyrite, and pyrite

Sulphides are related to a sheared zone or ribbon structure.

No development beyond assessment work.
Tip Top Mine: north of Bramlet Creek near the Branagan mine
Prichard formation; white sericitic sandstone and gray sericitic
shale lying horizontally
Veins conform to the bedding and range from a few inches to 2 feet
in thickness.
Quartz, sphalerite, pyrite, pyrrhotite, and limonite. Gold is vis-
ible under hand lens, but where it is not visible, assays are
very low. Wall rocks carry gold values with the veins.
Development consists of numerous short adits with stopes
Production for treatment in a ten-stamp mill amounted to about $2300.

Williams group: seven claims between Great Northern Mountain and Twin
Peaks near Libby Creek
Prichard formation; gray sandy shales lying horizontally
Veins conforming to the bedding are a few inches to 2 feet in thickness.
Also crosscutting veins attaining a thickness of 2 feet strike
east of northeast and dip steeply.
Quartz, galena, and pyrite with assays showing 0.04 ounces of gold
and 8.71 ounces of silver per ton
Development has been confined to open cuts.
MINES AROUND SALTESE

(Condensed from U.S.G.S. bulletin 450 by F. C. Calkins and E. L. Jones, 1912.)

Silver Cable Mine: headwaters of Brimstone Creek
Burke formation
Fissure vein striking east-west with a steep dip and 4 foot width
Quartz, siderite, galena, sphalerite, and tetrahedrite running 11% zinc and 24% lead with some silver
Development exceeds 1000 feet.

Syndicate Mine: four miles northwest of Saltese
Burke formation
Fissure vein striking N75°E, vertical, and 3 to 6 feet wide
Quartz, siderite, tetrahedrite, galena, chalcopyrite, pyrite, and overall high values in silver
525 feet of development

Bryan Mine: four miles north of Saltese
Burke and Revett formations; nearly vertical
Fissure vein dipping steeply to the south and striking N60°E
Siderite with bands of quartz and pyrite, galena, and tetrahedrite averaging 5 feet in width
2500 feet of development

Last Chance Mine: three miles north of Saltese
Burke formation
Two fissure veins, one striking east-west, and the other striking N50°W with vertical attitude

Quartz and siderite with galena, pyrite, tetrahedrite, stibnite, and high silver values

Development exceeds 700 feet with 2 adits, intermediate drift, shaft, and open cuts. $200,000 worth of shipping ore sold up to 1912.

Ben Hur Mine: three miles north of Saltse

Burke formation

Replacement of a quartzite bed by fine grained sulphides and quartz

Quartz, galena, stibnite, pyrite, chalcopyrite, and high silver values

1500 feet of development

Tarbox Mine: middle fork of Packer Creek

Burke formation

Two veins in a zone of gouge and breccia more than 300 feet wide

Quartz, siderite, galena, and pyrite

Development consists of a 500 foot shaft and more than 500 feet of drifts and crosscuts.

Meadow Mountain Mine: three miles east of Saltse

Burke formation

Two veins in gouge and breccia more than 300 feet wide

Quartz, siderite, galena, and pyrite

500 feet of workings
Barite Prospect: west fork of Packer Creek
Bedding-plane vein 1 foot thick in Revett quartzite

Hemlock Prospect: west fork of Packer Creek
St. Regis formation
Fissure vein 20 feet wide
Veinlets of quartz, galena, and much pyrite; low grade ore
300 feet of development

Richmond Mine: five miles south of Saltese at Bitterroot crest
Wishards sill and Wallace formation
Bedding-plane vein 5 to 10 feet thick
Quartz, siderite, and malachite
Development consists of three shafts and 500 feet of horizontal passageways.

Copper Age Mine: six miles south of Saltese at Bitterroot crest
Wishards sill and Wallace formation
Vein strikes N65°W and is 10 feet thick.
Quartz, siderite, chalcopyrite, and chalcocite
1000 feet of development

Manhattan Mine: six miles south of Saltese at Bitterroot crest
Wishards sill and Wallace formation
Quartz and siderite with stains in oxidized zone
700 feet of development

Alice Mine: on Kelly Creek
Wallace formation
Two veins 25 feet apart striking N85°E and dipping 70°N, each about 6 feet wide
Quartz, siderite, calcite, pyrite, chalcopyrite; low tenor
600 feet of development

**Alpina Prospect**: on Kelly Creek
Wallace formation
Vein 2 feet thick striking N85°E and dipping 65°N
Quartz, siderite, chalcopyrite, and gold
1500 feet of development

**Bald Mountain Mine**: south fork of Dominion Creek
Wallace formation
Bedding-plane vein striking N34°W and dipping 55°SW
Quartz, siderite, and sparse chalcopyrite
2000 feet of development

**Switchback Mine**: two miles south of Saltese
Wallace formation
Fissure vein 1 foot wide
Quartz, siderite, sparse chalcopyrite, and $2 per ton in gold
300 feet of development

**Agnes Mine**: two miles south of Saltese
Wallace formation
Fissure vein varying from a few inches to 8 feet in width
Quartz, siderite, and galena
800 feet of development
Taft Mine: on St. Regis River west of Saltese
Wallace formation
Fissure zone with mineralization
Quartz, siderite, chalcopyrite (2% copper) and $2 per ton in gold

Boston Colby Mine: one-half mile northwest of Saltese
St. Regis formation striking northwest and dipping 50° southwest
Bedding-plane faults with mineralization from 4 to 10 feet thick
Quartz, siderite, limonite, pyrite, and chalcopyrite carrying gold

Cooper Creek Mine: eight miles east of Burke, Idaho
Wallace formation
Fissure vein with 3000 feet of outcroppings
Quartz, galena, sphalerite, chalcopyrite, and high silver values

Metal Cove Mine: Freezecut and Snowshoe Creeks near Superior
Ravalli group
Fissure vein with 9000 feet of exposed outcrop
Quartz, galena, tetrahedrite, chalcopyrite, and high silver values
Development consists of three adits, 130 feet, 80 feet, and 60 feet long.
MISCELLANEOUS MINES OF IMPORTANCE

In 1931, Russell Gibson stated the following in Mining Truth, volume 16, number 9: "Lincoln county has produced more than $6,000,000 in gold, silver, lead, zinc, and copper, yet little is known about its ore deposits, and not much has been published concerning the geology of northwestern Montana". This statement holds true in 1947, although during the intervening sixteen years, small mines were opened up only to increase the number of tragic failures that little prospects in this area are noted for. The story of each is insufficient ore in sight accompanied by an expensive mill which was counted upon to produce early profits.

By definition, a good mine is one which can stand mismanagement. There have been several mines in each of Lincoln, Sanders, and Mineral counties that have met the qualifications of that definition and produced dividends for a few years.

By far the leader of mines in the above category is the Snowstorm mine in the Grouse Mountain district near Troy. The Snowstorm is credited with a gross production of $4,000,000. Shipments of high grade were first made in 1905, but from 1917 to 1928, it was a steady producer. Concentrates from a 500-ton mill were shipped during that time, and values in lead, zinc, gold, and silver were paid for. Tragedy struck in 1927 when the mill was completely destroyed by fire. It has been idle since.

The Snowstorm ore occurs in veins associated with a much altered metadiorite dike which is not far west of a strong trans-
verse fault. Numerous other small operations have been carried on in the mineralized zone around the Snowstorm, but none have made profits of any notability.

The Snowshoe mine was first opened in 1892, but extensive development was not begun until 1900. The total production up to 1931 amounted to about 130,000 tons which yielded $1,086,000 in net smelter returns. Values were in lead, silver, and gold.

It is common talk among the old miners that this property was not well managed, and the present owners believe that inefficient milling caused losses at times of 40 per cent of the values. Most of the Snowshoe workings are now inaccessible, but the owners state that thousands of tons of proven ore and partly blocked out ore remain.

The vein material occupies the fissured and sheared zone of the Snowshoe fault. On the east is the Prichard formation, while on the west is the Wallace formation. The main vein is composed of gouge, quartz, siderite, irregular masses of galena, and minor sphalerite. Another vein occurs 75 feet east of the fault vein, running parallel to it. Mine run ore averaged 10 per cent lead and 5 ounces of silver per ton.

In 1887, the Silver Butte was located at the headwaters of the West Fisher River on the Silver Butte mountain. A road was built up Vermillion Creek to the Silver Butte pass, and then it was blasted on up the precipitous slopes of the mountain to the adit. A narrow ledge was cut out of the steep slope for a camp area, and a 2800-foot adit was driven southeast in ore all of the way. For
a number of years, hand picked ore was hauled down the steep road
to the railroad at Trout Creek. Later, a $150,000 concentrator was
installed, but fire destroyed it in 1905. Since then, the mine
has been idle, although some development was done in 1946.

The Silver Butte vein strikes N 60° W and dips 30° S. In
the drift, it ranges from 10 feet to 14 feet thick, lying in a
bedding-plane. On the top of the mountain, the outcrop is 30
feet thick. Quartz, galena, sphalerite, chalcopyrite, and silver
values compose the ore minerals which occur in ore shoots.

Two miles northeast of the Silver Butte mine, the Viking
Mining Company explored a gold-quartz vein, but the hasty building
of a mill wrecked the company in 1938. The vein is a typical
bedding-plane ledge of banded quartz with small amounts of galena
and pyrite. Gold values in the quartz vein were sufficiently
high for commercial operation, but not sufficient ore had been
blocked out to tether operations to feeding a mill.

The vein crops out along the crest of a ridge, striking
almost north-south and dipping eastward at about 45°. The country
rock is typical Frichard argillaceous sandstone, but transverse
faults striking west of northwest have broken the vein into seg-
ments en echelon, displacement ranging from 3 feet to 50 feet.
The vein thickness ranges from a few inches to three feet. Pyrite
is disseminated in a quartzite bed on the footwall, and with it is
from a few cents to a dollar per ton in gold. While excavating for
the millsite, a metadiorite sill was discovered with extensive
quartz veinlets along the jointing cracks which assayed $14 per ton.
FLATHEAD COAL BASIN

(Condensed from E. & M.J. volume 54, by Herbert Wood, 1892.)

Coal is found in Cretaceous strata between longitude 114° and 114°30' just south of the 49th parallel. These Cretaceous formations are the connecting link in the great Cretaceous system that covered all of Montana and British Columbia to the Pacific Ocean. They are found in a basin which is part of the Rocky Mountain trench.

Cambrian quartzites are found overlying the upper Belt series, followed by Devonian, Carboniferous, and about 7000 feet of the Kootenai formation. All of the outcrops strike about N 10° W and dip northeast. The dip gradually lessens from the base of the series as a 1½ mile traverse is made eastward across the strike over the outcroppings that expose the upturned edges of the southwestern side of a synclinal fold. The more productive portion of the Kootenai formation is the basal 1000 feet. In that section, 15 to 20 coal seams are exposed, 6 or 7 being workable.

The Emerson Tunnel was 102 feet long in 1892, and its course is N 18° E. The following is a section in the tunnel:

![Figure 3]

About 75 or 100 square miles of coal field are exposed in the area, and the coal has been metamorphosed in places to anthracite. Otherwise, the coal ranges from lignite to bituminous. Production in recent years has been about 30 tons per day.
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<thead>
<tr>
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**Mineral County**

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- Amador: Iron Mountain, Ag, Pb, Cu
- Amazon-Dixie: St. Regis, Au, Ag
- Atlantic and Pacific: Iron Mountain, Ag, Pb
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CONCLUSIONS

The fact that two synclinal troughs expose Paleozoic and Mesozoic rocks which have been folded with the underlying Belt sediments indicates that the area in western Montana received sediments as part of the great Cordilleran trough until the widespread uplifting and folding of the Laramide orogeny. Since upper strata of the Prichard formation are exposed at elevations of 7000 feet above sea level, average uplifting of the entire mass from a sea level datum plane was at least 30,000 feet.

Magma intruded the Belt sediments to a more or less degree up to the surface that is at present exposed. Intrusives that are now exposed apparently came from chambers not very distant from the main magma body, but the absence of volcanic pipes gives very little reason to believe that extrusives of Upper Cretaceous age were emitted as they were in central Montana. However, hydrothermal juices from the magma escaped into post-faulting ruptures of the Belt rocks in very great amounts. Assigning an age to the numerous metadiorite sills, the Wishards sill, and the Perma sills could only be a guess. They are folded and faulted with the sediments, and evidently they intruded while the sediments were horizontal, although some forces must have been active to provide zones of weakness along the bedding-planes over great areas. No evidence exists that can tie the widespread quartz deposition to these sills.

Compressive force was evidently active from the first stir-
ring of orogeny until the last. During that time, the force persisted from the west-south-west, first folding the sediments, but as the folds reached symmetrical form, their unyielding nature resulted in a mass movement of the entire body to the eastward. This could only be made possible by a fluid magma surface upon which the body could slide. The Lewis overthrust is an exposure of this great mass movement, while the Osburn fault is apparently a rupture which resulted from resistance by a pivot on the southern regions. The great longitudinal faults are true normal faults, and they are probably caused by reactions of adjustment as the great body of rock moved eastward.

Mineralization took place all during the orogenic activity. Gold-quartz veins are almost without exception associated with bedding-plane faults along which the strata adjusted itself while being folded. Such mineralization also was simultaneous with the slipping of the beds over one another, hence it is likely that the gold-quartz deposition was the first of all igneous activity to take place. The great steeply-dipping normal faults of both transverse and longitudinal trends received hydrothermal mineralization during their activity. Lamprophyres and mesothermal lead-silver deposits are typical of these faults, and such mineralization is widespread and often rich.

Erosion of the uplifted mass must have been very intense during the late Cretaceous, because the original quantity of rock which was believed to have been present is now half gone, yet in the Hog Heaven district minor extrusives of Eocene age still
remain. Also, Tertiary lake beds and glacial morains are still very much in place, so it is reasonable to suggest that the present erosion surface is practically the same as at the close of the major orogenic activity. Possibly, the vast Upper Cretaceous continental series of sediments were derived from western Montana. It would be interesting to correlate the grains of the Lance or Fort Union formations with diagnostic minerals from the roots of the old highlands which are now all that remain of them in northwestern Montana.

The prospector's tales are not unfounded. Hundreds of mineral deposits crop out in the five counties in western Montana. However, the region is primarily for prospectors. Bonanzas may exist, but they have not been found during the first 100 years of habitation by white men. Commercial ore bodies are very rare, assuming that a commercial ore body must support a stock company. However, plenty of veins exist which are fully capable of supporting partnerships where the partners do their own work and furnish the ingenuity which owner-operator entrepreneurs of America are famous for. Should activity of that nature spring up in western Montana, it is possible that large mines may be discovered, but in the meantime, the area can only be considered as a possible future reserve of lead, zinc, and copper. Stock companies and government agencies are very unlikely to establish any important production figures in the next decade.
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EXPLANATION

- **Q61**: Sand, loam, glacial debris, lake beds
- **K1P**: Paleozoic and Mesozoic Sediments
- **A8**: Missoula group, Striped Peak fm.
- **A3-7**: Wallace (Siyeh) group - Helena, Spokane, and Newland fm.
- **A2-4**: Ravalli group - St. Regis, Revett, and Burke fm.
- **A1**: Pritchard fm.
- **I9**: Igneous rocks

Legend:
- **_boundaries**
- **Fault**
- **Contact**
- **River and stream**