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PROGRESS REPORT ON

GEOLOGIC INVESTIGATIONS IN THE KOOTENAI-FLATHEAD AREA, NORTHWEST MONTANA

2. SOUTHEASTERN LINCOLN COUNTY

By

Willis M. Johns

This Bulletin has been prepared by the Montana Bureau of Mines & Geology under a cooperative agreement with the Great Northern Railway Company and the Pacific Power & Light Company

MONTANA BUREAU
of
MINES AND GEOLOGY

Butte, Montana

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PROGRESS REPORT ON GEOLOGIC INVESTIGATIONS IN THE KOOTENAI - FLATHEAD AREA, NORTHWEST MONTANA

2. SOUTHEASTERN LINCOLN COUNTY

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ABSTRACT

The mapped area embraces approximately 800 square miles of mountain terrain of the Purcell, Selish, and Cabinet ranges within the 30-minute Thompson Lakes quadrangle.

The quadrangle, similar in lithology and structure to the Libby and Yaak River quadrangles, is underlain by argillites, quartzites, and limestones of the Precambrian Belt series. These sedimentary rocks are subdivided into five major conformable groups. They are the Prichard argillite of the Pre-Ravalli group, the Ravalli quartzite of the Ravalli group, the Wallace limestone and argillite of the Piegan group, and the Striped Peak quartzite and Libby argillite of the Missoula group. Rather rapid although gradational changes in color and lithology occur along the strike in the Wallace and Striped Peak formations.

Igneous rocks are present in the northwestern part of the quadrangle as a small pyroxenite stock and as sills and dikes of metadiorite, diorite, and porphyritic quartz latite. Igneous rocks are absent in the other parts of the quadrangle.

Folding and faulting attributed to the Laramide orogeny has buckled the Belt sediments into moderate and broad northwest-trending anticlines and synclines which are displaced by northwest and east-west faults. Subsidiary faults strike northeast and north.

Gold-quartz, silver-lead-zinc, tungsten-quartz, and copper veins occur as lodes in the mapped area. Some gold placers have been productive, although production from these properties has been limited. Vermiculite is mined from the Rainy Creek stock northeast of Libby.

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

This report covers only the progress made during 1959 on the investigations of the geology and mineral resources of northwestern Montana. The project is directed by the Montana Bureau of Mines and Geology and is sponsored by the Great Northern Railway Company and Pacific Power & Light Company.

The objectives of the five-year program are to establish the geologic data for Lincoln and Flathead Counties and part of Lake County as an aid to prospecting and to help stimulate economic development activities which will result in related growth of northwestern Montana.

The program cost is shared equally by the railway company and the power company, both of which serve the area under investigation. Survey results are published annually by the State Bureau and are available to the public and interested parties on an equal basis.

The first progress report (1. Western Lincoln County, Montana Bur. Mines & Geol. Bull. 12) covers the general geology and stratigraphy in greater detail than will subsequent reports such as this, which will stress only the economic geology of the area. The final report, to be published upon the completion of the program, will summarize results of all the field work.

SCOPE OF REPORT

During the 1959 field season reconnaissance mapping of the areal geology of the 30-minute Thompson Lakes quadrangle in eastern Lincoln County was completed. The quadrangle (see fig. 1) includes about 800 square miles or 22 townships, also in the northwest corner of the State. Considerable mapping was also done in the north half of the Yaak River quadrangle.

Field work commenced on June 1st and ended November 1st. Geology was plotted on U. S. Forest Service planimetric maps used in conjunction with Forest Service aerial photographs.

For a more detailed account of previous work, location, topography, climate, geomorphology, and glaciation the reader is referred to the first progress report on geologic invistigations in the Kootenai-Flathead area, northwest Montana (Montana Bur. Mines & Geol. Bull. 12) published in 1959.

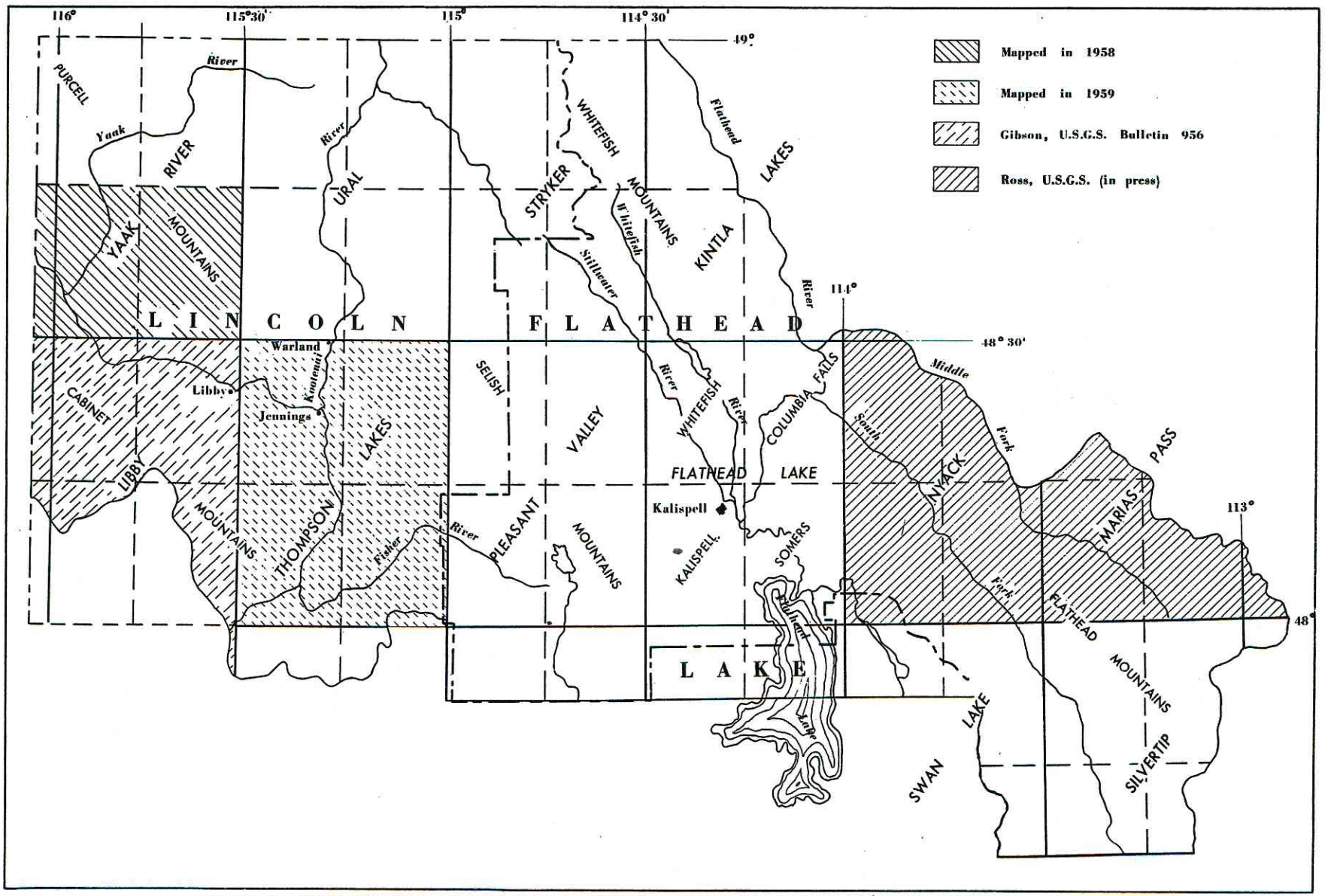

FIGURE 1 — INDEX MAP OF NORTHWEST MONTANA SHOWING LOCATION OF QUADRANGLES BEING MAPPED

ACKNOWLEDGMENTS

Mr. W. S. March, Jr., Associate Director, and Mr. U. M. Sahinen, Chief Geologist, Montana Bureau of Mines and Geology, gave valuable counsel and critically read the manuscript. Mr. R. A. Watson, Geologist, Mineral Research and Development Department, Great Northern Railway Company, and Mr. G. A. Duell, Staff Geologist, Pacific Power & Light Company, furnished advice and constructive criticism.

Mr. L. P. Beer, graduate student from the University of Massachusetts, mapped the northwest 15-minute Thompson Lakes quadrangle. Dr. G. E. McGill, University of Rochester, and field advisor for Mr. Beer, field checked this part of the mapped area. Mr. Beer provided some data on economic deposits in the northwest 15-minute Thompson Lakes quadrangle.

The writer was ably assisted in the field by D. Hutchison and K. T. Bondurant. Rock and ore analyses were made by C. J. Bartzen, Bureau Analyst, and Roger Holmes drafted all maps.

The writer expresses his thanks to H. K. Waylett, L. W. Bolyard, O. V. Miller, D. Larue, H. P. Reinshagen, Jr., and the late J. K. Potter of Libby; J. D. Daniel of Valcour; A. E. Lewis of Dayton; and U. L. Poston, W. C. Kirkpatrick, V. Strodtbeck, A. Darling, A. M. Johnson, and F. A. Stahl of Kalispell, for their courtesy and cooperation.

PREVIOUS WORK

Previous work in the Thompson Lakes quadrangle includes reports by Pardee and Larsen (1929) and Perry (1948) on the occurrence of vermiculite in the Rainy Creek district. Alden (1952) briefly describes glacial deposits on Libby Creek, Calkins and MacDonald (1909) describe geologic structure, and Gale (1934) describes Middle Cambrian fossils in or near Swamp Creek. Gibson (1948) mapped the Libby quadrangle and described mineral deposits within that quadrangle and other nearby properties. Lambert's geologic reconnaissance mapping in northwestern Montana was used for compilation of the State Geologic Map of Montana. Schofield (1915) and Leach (1958) published reports of the geology of southern British Columbia, and Ross and Rezak (1959) recently reported on rocks and fossils in Glacier National Park.

G E O G R A P H Y

LOCATION AND ACCESSIBILITY

The mapped area (pls. 1 to 4) is in the eastern part of Lincoln County between latitudes 48° and 48°30' and longitudes 115° and 115° 30'. U. S. Highway 2 traverses the south and southwest portion of the quadrangle. State Highway 37, between Libby and Eureka, follows the Kootenai River to Jennings, Warland, and Rexford. County, Forest

Service, and private logging roads follow Fisher River, East and West Fisher, Wolf, Dunn, and Cripple Horse Creeks and their tributaries. Kenelty and Fritz Mountains and the Calyx-Satire-Mt. Rogers area are accessible only by Forest Service trails.

The Great Northern Railway follows the Kootenai River from Libby, past Jennings and Warland, to Rexford, Eureka, and Whitefish.

TOPOGRAPHY AND DRAINAGE

The terrain in the quadrangle is steep, rugged, and heavily forested. Elevations of peaks range from 4,000 (McMillan Mountain) to 6,475 feet (Calyx Mountain). Most peaks are between elevations of 5,000 and 6,000 feet. The highest point in the quadrangle, at a ridge elevation of 6,609 feet, is south of Barnum Creek in the southeast corner of the quadrangle.

The area is drained by the Fisher and Kootenai Rivers and their tributaries. The average gradient of the Fisher River between Loon Lake and the Kootenai River is approximately 37 feet per mile. The average gradient of the Kootenai River between Cripple Horse and Rainy Creeks is 5.3 feet per mile.

The Kootenai River is the arbitrary boundary between the Purcell Range to the northwest and the Selish Range to the east. The Cabinet Mountains are bounded by the Fisher and Kootenai Rivers to the south and southwest.

CLIMATE AND VEGETATION

Normal annual rainfall in the Libby area is 18 inches. Average reported maximum and minimum temperatures from the U. S. Weather Bureau for 1956 and 1957 were 99° and -28° F., with a mean annual temperature of 44° F. The area near Libby is in the snowbelt of northern Idaho and western Montana. Seasonal snowfall averages about 61.50 inches.

Throughout the quadrangle slopes are covered with secondary tree growth. Fir, pine, and other conifers maintain a thriving and expanding lumber industry. Some virgin timber remains along the Fisher River, on Fritz Mountain, in Atlanta Creek, and in other areas. The former large stands of merchantable timber have been cut. The U. S. Forest Service and the lumber industry maintain a carefully planned program to insure the preservation of forest lands for the future.

GLACIATION

Evidence that the Wisconsin stage of the Cordilleran ice sheet extended to and south of Cripple Horse Creek was found in the vicinity of Summit Springs, Weigel Mountain, and near the

headwaters of Dry Fork Creek, a tributary of Wolf Creek. Glacial striations trending S. 5°-10° E. and S. 45° W., were noted at several of these localities. Boulders of Wallace limestone, believed to have been dropped by the ice sheet, were found lying on Prichard bedrock. The elevation of the terrain on which this material was dropped ranges between 4,500 to 5,000 feet; the minimum thickness of ice in the Kootenai River Valley near Warland therefore must have been at least 2,800 feet.

Glacial till was mapped north of Loon and Horseshoe Lakes, whereas moraine material believed to be a lateral moraine was observed in the NW$\frac{1}{4}$ sec. 22, 1,000 feet northwest of Loon Lake. This constructional feature trends N. 55° E., is about 600 feet long, and blocks a south-flowing stream. A basin, believed to be a kettle, occurs a few hundred feet north of the center of sec. 27, T. 27 N., R. 28 W.

Glacial lacustrine silts in the tributaries of Fisher River (Tepee, Squaw, and Harris Creeks) were deposited in an ice-impounded lake which reached the 3,500-foot elevation. Sparse exposures of lake bed silts and clays were mapped to elevations of 3,500 feet northeast of Loon Lake in Pleasant Valley. Glacial till and drift deposits in this area and south of Loon and Thompson Lakes were mapped above and below the 3,500-foot contour.

ROCK TYPES

Conformable sedimentary rocks of the Precambrian Belt series have been mapped in the Coeur d'Alene district, and in the Trout Creek, Libby, Yaak River, and Thompson Lakes quadrangles.

Within the mapped area all Belt groups are present including the Pre-Ravalli group (Prichard formation), Ravalli group, Piegan group (Wallace formation), and Missoula group (Striped Peak and Libby formations).

Paleozoic sediments tentatively identified in Swamp Creek as undifferentiated Middle Cambrian sandstones, shales, and limestones, were first observed by Calkins and MacDonald (1909, p. 43) and Gale (1934, p. 174). Mesozoic sediments are not present in northwestern Montana.

Cenozoic rocks include Quaternary glacial till and moraine; lacustrine deposits of sand, silt, and clay; and terrace gravels. Recent alluvium is present in river and stream valleys.

Igneous rocks occur only in the northwest part of the quadrangle. Here, a pyroxenite-syenite stock intrudes Wallace sediments in Rainy Creek. Late Mesozoic or Early Tertiary diorite and quartz latite porphyry sills and dikes are found in Kennedy Creek. A Precambrian metadiorite sill outcrops east of Canoe Gulch.

There is a similarity in lithology between Wallace and Libby strata throughout the quadrangle. In southern British Columbia Schofield (1914, p. 11) observed that the Siyeh and Gateway formations were lithologically similar in the Galton and Purcell Ranges in British Columbia. Ross and Rezak (1959, p. 416) remark about the similarity of Siyeh and Libby limestone in the Glacier Park section. The Libby formation in the Thompson Lakes quadrangle (equivalent in part to Gateway) is more arenaceous than Wallace strata; consequently, identification by lithology aided by stratigraphic position is a more valid method for determining the rock formation than separating them only on the basis of color.

THE PRECAMBRIAN BELT SERIES

Individual thicknesses of the Ravalli, Wallace, and Striped Peak vary considerably throughout the quadrangle. The Ravalli group ranges in thickness between 7,100 feet along the Kootenai River near Warland and 15,000 feet near Hornet Ridge. The Ravalli is about 7,400 feet thick at Wolf Creek. An incomplete section of the Wallace along the Kootenai River measured 15,000 feet. A complete section near Butler Creek measure 14,000 feet; whereas, on Satire Mountain a section measured 11,300 feet. The Striped Peak, in an incomplete section on Fisher River, was 2,300 feet thick. Other sections in Squaw Gulch and in the Mt. Fritz vicinity measured from 3,000 to 4,500 feet thick.

The minimum thickness of outcropping Belt sediments in the Thompson Lakes quadrangle is about 31,000 to 32,000 feet. This only accounts for a few thousand feet of upper Prichard beds that outcrop in the quadrangle. Mr. Bateman* of the U. S. Geological Survey stated a measured section of Prichard along the Clark Fork Valley near Noxon measured 17,000 feet. If the thickness of the Prichard approaches this figure in the mapped area, it is conceivable that the thickness of the entire Belt section in the area may be 45,000 to 50,000 feet. Nowhere in the quadrangle is the base of the Prichard exposed. The top of the Libby is an erosion surface. The Ravalli and Wallace may be decreasing in thickness to the east and southeast of the quadrangle.

A rock-color chart published by the Rock-Color Chart Committee of the G.S.A. was used to standardize color descriptions of the groups and formations in the quadrangle.

Pre-Ravalli Rocks

Prichard Formation.--Prichard metasediments are confined to the northeast and eastern parts of the quadrangle where they occur as the west limb of the Wolf Creek anticline. The greater number of quartz veins were mapped in the formation.

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*Personal communication.

The Prichard lithology is consistent throughout the quadrangle. Outcrops are medium dark-grey to medium-grey and medium light-grey argillites. A greyish-blue biotite-bearing argillite is common. Abundant fine biotite and sparse pyrite occur throughout the Prichard. Sparse sandy horizons and quartzite beds are present, although the Prichard in the mapped area is essentially argillaceous.

A distinctive banding, which occurs in no other formation, is present in the upper beds of the formation. The bands are 1/16" to 1/4" thick of contrasting grey and greyish-blue color.

The formation is thin to medium bedded. Ripple marks and mud cracks are not common. The strata are often rust-colored brown to light brown on weathered surfaces.

In Cripple Horse Creek (sec. 7, T. 31 N., R. 27 W.) a calcite-bearing medium-grey to dark greyish-blue argillite has calcite filled veinlets and small elongated calcite masses similar in appearance to poorly-developed molar tooth structure characteristic of certain Wallace horizons. These calcite-bearing beds are not extensive.

Good exposures of the Prichard-Ravalli contact zone occur northwest and southeast of the Kootenai River, in Wolf Creek, and north of Pleasant Valley. The conformable contact is gradational for distances of 800 to 1,000 feet. Near the Kootenai River the contact grades from medium-grey sandy argillite of the Prichard to light-grey quartzite of the Ravalli. The contact at Pleasant Valley grades from medium dark-grey to medium-grey argillite to medium-grey and medium light-grey quartzite and quartzitic argillite. Quartzite and argillite horizons are interbedded within the contact zone.

The base of the Prichard is nowhere exposed in the quadrangle, and only a few thousand feet of upper Prichard beds were mapped in the northeastern part of the area.

Ravalli Group

Gibson reported that the Ravalli, north of the Clark Fork River in the Cabinet Mountains, could not be further subdivided. In the areas so far mapped the author is in accord with this observation.

The Ravalli group outcrops in the southwest corner of the quadrangle, and again in the west limb of the Wolf Creek anticline to the northeast and east.

The group is dominantly quartzitic and comprises quartzites and argillaceous quartzites which range from medium grey to white in color. The quartzites contain small "limonite-filled" voids or blebs of iron oxides in addition to fine- to medium-sized grains of biotite and octahedral crystals of magnetite. Some pyrite is present. Individual beds are sandy or shaly.

A lower Ravalli horizon northwest of the Kootenai River in sec. 35, T. 32 N., R. 29 W. is a black noncalcareous quartzitic argillite not found southeast of the Kootenai River.

In the Ravalli near the Piegan contact are peculiar lineally-arranged hieroglyphic-like white "markings" $\frac{1}{4}$- to 1-inch long in medium- to light-grey quartzite. These "pod-like" bodies have apparently the same lithologic nature as the enclosing rock. Good exposures were mapped near the contact in Dunn and Wolf Creeks. The horizon may be thinning southeastward since only a small outcrop was mapped at Wolf Creek. Ross and Rezak (1959, p. 414) reported inclusion-like patterns in the Siyeh limestone whose origin is not understood.

The thickness of the Ravalli is quite variable within relatively short distances (4 to 8 miles). A section across Jackson Creek near the Kootenai River measured 7,070 feet thick. Along section A-A' (see pl. 1) the thickness is 15,000 feet. Along A-A' (see pls. 3 and 4) the thickness decreases to about 12,000 feet.

The contact zone between the Ravalli and Piegan is conformable and gradational for distances of 800 to 1,200 feet respectively in Pleasant Valley and along Wolf Creek. North of Pleasant Valley medium light-grey argillaceous quartzite of the Ravalli group underlies pale green-grey argillite and quartzitic argillite mapped for this report as lower Piegan.

The Ravalli tends to form blocky cliffs and talus slopes. Ripple marks are sparingly present. Individual beds are from a few inches to several feet thick.

Piegan Group

Wallace Formation.--The Wallace strata of the Piegan group are the most widespread outcropping rocks in the area. They occur extensively throughout the north, central, and western parts of the quadrangle. From the base to the top, Wallace rocks are grey, green, green-grey, and dusky-yellow argillites which are more sandy, shaly, and quartzitic near the base. Limestone and dolomite beds, although present, are not as extensive as in the Yaak River quadrangle. Greyish-red shale and occasional quartzite beds are present near the top. Wallace beds follow the general trend of other Belt groups; they strike in a northwest direction. North and south of Kootenai River the lithology is more heterogeneous. Toward the central and west parts of the area it is less so. Beds in this section are similar to the Wallace formation described in the Libby quadrangle.

In a section perpendicular to strike from the Montezuma property (sec. 32, T. 27 N., R. 30 W.) past Teeters Peak to U. S. Highway 2, basal beds include medium-grey and light-grey argillites, argillaceous or sandy shales, and quartzites. As one progresses upward in the section the Wallace formation becomes more calcareous with dark-grey, medium-grey, and grey-green argillites and

and sandy shales, also subordinate amounts of medium-bedded pyritized dolomitic and calcareous limestone are present. Sericite is found locally while mud cracks are more abundant than ripple marks throughout the quadrangle.

East of Teeters Peak to U. S. Highway 2, middle and upper Wallace is thin-bedded or thinly-laminated medium-grey, greenish-grey, and pale greenish-grey argillite locally interbedded with small amounts of brown to dark grey-green calcareous argillite. Sparse dark- and light-grey limestones and dolomites are present. Pale-olive and dusky-yellow shaly argillites are conspicuous and extensive in middle and upper Wallace beds. Mud cracks and sparse ripple marks are present. A conspicuous feature of the upper Wallace in this locality is its argillaceous and noncalcareous nature. West of Swamp Creek and Fisher River several greyish-red argillite and/or shale and occasional quartzite horizons are present. These zones are not extensive and are mapped as Wallace strata. East of these horizons in Squaw and McKillop Creeks the Striped Peak is easily recognized by extensive outcrops of greyish-red and grey sericitic ripple-marked and mud-cracked quartzite which is the most conspicuous of the Belt formations in this area.

At Satire Mountain and at Cow Creek the Wallace formation is a thin- or medium-bedded argillite whose color ranges from pale green, olive green, and grey green to a medium-dark greyish blue, dark grey, and dusky yellow. Along the strike to the southeast to to a point several miles northeast of Loon Lake, Wallace lithology changes locally to dark- and medium-grey pyritic limestones and dolomites. The author is inclined to believe a gradational lithologic change has taken place.

Wallace lithology is observed perpendicular to strike along a paralleling-trending ridge south of Wolf Creek. Basal and lower middle beds are ripple marked and mud cracked. Medium-grey, greenish-grey, and olive-green argillites and shaly argillites with minor beds of dark- or medium-grey quartzite and greyish-purple quartzitic argillite are mapped at this locality.

In the middle and upper third of the section ripple-marked and mud-cracked olive-green, greyish-green, and dusky-yellow argillites and shaly argillites predominate. Greyish-brown quartzite, sandstone, and sandy argillite and greyish-purple shaly argillite are also present.

Near the top of the section greyish-red quartzite and shale is interbedded with grey-green, olive-green, and dusky-yellow argillite. Some horizons are calcareous and sandy, and a light-brown or buff dolomitic limestone is mapped near the top of the section in this area.

In the northwestern 15-minute quadrangle thin laminated light- and dark-grey and green noncalcareous argillites are present in basal and upper Wallace beds. Calcareous bluish-grey, dark grey-green, and dusky-yellow argillites, limestones, and dolomites comprise the middle and upper Piegan.

The thickness of the Wallace varies from 11,000 to 15,000 feet in the quadrangle. In the northwest 15-minute quadrangle it is approximately 15,000 feet, whereas along section A-A' (see pls. 1 and 2) and A-A' (see pls. 3 and 4) the thickness is 14,000 and 11,300 feet respectively.

The contact between Wallace and Striped Peak metasediments is both conformable and gradational for a distance of several hundred feet.

The contact is placed where greyish-red, grey, and purple quartzite, argillite, and shale overlie thin-bedded greyish-green, olive-green, and dusky-yellow argillite of upper Wallace beds.

Mud cracks, ripple marks, clay chips, and mud balls are fairly abundant in the formation. Sericite is locally present.

Schofield has recognized the Kitchner and Siyeh (correlated with lower and upper Wallace of the Piegan group) as two separate lithologic units in British Columbia. The Kitchner is described as largely calcareous argillites, quartzites, and limestones whereas the Siyeh is dominantly purple and green siliceous argillites. Some thin-bedded massive grey limestone occurs toward the center of the Siyeh.

Basal Wallace beds in the quadrangle are thin-bedded alternating grey argillite and medium- and light-grey quartzite followed by calcareous grey argillites, shaly argillites, and some sandstone. Toward the center and upper half various shades of green argillite, and banded green-grey argillite with dusky-yellow horizons are present throughout a large part of the formation. Increasing amounts of dark- and medium-grey limestone occur in the upper third of the section. Along the strike limestone beds grade into argillites in some areas.

Missoula Group

The Missoula group includes the Striped Peak and Libby formations which have been mapped as the Gateway, Phillips, and Roosville formations in British Columbia. Canadian geologists have not recognized the Striped Peak equivalent north of the International Boundary. Daly (1909, p. 135) recognized a white and grey quartzite with intercalations of argillite along the International Boundary in the Purcell Range. In a progress report (1904) he proposed and later withdrew the formational name Yahk for these mud-cracked and ripple-marked quartzites and later included them in the Moyie formation. Daly thought the Moyie in the Purcell Range (1912, p. 136) was equivalent to the Gateway, Phillips, and Roosville formations of the Galton Range. The confusion of stratigraphic sequences was cleared when Schofield (1914, p. 8) dropped the name Moyie formation from the Purcell series after correlating the Moyie with the Siyeh by stratigraphic evidence. There is some evidence that points out a similarity between the Yahk and Striped Peak formations; however, it is possible the Yahk quartzite may

correlate with quartzitic horizons mapped in the Libby and Thompson Lakes quadrangles toward the top of the Wallace (Siyeh) formation. The name Yahk quartzite at the International Boundary is tentatively proposed to correlate with the Striped Peak in the Thompson Lakes and Yaak River quadrangles (see fig. 2); however, the correlation is only inference and as pointed out above, the possibility of these quartzite horizons occurring in upper Wallace should not be overlooked.

Striped Peak Formation.--The formation outcrops found in Squaw and McKillop Creeks, near Fritz Mountain, crosses upper Snell and lower Wolf Creeks, and continues down the Fisher River to the Kootenai River. South of Thompson Lakes the Striped Peak is mapped largely on the basis of float. The formation is the easiest to identify because of its quartzitic to shaly nature, thickness, and greyish-red to grey color.

A distinct lighologic change occurs north of Wolf Creek. To the south the formation is a quartzite. To the north the beds are argillites or shaly argillites with only minor quartzite horizons. The Wolf Creek fault is believed to have little or no relation to this lithologic change, since movement is strike slip. A similar lithologic change in Striped Peak lithology is observed north and south of China Mountain in the Yaak River quadrangle.

The formation south of Wolf Creek is dominantly a greyish-red and grey sericitic and ferruginous quartzite with minor shale and argillite intercalations. North of Wolf Creek greyish-red and purple sericitic argillite and dark-green and green-grey argillite predominate.

Outcrops in Squaw and McKillop Creeks are noncalcareous ferruginous grey and greyish-red sericitic quartzites with subordinate amounts of greyish-red and medium-grey and light-grey sand, shale, and/or argillite. The formation has an abundance of mud cracks and ripple marks.

Along the lower Fisher River noncalcareous sericitic, ripple-marked and mud-cracked, greyish-red and purple argillites, with local sandy facies, are overlain by light- and dark-green thin-banded argillites. The top of the Striped Peak along the Fisher River is an erosional surface with upper beds removed.

The transition zone at Wolf Creek is an argillite with subsidiary quartzite facies. Greyish-green and olive-green argillites, increasing northward, are present near the top of the erosion surface in this locality.

Two or more algal horizons and an edgewise conglomerate are mapped in the formation. Abundant quartz veinlets, from an inch to several inches wide, parallel the strike of the beds. The vein quartz is massive and white colored, with little or no associated mineralization.

The minimum thickness of the Striped Peak formation in an incomplete section along the Fisher River is 2,325 feet; thicknesses

<table>
<tr><td></td><td>Coeur d'Alene district, Idaho

Ransome</td><td>Libby quadrangle

Gibson</td><td>Yaak River quadrangle

Johns</td><td>Thompson Lakes quadrangle

(this report)</td><td>International Boundary Purcell Range

Daly</td><td>British Columbia

Schofield</td></tr>
<tr><td rowspan="2">Missoula group</td><td></td><td>Top eroded

Libby
6,000</td><td>Top eroded

Libby
9,000</td><td>Top eroded

Libby
7,600</td><td rowspan="2">Roosville

Phillips

Gateway

Yahk (?)</td><td rowspan="2">Gateway
2,000
Purcell lava
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<tr><td>Top eroded
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<tr><td rowspan="3">Ravalli group</td><td>St. Regis</td><td rowspan="3">Ravalli

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<tr><td>Revett</td></tr>
<tr><td>Burke</td></tr>
<tr><td>Pre-Ravalli rocks</td><td>Prichard</td><td>Prichard

9,700</td><td>Prichard

9,000</td><td>Prichard

6,000</td><td>Aldridge</td><td>Aldridge

8,000</td></tr>
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Figure 2.--Correlation of Belt series in the Thompson Lakes quadrangle with formations in nearby areas.

for the complete section vary between 4,200 to 4,500 feet in the central part of the quadrangle. In Squaw Creek the section is about 3,000 feet thick.

The contact between the Striped Peak and Libby is gradational for 300 to 500 feet. The contact was placed where greyish-red and grey quartzites and shales are overlain by grey-green, dusky-yellow, and moderate yellowish-green and grey slightly calcareous and ferruginous argillites which are locally sandy. A few beds of yellow limestone are present. Green argillites occur higher up in the Libby section.

Libby Formation.--The formation is mapped in Tepee and Cowell Creeks, around Kenelty Mountain, and in Houghton, McGinnis, and Elk Creeks south of U. S. Highway 2.

Abundant argillites and some limestone and dolomite are present. Locally, argillite beds are calcareous and interbedded with sandstone.

Prevailing colors of the ferruginous argillites and sandstones are green, greyish green, dusky yellow, yellowish green, and grey. Yellow to yellowish-brown limestones and dolomite are not extensive.

Green and grey argillites in Cowell Creek are both ferruginous and calcareous, and outcrop extensively in this drainage.

At Kenelty Mountain, green, grey, and dusky-yellow argillites are in some instances limey. Limestone and dolomite, although not extensive, also occur in the area. At least two or more algal horizons are observed.

At Houghton and Elk Creeks grey, green, and yellow argillites and shales with sandy zones are mapped. Some quartzitic argillite and yellowish-brown shaly argillite is sparingly present.

The Libby is about 7,600 feet thick along section A-A' (pl. 3). The top is eroded so that the entire thickness of the formation is unknown.

PALEOZOIC ROCKS

Cambrian (Undifferentiated)

Rocks believed to be of Paleozoic age are first observed and briefly described by Calkins and MacDonald (1909, p. 82) at Swamp Creek in sec. 15, T. 28 N., R. 30 W. Gale (1934, p. 179) concluded that a red and grey fossiliferous sandy shale in the area represented the Middle Cambrian Gordon formation, and is in part, equivalent to the Spence and Wolsey shales.

Along the east and west sides of Swamp Creek in secs. 10 and 15, massive limestones and dolomites are dark grey to very light grey in color. They are not similar to the other limey rocks in the

Belt series. Other dark- to light-grey limestones, mapped as Middle Cambrian (?), outcrop east of Fisher River in secs. 4 and 9, T. 26 N., R. 29 W.

Three representative samples (nos. 9, 12, and 13 in Appendix) of limestone and dolomitic limestone were assayed. The Al_2O_3 and SiO_2 content of these samples are very low in contrast to moderate amounts of alumina oxide and high silica in other known Belt limestones. For additional comparisons with Belt limestone assays the reader is referred to Montana Bureau of Mines and Geology Bulletin 12.

The limestones in Swamp Creek might be correlative with lower Paleozoic formations. A massive dark-grey limestone in the $NW\frac{1}{4}$ sec. 10, T. 28 N., R. 30 W. has a fetid odor when broken. Fossils in the limestones at Swamp Creek are difficult to find. Possible fossil fragments found so far are difficult to identify; consequently, no positive dating of the limestones has been made.

These sediments are probably dropped fault blocks and may be overturned as suggested by Gale (1934, p. 175). Faulting may be more extensive and complicated in Swamp Creek valley than shown on the geologic map. If the massive limestones north of U. S. Highway 2 near the mouth of East Fisher and Houghton Creeks can be correlated with the limestones in Swamp Creek, a concealed fault beneath Fisher River valley must separate the Wallace formation to the west from the inferred Paleozoic rocks to the east.

QUATERNARY SEDIMENTS

Glacial Deposits

Glacial deposits in the quadrangle are present as drift, ground moraine, till, and as lacustrine stratified silts and clays. The material is unconsolidated and believed to be of Pleistocene age. Glacial-lake deposits overlying glacial drift are mapped to elevations of 3,500 feet in the quadrangle.

Lacustrine silts are buff colored and lie horizontal. They occur extensively along the upper and lower Fisher River. Without doubt a glacial lake occupied the Fisher River drainage from the Kootanai River to Thompson Lakes. Evidence that ice also was present in the Loon-Thompson Lakes area is indicated by the presence of ground moraine and several kettle holes above the present lake elevation.

A bouldery lime-cemented conglomerate with unsorted and partially-cemented sand and gravel horizons was noted adjacent to U. S. Highway 2 near the mouth of East Fisher Creek. No striated rocks were found at this exposure. The cemented conglomerate may be of fluvial origin.

Recent Alluvium

Recent alluvium borders the Fisher River and other stream channels in the quadrangle. Gold-bearing gravels in Recent alluvium have been productive in lower Libby Creek, Atlanta Creek, and Wolf Creek.

IGNEOUS ROCKS

By Lawrence P. Beer

Augite Pyroxenite Stock

A large igneous stock 3 1/3 miles long by 2 miles wide lies in the northwest quarter of the Thompson Lakes northwest 15-minute quadrangle. It is oriented with its long axis trending north. It consists primarily of augite pyroxenite altered on a large scale to biotite, hydrobiotite, and vermiculite. Veins of asbestos intrude the pyroxenite (see pl. 2). Outcrops of this body are very few, and the only good exposures are at the Zonolite Company's open pit in the vicinity of Vermiculite Mountain (east central part of sec. 22, T. 31 N., R. 30 W.)

Four alteration minerals predominate: asbestos (tremolite-actinolite), biotite, hydrobiotite, and vermiculite. The name hydrobiotite is applied to the interstratified biotite-vermiculite from Libby. This mineral along with vermiculite and biotite, constitutes the commercial vermiculite ore.

At the open pit location the augite pyroxenite occurs as a medium- to coarse-grained medium light-grey to yellowish-green rock locally very friable. Unaltered biotite and minor amounts of orthoclase are disseminated throughout. The pyroxenite is intruded by thin veins of asbestos (tremolite-actinolite). Bodies of almost pure augite are observable at some localities within the pit. The vermiculite is very difficult to distinquish from unaltered biotite, yet in some outcrop zones it has a distinctive silvery-gold coloring.

In thin-sections, under the microscope, the pyroxenite contains approximately 5 percent orthoclase, exhibiting excellent Carlsbad twinning under polarized light and distinct cleavage planes under plain light. These grains of potassium feldspar are well-fractured into angular pieces. There is less than 5 percent quartz and less than 1 percent plagioclase (exhibiting both albite and pericline twinning).

The only contact zone of the pyroxenite stock with the strata occurs in the western half of sec. 25, T. 31 N., R. 30 W. where the pyroxenite body meets the calcareous dark-grey argillite of the Piegan group. In a gradational contact zone of approximately 200-300 feet, the argillitic beds are altered to an almost sericitic schistic rock locally rich in magnetite and apatite.

This body as well as many dikes and sills of basic and acidic composition intruded the Belt rocks in late Mesozoic or early Cenozoic time as a result of the Laramide orogeny. Pardee and Larsen (1929) believe the pyroxenite intruded the Belt strata in Late Cretaceous possibly early Tertiary time.

Syenite Stock

A body of syenite intrudes the Belt rocks adjacent to the southwest side of the pyroxenite stock. This syenitic body is approximately 2 1/3 miles long by 1 mile wide and its long axis is oriented in a northerly direction. The scarcity of exposures of syenite complicates the location of the exact boundaries of the stock and also makes it difficult to determine whether it occurs as a singular stock or a series of interlocking intrusive dikes and sills.

In outcrop the syenite occurs as a medium- or coarse-grained buff to pale yellowish-green and grey rock containing amounts of muscovite and limonite. In thin-section, under the microscope, the rock shows well defined crystals of orthoclase. Grains range in size from .15 to .23 millimeter. Limonite is disseminated throughout; it appears through the microscope as yellow-red-brown bodies in reflected light, medium-dark brown in plain light, and medium-dark brown to black in polarized light. Muscovite mica appears as bodies showing brilliant second-order maximum interference colors (red, yellow, green) under crossed-nicols. Grain size of the mica ranges from .15 to 2.0 millimeters. Minor amounts of quartz, exhibiting slight undulatory extinction, vary in size from .15 to .23 millimeter.

Mineral composition through modal analysis shows 61.6 percent orthoclase, 22.9 percent limonite, 11.0 percent muscovite, and 4.5 percent quartz.

This body appears to be correlative in age with the pyroxenite stock, either late Mesozoic or early Cenozoic, and probably was intruded during the Laramide orogeny.

Dikes and Sills

At least eight dikes and sills occur within this 15-minute quadrangle, varying in composition from diorite, metadiorite, and quartz latite porphyry to almost pure wollastonite. These intrusive bodies range in size from 50 to 75 feet in width and from 1/8 to 2 1/2 miles in length.

Except for the metadiorite sill of Precambrian age, precise age-dating for the other seven dikes and sills is very inaccurate since evidence is almost completely lacking. These bodies may only be considered as post-Beltian since they intrude only the Piegan group which is of upper Precambrian age. The intrusives are considered in this report to be Mesozoic or Cenozoic in age in order to correlate with the dikes and sills of comparable

lithic description in the Libby quadrangle to the west (Gibson, 1948).

Metadiorite.--A metadiorite dike similar in lithology to several dikes and sills mapped by Gibson in the Libby quadrangle, is located near the junction of the Fisher and Kootenai Rivers. This intrusive body strikes north-northwest and south-southwest. It extends from the center of sec. 6, T. 30 N., R. 29 W., south-southeastward under the Kootenai, where it is covered by the Quaternary floodplain sands and fine gravels, to the southeast corner of sec. 17, T. 30 N., R. 29 W., where it ends abruptly against the red-grey-purple argillites of the Striped Peak formation. On the south side of the river it divides into two sills.

In outcrop these sills occur as a very fine-grained dark-green rock containing needles of feldspar and locally containing veinlets of white and pink calcite varying in width from 1/16 to 1/2 inch.

Under the microscope thin-sections of the sills were found to contain needles and grains of plagioclase exhibiting good pericline twinning and varying in width from .05 to .225 millimeter and in length from .35 to 2.0 millimeters. Even more abundant than the feldspar are grains of hornblende which in plain light show a yellow, light- and dark-brown, and light-green color, as well as a slight pleocroism. In polarized light the hornblende is a dark-green to almost black color. The fineness of the hornblende is reflected in the fact that their grain size rarely exceeds .02 millimeter.

Grains of quartz varying in size from .05 to .1 millimeter are disseminated throughout while tiny white veinlets of calcite cut through the hornblende-rich rock. These calcite veinlets contain calcite grains varying in size from .55 to 2.1 millimeters.

Peculiar star-shaped bodies occur locally while platy and needle-like bodies of the same mineral are disseminated throughout. These bodies or "stars" as well as the plates and needles of the mineral appear golden in color under crossed-nicols, and are slightly anisotropic, while under plain light they appear golden brown. After careful examination these star-like bodies are found to by cyclic twins of orthorhombic aragonite. They vary in size from .075 to .2 millimeter.

Results of a modal analysis of the metadiorite sill are 53.4 percent hornblende, 18.0 percent calcite, 12.7 percent plagioclase, 8.9 percent quartz, and 6.9 percent aragonite.

From its cross-cutting relationships, this intrusive sill may be post-Piegan-pre-Striped Peak.

Quartz Latite Porphyry.--Four quartz latite porphyry bodies ranging in width from 50 to 75 feet and in length from 1/8 to 1/2 mile, lie within the northwest quarter of the quadrangle. Two are found north of the pyroxenite stock while the other two are located

southwest of the syenite stock. Their locations are:

1. Northeast corner of sec. 32, T. 31 N., R. 30 W.
2. Southwest quadrant of sec. 33, T. 31 N., R. 30 W.
3. Southeast corner of sec. 9, T. 31 N., R. 30 W.
4. West-central part of sec. 11, T. 31 N., R. 30 W.

In outcrop these dikes and sills occur in the form of massive bodies characterized by having a dark yellowish-green and brown to black groundmass with strikingly light-grey to white phenocrysts of feldspar. These phenocrysts vary in size from 1/8 inch subangular bodies to 1 inch long and 3/10 inch wide rectangular bodies. Three of the intrusive dikes and sills have excellent outcrops while the fourth body, in sec. 33, T. 31 N., R. 30 W., is located on the basis of a half mile long zone rich in quartz latite prophyry "float." In this latter body the phenocrysts attain their greatest size. Most of these porphyritic bodies are weathered a dark grey to rusty-orange brown.

Microscopic analysis of thin-sections of two of the intrusives shows a very fine groundmass slightly richer in plagioclase than in orthoclase, and very rich in ferromagnesian minerals. The groundmass also contains hematite with minor amounts of limonite both of which appear opaque under plain and polarized light, and dark red to black and dark brown to black respectively in reflected light. Grain sizes for the iron oxide minerals vary from .1 to .425 millimeter. Angular to subrounded grains of quartz are disseminated throughout and vary in size from .05 to .425 millimeter. The exact mineral composition of the background material is impossible to determine due to its extremely fine-grained nature.

The phenocrysts are predominately plagioclase feldspar although some phenocrysts of quartz can be recognized. Albite feldspar seems to be most abundant and exhibits excellent albite, carlsbad, and pericline twinning. The size of these white to yellowish-grey bodies varies from .35 to .7 millimeter in width and from 1.0 to 2.35 millimeters in length. In almost every feldspar phenocryst, intense sericitization has obscured the marginal zones.

Diorite.--Two diorite dikes, both oriented with their axes almost east-west occur just south and southwest of the large syenite and pyroxenite stocks. One body slightly over a half mile long is in the $W\frac{1}{2}$ sec. 34, T. 31 N., R. 30 W., while the other dike, almost 1 mile long is in the $N\frac{1}{2}$ sec. 33, T. 31 N., R. 30 W. Both dikes range in width from 50 to 75 feet.

In outcrop, these bodies are medium grained and are light-yellowish orange to light grey. They weather to a bright-yellowish orange. Small needles and grains of black pyroxene are disseminated throughout the groundmass, in some localities attaining a high percentage of the mineral composition.

From thin-sections of both bodies analyzed under a polarizing microscope, the diorite is found to contain a great deal of plagioclase showing good pericline twinning and some albite twinning, and varying in grain size from .8 to 2.25 millimeters. Pyroxene also makes up a fair percentage of the groundmass and is characterized by its occurrence as needles and grains varying from .05 to 1.45 millimeters. In plain light these grains are medium-dark green showing poorly-defined prismatic cleavage at angles of 85^{o}-95^{o} while under polarized light, they exhibit a dark-green color. The pyroxene is probably diopside since the extinction angle for the grains ranges from 37^{o}-50^{o}.

In addition to the major constituents, plagioclase and hornblende, minor amounts of quartz and magnetite are scattered throughout. Quartz grains vary in size from .125 to .15 millimeter and appear subangular to subrounded. Magnetite grains appear opaque under plain and polarized light, and steel grey and blue black under reflected light. Most bodies of magnetite are weathered around the edges to a yellowish-brown limonite coating. This oxidation of the magnetite is probably the cause of the iron oxide yellowish-orange coating in outcrop. Grains of this mineral vary in size from .1 to 2.05 millimeters with most particles between .3 and .8 millimeter.

Summary of Igneous Rocks

Each igneous body in the quadrangle is found at the core of a ridge. These ridges vary in elevation from 3,000 to 5,000 feet and range in relief from several hundred feet to several thousand feet. The igneous bodies, being more resistant to erosion, become topographic highs or mountains and ridges. Belt rocks such as the Piegan argillite are very easily eroded; consequently becoming topographic lows and accentuating the relief of the quadrangle.

S T R U C T U R A L G E O L O G Y

SEDIMENTARY ROCK STRUCTURE

Sedimentary rocks are folded into moderate to broad anticlines and synclines trending northwest to north, and are displaced by both longitudinal and transverse faults. Folding in the Swamp Creek valley is complicated and some overturning of steeply-dipping beds is present. Folding is attributed to the Laramide orogeny during which time the Rocky Mountains came into existence.

Wolf Creek Anticline

The major structure occupying part of the east half of the quadrangle is the Wolf Creek anticline. The anticlinal axis of this fold parallels Dry Fork valley, crosses Wolf Creek, to trend in a southeast direction through Boulder Hill into the Pleasant Valley quadrangle. Prichard, Ravalli, and Wallace sediments are exposed on the west limb of this broad symmetrical structure. The fold is

displaced by a fault along Wolf Creek. Small quartz veins cross the anticline at angles of 35°-65°, averaging 55°.

Other Folds

A small symmetrical double-plunging syncline follows Fisher River valley from the Kootenai River to Wolf Creek. The fold continues southeast, crosses upper Snell and McKillop Creeks, and dies out west of the Pine Creek-Thompson Lakes fault where it plunges to the north. A fault closely parallels the axis of the fold from the Kootenai River to McKillop Creek (see pls. 2 and 3). The fold is also displaced by the northwest-striking Pine Creek-Thompson Lakes fault (see pl. 3).

A major southeast-plunging anticline strikes N. 15°-45° W. from the northwest corner of the quadrangle to and along the Kootenai River through Vian and Brush Creeks, to plunge beneath Libby beds at McKillop Creek. The Pine Creek-Thompson Lakes fault follows the crest of this fold. To the west of this anticline a nearly-isoclinal, faulted, and tilted (?) syncline is mapped on Kenelty Mountain. The continuation (?) of this syncline is believed to extend northwest past Tepee Creek, through upper Cowell and Detgen Creeks, past Elliott Creek, to disappear beneath Quaternary silts and gravels. The synclinal is cross-faulted in Pleasant and Fisher Valleys, and a half mile north of upper Cowell Creek. The continuation of folding to the west includes another anticline and a faulted syncline (?) in the Swamp Creek valley.

FAULTS

Two groups of faults trending N. 20°-50° W. and N. 65° E. are mapped. One fault striking north crosses Swamp Creek valley. Two other doubtful faults strike N. 15°-25° E.

The larger and older of the two groups are the northwest faults which in some instances extend for 40 miles. East-striking faults displace northwest faults, and with few exceptions all have moderate to high-angle to vertical dips.

Description of Faults

The major fault in the quadrangle is the Pine Creek-Thompson Lakes fault extending northwest from Thompson Lakes to the Kootenai River and up Pipe Creek into the Yaak River quadrangle. Recent mapping indicates this fault may continue to the International Boundary. If it is continuous for this distance the length of the fault trace may approach 80 miles. The fault is mapped for a distance of 40 miles in the quadrangle. For 2/3 of this distance the fault parallels and follows the crest of an anticline (see pls. 3 and 4).

The fault is a high-angle structure with the west side dropped relative to the east side. One exposure of the fault zone

1 mile west of Rainy Creek road consists of a 10-foot brecciated zone. Two minor subsidiary faults occur on both sides of the main fault. Other evidence for the structure is diverse dips along the trace of the fault and physiographic evidence of linear-trending valleys and saddles.

East-striking faults are mapped in Cripple Horse and Wolf Creeks, and other parts of the quadrangle. The fault at Cripple Horse Creek is suggested by extreme divergent strikes and dips north and south of the valley proper, a subsidiary parallel-trending structure on the north slope of the valley, and a linear trend of the valley.

The Waylett vein occupies a pre-mineral fault which strikes N. 25° W. and dips 20° NE. Drag folding is present on the west side. The structure is interpreted to be a low-angle reverse fault.

The syncline in the area of Kenelty and Wapiti Mountains is bordered by two northwest faults in McKillop Creek and upper Fisher River valley, and two east-striking faults in Fisher and Pleasant River valleys. It is believed tilting of the block may be partially responsible for the attitude of the beds.

Another northwest-trending fault parallels a syncline from McKillop Creek to the Rainy Creek stock, following the lower Fisher River for a distance of 9 miles. The east side has dropped about 500 feet relative to the west side.

Several northwest faults are mapped paralleling Swamp Creek valley. Near the center of sec. 22, T. 28 N., R. 30 W., the valley is constricted and makes a sharp right turn. A fault is observed at this locality east of U. S. Highway 2. Evidence for the fault is suggested by diverse strikes and dips and the presence of drag folds. Drag folding adjacent to the fault indicates the west side has dropped relative to the east side.

Two other faults of this group strike northwest to northeast and form a V-like graben south of Cripple Horse Creek. Ravalli quartzite is in the down-dropped block bounded by Prichard strata to the east and west.

A fault striking N. 50°-55° is mapped at McKillop Creek. The fault, displaced by an east-trending fault in Fisher River valley, continues northwest up Harris Creek, passing near Brush Mountain, to disappear beneath Quaternary sediments at Elliot Creek.

A fault striking north and dipping 80° E. in the E½ sec. 15, T. 28 N., R. 30 W. The fault intersects and displaces Cambrian sediments. One exposure of the fault zone is 4 to 5 feet wide.

Other north- and northeast-striking faults are mapped.

Age of Faults and Folds

It is not possible to accurately date the age of folding and faulting, since fossil evidence might indicate that the most recent sediments mapped are Middle or Late Cambrian in age. The sediments tentatively assigned to this period were involved in the folding and subsequent faulting; therefore, the only definite statement that can be made is that folding and faulting is post Cambrian.

Others have assigned folding and igneous activity in northwestern Montana to the Laramide orogeny occurring during late Cretaceous to early Tertiary time. Faulting post-dates folding throughout northwest Montana, and is in part, undoubtedly related to Laramide mountain building. However, additional faults or movements along older faults may have occurred during uplift and rejuvenation of the Rocky Mountains in late Tertiary time. There is some evidence that movement along pre-established east-striking faults has occurred during Recent geologic time.

Summary of Faulting

The two major fault groups in the quadrangle are northwest- and east-striking. One north-striking fault and two doubtful northeast-striking faults were mapped; however these are not included as separate groups, although north- and northeast-trending faults are recognized in the Yaak River quadrangle.

The northwest faults are older than east-trending faults and the two doubtful northeast faults are believed to displace east-west faulting.

O R E D E P O S I T S

Ore deposits in the Thompson Lakes quadrangle are both lode and placer. Production from the lodes has been negligible. Placers have been inactive for many years and production of gold from these operations was without doubt small. Some uranium mineralization is reported near Rainy Creek stock.

Lode deposits are classified as gold-quartz veins, tungsten-quartz veins, silver-lead-zinc veins, and copper veins. Gold is found in the native state, tungsten as the mineral scheelite, silver in tetrahedrite, and most of the copper in the mineral chalcopyrite. Galena and sphalerite are the principal lead and zinc minerals.

Veins are present as fissure fillings and replacements in faults and/or sheared zones in sedimentary rocks, and in a few places in igneous rocks. Igneous rocks are not present in the quadrangle except in and near the Rainy Creek stock.

LODES

Gold-Quartz Veins

These veins range from a few inches to 3 feet wide, and contain native gold in massive or crystalline quartz gangue with minor amounts of sulfides. The Midas mine has appreciable amounts of scheelite associated with gold and quartz. Gold particles are usually not visible to the naked eye, although the Gloria (Little Annie), Fisher Creek, and Tip Top properties have produced ore with considerable visible native gold. Gold in quartz from the Gloria is pale to bright yellow and occurs as minute irregular-shaped and/or elongated particles. It is both wirelike and smooth. Gold found in oxidized parts of the veins is rough, gnarled, and irregular. Gold is most commonly associated with quartz, sphalerite, pyrite, and pyrrhotite.

Tungsten-Quartz Veins

The Waylett property or Miller Creek is the only prospect in the quadrangle with scheelite-quartz mineralization. These veins also contain negligible amounts of gold. Scheelite occurs as white blebs and masses in white massive quartz veins or veinlets. The scheelite fluoresces white or bluish white under short-wave ultraviolet light.

Silver-Lead-Zinc Veins

Silver-lead-zinc minerals in narrow veins have been developed at the Montezuma property on West Fisher Creek 2 miles south of the Midas mine. Considerable native gold is associated with the sulfides. Silver occurs in tetrahedrite; minor copper as chalcopyrite, copper oxides, and carbonates; and lead and zinc as galena and sphalerite respectively.

Copper Veins

Sparse to moderate amounts of chalcopyrite and copper oxides and carbonates are associated with quartz in fissure-filled veins throughout the quadrangle. Pyrite is usually the most abundant sulfide. Gangue minerals are quartz and iron oxides. Sericite is sometimes present. The Potter property northwest of Crystal Lake is an example of this type of deposit.

DESCRIPTION OF MINING PROPERTIES, THOMPSON LAKES QUADRANGLE

Montezuma

The Montezuma prospect is 2 miles southeast of the Midas mine on the east side of West Fisher Creek in sec. 32, T. 27 N., R. 30 W. The property at one time was owned by the late Jack Bohemia of Libby. It was later acquired by Mr. Jack Larue of Libby, and is presently being developed by Messrs. G. Derikson and A. C. Lewis of Polson and

Dayton, Montana. Six unpatented claims (Hallalujah and Hallelujah 1 to 5) are in a group extending north.

The Montezuma veins are in basal Wallace beds of medium-grey to medium light-grey argillite, shale argillite, and argillaceous quartzite. A few thin- to medium-bedded horizons of grey dolomitic limestone and light-grey to white quartzite are present northwest and northeast of the property.

The property is developed by 2 adits (lower adit inaccessible), an inaccessible 30-foot inclined shaft, and 12 or more pits and trenches. The lower adit, reported to be 385 feet long, is presently being reopened. An upper adit 90 feet long is accessible but difficult to enter.

The Montezuma vein parallels the dip and strike of adjacent sedimentary beds; however, in some instances the dip is greater. The vein strikes N. 25°-30° W., and dips 50°-55° NE. The quartz vein in the lower adit is reported to be up to 20 inches wide with an average width of 10 inches. A 3- to 6-inch hanging wall section of the vein assays $50 a ton in gold (1.42 oz.). The vein in the upper adit averages about 14 inches wide. The vein material includes tetrahedrite, galena, sphalerite, chalcopyrite, and pyrite, with minor amounts of azurite and malachite in a gangue of quartz and other carbonate minerals. A dump sample from the lower adit assayed 0.12 ounce gold, 8.30 ounces silver, 0.68 percent copper, 1.0 percent lead, and 1.5 percent iron. No scheelite is reported in the sample; however, small amounts of tungsten are found in the ore. Mr. Lewis reports a representative sample from the upper adit assayed 1.30 ounces gold, 22 ounces silver, 76 percent silica, and some lead and copper. After smelter and freight charges were deducted, the ore was valued at $55 a ton. A selected sample, across a 4-inch width, assayed $76 (2.17 oz.) a ton in gold and silver. A 6- to 8-inch vein is exposed at the collar of the inclined shaft. A 3-foot banded vein of quartz and argillite exposed in an upper pit assayed $6.40 a ton in gold and silver. Other pits and trenches expose quartz veins 24 inches wide. The relationships of these veins are not clear; some exposures may be related to 1 vein or there may be 2 or more parallel veins in the area.

No production is reported from the property.

Waylett Group

The Waylett or Moose Hill group of unpatented tungsten claims includes 12 lode claims, a placer claim, and a millsite. These are between 2 tributaries of Miller Creek in secs. 20, 28, and 29, T. 27 N., R. 30 W. The prospect is 31 miles by road from Libby and 1 mile east of the Midas mine.

The area was first prospected in 1905 by Messrs. McDonald and McKay who were looking for extensions of the Midas vein. A quartz vein and sheared zone were discovered in secs. 20 and 28, which were later developed by an adit and several shallow shafts

and pits. The very sparse gold content of the vein discouraged further development.

The presence of scheelite in the Midas vein was discovered in 1916, and between 1949 to 1951, Messrs. H. K. Waylett and R. C. Jones of Libby prospected the vein in secs. 20 and 28 finding scheelite in several of the old pits and shafts. The Moose Hill group of claims were located in 1951. In 1952 the property was leased and optioned by Mr. J. C. Forkner of Fresno, Calif. Considerable bulldozer trenching, exposing the sheared zone in sec. 20 was done during 1952 and 1953.

Upon expiration of the first lease, Messrs. Clair Wyncoop and Kenneth Morlan leased the property. Additional diamond drilling and trenching in secs. 20 and 28 were undertaken to determine grade and extent of the tungsten ore body. About $45,000 were reported spent on this exploration program. The lease expired in 1957, and since that time only sporadic activity is reported.

An 8-foot vein containing massive white quartz and very little scheelite outcrops along a Miller Creek tributary in sec. 28. The vein is exposed by three bulldozer cuts and an inaccessible inclined shaft. A chip sample across the vein assayed a trace of gold and silver. No scheelite was observed under the short wave ultraviolet lamp. The presence of gouge and shattered vein material along the creek bottom may be indicative of post-mineral faulting along and parallel to the strike of the vein; however, the presence of faulting is not confirmed. The southeast extension of the vein west of Teeters Peak must nearly conform to the creek bottom as quartz float can be found most of this distance. In the early days gold-bearing float was reported discovered in this vicinity and west of Teeters Peak. Gold in commercial quantities has never been found in exposed sections of the vein to the writer's knowledge. The Waylett vein extension is traced southeast to Fisher Creek. Samples of vein material were "lamped" for scheelite with negative results.

Most of the bulldozer trenching and all diamond drilling was done on the sheared zone in sec. 20 (mapped as vein extension from sec. 28). The development work consists of 20 trenches, 25 vertical and inclined diamond drill holes to depths between 45 to 60 feet, and 3 pits.

Trenches have exposed 2 near-parallel shear-zones of undetermined width 300 feet apart. The zones trike generally N. 20°-30° W., and dip from 80°-85° E. Within the sheared zone quartz veinlets and breccia recemented with quartz contain scheelite. Evidence of 2 periods of pre-mineral movement is observed at 1 bulldozer cut where vein-quartz filled a small fault and also a portion of the displacing fault.

Scheelite is found as masses and small disseminated white blebs in quartz. The mineral cannot be megascopically identified without the aid of short wave ultraviolet lamp. Small amounts of a grey mineral, believed to be tetrahedrite, have been reported found in the veins.

The country rock in the vicinity of the prospect is a grey calcareous argillaceous quartzite of the Wallace formation. Some dark- and light-grey contorted dolomitic limestones are present in the area. Wallace bedrock strikes N. 20°-30° W. and dips 40°-80° NE.

More evidence for a post-mineral low angle fault paralleling the vein in sec. 20 is the presence of "vein bending" near the hanging wall (west side) and the presence of undisturbed beds in the hanging wall (east side) suggests that post-mineral faulting is responsible for the disturbed attitude of the vein and sediments. From the presence of drag folds west of the vein in sec. 28, it is believed that low angle reverse or underthrust faulting dropped the west (footwall) side.

The sheared zones have not been traced north of the center of sec. 20. These zones consist of numerous small veins and veinlets that may represent "horse tailing" or termination of structure.

Representative samples of scheelite-bearing quartz in sec. 20 assayed 0.22 percent to 0.68 percent tungsten oxide (WO_3). Selected specimens assayed as high as 3.72 percent WO_3. A channel sample across an 8.4-foot width in a sheared zone assayed 0.77 percent WO_3.

There has been no production from the property to this time (April 1960).

Potter

The Potter prospect is about 2 miles west of Loon Lake and a half mile north of U. S. Highway 2 in the SW¼ sec. 20, T. 27 N., R. 28 W. The property was acquired by the late Mr. J. K. Potter of Libby during the early thirties. The prospect was actively developed between 1937 and 1945. The mineral rights for an undetermined amount of homestead land in sec. 20 was obtained by Mr. Potter during the mid-thirties. Surface buildings include a cabin, bunkhouse, and compressor building which are in fair condition.

The fissure vein is developed by a caved inclined shaft and partially accessible crosscut adit. The crosscut adit is driven to intersect the vein at a lower elevation.

At the collar of the shaft a vertical quartz vein strikes N. 50° W. and dips 30° SW. The structure is 2 feet wide at the surface which includes 1 foot of mineralized quartz and 1 foot of brecciated quartz and clay gouge. Vein sulfides identified were chalcopyrite and pyrite. Other vein minerals were quartz, malachite, and calcite. A channel sample of the quartz fraction assayed 1.26 percent copper, 2.8 percent iron, and traces of lead, zinc, and silver.

The gouge and brecciated quartz assayed 0.90 percent copper, 2.20 percent iron, and traces of lead and silver.

A selected sample from the adit dump contained chalcopyrite, pyrite, azurite, and malachite in a gangue of quartz and calcite. The sample assayed 1.42 percent copper and 1.30 percent iron.

Mr. Potter reported that in a drift off the adit, discontinuous lenses of chalcopyrite up to a foot wide assayed 20 percent copper. Mr. Jack Larue of Libby reports* that 1 irregular-shaped lense of massive chalcopyrite appeared to widen beneath the base of the adit.

Country rock in the vicinity of the property is light-grey quartzite and grey calcareous argillite that strikes N. 40°-80° W., with southwest dips of 30°-35°.

There has been as yet no production from the property.

Kirkpatrick

The Kirkpatrick prospect is on the north slope of Atlanta Creek in the NW¼SE¼ sec. 15, T. 29 N., R. 27 E., a few hundred feet east of the line between the SW and SE¼ of the section (see fig. 3). Mr. Kirkpatrick owns the surface and mineral rights of the SE¼ sec. 15, which was originally the Marfield homestead. The quarter section was acquired by Mr. Kirkpatrick in 1931. The surface and mineral rights to the SW¼ sec. 15 were at one time owned by Mr. A. O. Baumann who later sold the property to the J. Neils Lumber Company. Sec. 16 is believed to be a school section.

The prospect is developed by an 80-foot adit, a 35-foot caved shaft, and a bulldozer cut several hundred feet in length. Several pits are located in the vicinity. Most development work was done between 1931 to 1933. Additional bulldozing and and exploration were done in 1958 and 1959. The property has not produced any ore to the writer's knowledge.

Two vertical intersecting quartz veins from 6 inches to 30 inches and 4 inches to 14 inches wide respectively strike east-west and N. 70° W. Another flat-lying sulfide-bearing veinlet 2 inches wide parallels the bedding. The Prichard strata near the property are flat to gentle-dipping medium-grey and greyish-blue banded quartzites and quartzitic argillites.

The east-west vein is developed by an 80-foot adit. Very sparse sulfide minerals noted in the vein were galena and pyrite. Vein material is essentially quartz with some iron oxides. A chip sample across a 2-foot width at the face of the adit assayed a trace of gold, silver, and lead.

The N. 70° W. vein is developed by a shallow pit in a bulldozer cut. The quartz vein as exposed in the pit is 1 foot wide and carried minor amounts of hematite and limonite. The vein was not sampled.

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*Personal communication.

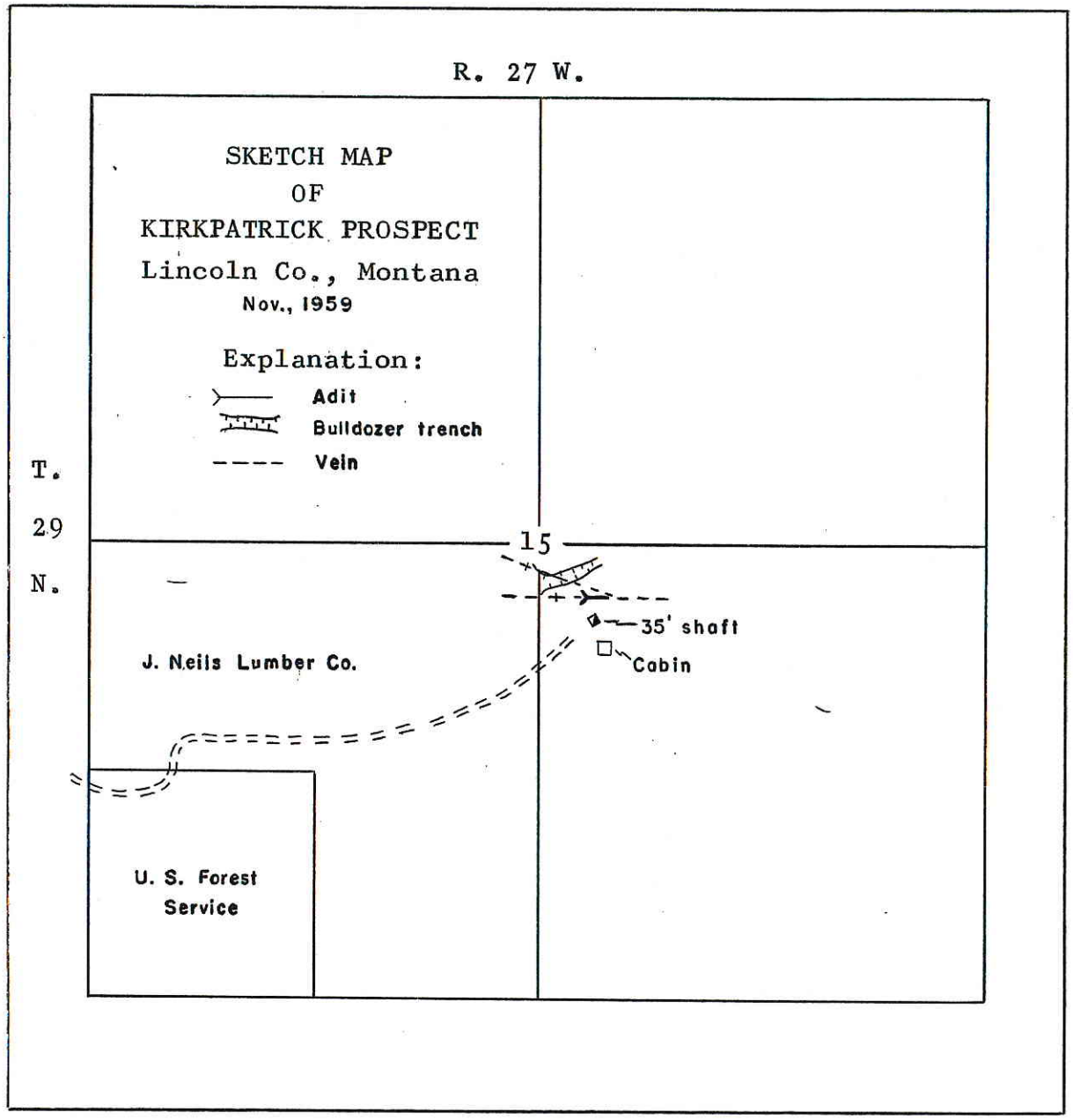

Figure 3.--Sketch map of the Kirkpatrick prospect.

Selected specimens from the "bedding veinlet" near the south end of the bulldozer cut assayed a trace of gold, silver, lead, and zinc, 0.20 percent copper, and 5.40 percent combined iron oxides. Small amounts of chalcopyrite, covellite, galena, and sphalerite were noted in the quartz gangue. Pyrite and iron oxides are the more abundant vein minerals.

Mr. Kirkpatrick reported the caved shaft intersected a narrow east-west (?) vein containing quartz and pyrite.

Boulder Hill

This prospect is in the NW¼ sec. 15, T. 29 N., R. 27 W., on a grass-covered and sparsely-timbered slope east of Atlanta Creek--locally known as Boulder Hill. Two claims, the Hope and Boulder Hill, were relocated by Mr. Charles C. Strodtbeck in 1946. The property has been inactive for the past 10 years.

In 1903 Messrs. Knut Tideman and Charles Strodtbeck located 2 claims after finding gold-bearing quartz float in the vicinity. In 1906 a syndicate became interested in the property and subsequently leased the ground for a period of time. The property was periodically active until 1939 when Mr. Strodtbeck commenced actively exploring the quartz vein. Development work continued until 1947.

A 4-inch vein of iron-stained quartz outcropping near the top of Boulder Hill strikes N. 70° W. and dips 85° SW. The country rock is Prichard argillite. The covered northwest extension of the vein on Boulder Hill is developed by 2 inaccessible adits and 50 pits and trenches. The vein was exposed by these pits and trenches at intervals of 30 to 50 feet for a distance of a half a mile.

Mr. Vern C. Strodtbeck of Kalispell reports that the 2 adits are 50 and 500 feet long. The quartz vein in the 500-foot adit is up to 18 inches wide, and averages 10 inches. Sections of this quartz vein assayed* $5 a ton in gold and silver and the vein was lost through faulting near the tunnel face.

Representative samples of quartz from the adit dump assayed 0.10 ounce gold and 0.04 ounce silver.

Strodtbeck

This prospect is in gently-dipping Prichard beds in the NW¼ sec. 4, T. 29 N., R. 27 W. on Redemption Ridge. It was relocated by Mr. Charles A. Strodtbeck of Kalispell in November 1931. The property includes 3 unpatented claims. Development work amounts to a 10-foot discovery shaft and several pits and trenches. The prospect has been inactive for many years.

Several vertical parallel quartz veins several inches wide strike N. 60°-65° W. Sparse mineralization in 3- to 4-inch veins includes galena, cerussite, anglesite (?), chalcopyrite, azurite, chrysocolla, and pyrite. Hematite and "limonite" fill vugs and occur as psuedomorphs of pyrite. The veins are in medium- and dark-grey argillite striking N. 20° W. and dipping between 5°-10° SW.

The axis of the Wolf Creek anticline is a short distance east of the property. The southeast projection of the quartz veins intersects the axial trace of the fold at angles of about 55°.

Reported production from the property amounted to 1 car of ore shipped prior to the relocation of the Great Northern tracks

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*Personal communication.

to the Kootenai River. The vein width and amount of development do not appear to substantiate production from the property.

Selected specimens of dump material assayed 0.24 ounces gold, 0.30 ounces silver, 0.40 percent copper, and 1.8 percent lead.

Raven

The Raven group and the Lucky Mac group include 6 and 8 unpatented claims each respectively in secs. 21 and 28, T. 31 N., R. 30 W. in the Rainy Creek district. The groups were staked by Messrs. J. D. Daniels, H. C. Daniels, and H. Daniels of Valcour and Libby in 1955. The property is 2 miles southwest of the Zonolite Co. mine. The information has been kindly supplied by Mr. and Mrs. J. D. Daniels.

Development amounts to a 20-foot adit and 9 bulldozer cuts on a sheared zone. Two pits have exposed a vein paralleling a ridge top. The property is near the contact zone of syenite and Wallace country rock.

A sheared zone striking north and dipping 60° E. lies in the SW¼ sec. 21. The zone is from 8 to 25 feet wide. A short adit is on the structure. Quartz is the most abundant mineral, although some galena, cerussite, chrysocolla, malachite, tremolite, and jasper are present. A sample of the vein material assayed 1.6 percent copper.

Approximately a quarter of a mile east of the sheared zone is a parallel-striking mineralized zone that follows a ridge. Quartz, galena, and fluorite have been observed in radioactive ore from 2 pits. Mr. Daniels states that radioactivity can be traced on surface for a distance of 1,500 feet along the strike of the vein.

Selected specimens assayed 17.0 percent lead and 0.75 ounce silver. Mr. Daniels reports that a specimen from the vein on the ridge assayed 7.5 percent zirconium oxide.

The vein and sheared zone is near the contact between the Wallace limestone and syenite. Wallace country rock in the area strikes north and dips 40° E.

No production has been reported from the property.

Hathaway (LB-1)

In the early 1900's Mr. George Hathaway and others developed a small quartz-copper vein on a north-trending ridge between Reinshagen and Canoe Gulches in the SW¼ sec. 7, T. 30 N., R. 29 W. The prospect is believed to be on ground owned by the Northern Pacific Railway. The property is accessible by State Highway 37 and a U. S. Forest Service road to within a third of a mile of the adit.

Development work includes an accessible adit 300 feet long, and crosscuts totaling 150 feet driven perpendicular to the vein. A small open cut exposes the vein on the surface 150 feet north of the portal of the adit.

The vein at the outcrop is 10 to 12 inches wide and decreases irregularly in width with depth. It is vertical and strikes N. 74° E. Minerals present are chalcopyrite, malachite, galena, and pyrite. At the adit the vein is barren and pinches to a few inches along strike.

The vein is in red-grey-purple argillaceous sediments striking N. 50° W. and dipping 38° E.

A normal sample across the vein assayed 4.25 percent copper, 0.50 percent lead, 6.30 percent iron, a trace of zinc, and 0.90 ounce silver.

No ore have been produced from the prospect.

Kennedy

During the middle 1950's Messrs. Russel Deist, Lloyd Gould, H. P. Reinshagen, Jr., and Less Bloom located a group of claims in sec. 34, T. 31 N., R. 30 W., on the north side of Kennedy Gulch approximately $1\frac{1}{4}$ miles east of State Highway 37. At individual locations abnormal scintillator readings indicated the presence of radioactive material associated with igneous rocks.

The claims are developed by several bulldozer cuts. No uranium mineralization of any consequence was found during development work. Radioactivity in the area may have been caused by sparse amounts of autunite occurring in the dike and surrounding Wallace country rock. Selected specimens were reported to assay up to 0.20 percent U_3O_8 (uranium oxide).*

Bulldozer cuts expose a diorite dike which is half a mile long and 50 to 100 feet wide. The dike is locally stained with small amounts of iron and copper. Pyrite crystals up to $\frac{1}{4}$ inch in diameter are sparsely scattered throughout.

Selected samples at 2 locations (LB-5 and 6, see pl. 2) assayed 0.60 and 0.26 percent copper respectively, and a trace of silver and zinc. Neither sample was radioactive.

The ground has been relocated by Messrs. Russell Deist and Lloyd Gould.

Other Prospects

A 12- to 18-inch vein outcrops for a distance of 40 feet in sec. 17, T. 30 N., R. 27 W. The vein is developed by a 3-foot pit.

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*Reinshagon, H. P., Jr., personal communication.

White massive quartz with hematite and limonite filled vugs occurs in medium dark-grey Prichard argillite. Sedimentary beds strike north and dip 14° E. The quartz vein trends N. 80° E. and dips 85° N. Vein material assayed a trace of gold and silver.

A second quartz vein outcropping in sec. 29, T. 30 N., R. 27 W. is 6 to 30 inches wide. The vertical vein strikes N. 70° W. White vuggy iron-stained quartz is barren of sulfide mineralization. The vein is developed by 2 shallow pits. The vein cuts medium dark-grey quartzitic argillite, striking N. 15° W. and dipping 6°-12° W. of the Prichard formation. Other small quartz veins are mapped along the Wolf Creek road in the E½ sec. 21, T. 29 N., R. 28 W.

Two parallel east-striking vertical quartz veins are mapped 1,000 feet southeast of Fisher Mountain in the SE¼ sec. 31, T. 29 N., R. 29 W. The veins are 1 foot wide and about 50 feet apart. One vein, developed by a 6-foot pit, contained quartz, sparse chalcopyrite, pyrite, tenorite (?), and azurite. Country rock is mud-cracked medium-grey argillite and calcareous limestone of the Wallace formation. Selected specimens from the discovery pit assayed 1.20 percent copper, and a trace of lead and silver.

A prospect near the Kootenai River (LB-2, see pl. 2) in the SW¼ sec. 15, T. 31 N., R. 29 W., is on the side of a steep cliff several hundred feet east of the Canyon Creek road. The country rock is Ravalli quartzite and argillite containing disseminated biotite and magnetite. Samples of material assayed 0.54 percent copper, and a trace of lead and zinc.

A quartz vein of undetermined width (possibly a foot or more) was observed a mile west of the Zonolite Co. open pit on the northeast side of a small ridge. The vein is developed by 4 pits. Since outcrops are scarce and the hillside covered with quartz float, the trend of the vein or veins is difficult to determine. Small amounts of galena and malachite were associated with dump material. Selected dump specimens assayed 0.40 and 0.34 percent copper, and a trace of lead and silver.

Quartz veinlets associated with a metadiorite sill occur near the center of sec. 36, T. 31 N., R. 31 W., about 4 miles northwest of Libby. The sill lies west of the boundary line in the Libby quadrangle. A sample of vein material assayed 0.16 percent copper, 11.80 percent iron, 0.60 ounce silver, and a trace of gold, zinc, and manganese.

A short adit in Cambrian (?) limestone was noted in the N½NE¼ sec. 15, T. 28 N., R. 30 W. The adit is several hundred feet north of U. S. Highway 2. The dump is visible from the road. The adit was driven in a northerly direction along joints or small faults. No mineralization was found in the tunnel.

Another adit, not found by the writer, has been reported a short distance east of Fritz Peak.

A 65-foot vertical shaft is sunk on iron-stained fault breccia on Sullivan Peak near the section line between secs. 28 and 29, T. 29 N., R. 27 W.

The work was done prior to 1900 by a stock company formed for this purpose. No other information concerning the venture was obtained. The company was reported to be looking for copper.

Undeveloped Surface Veins

A 2-foot quartz vein is mapped in the NW$\frac{1}{4}$ sec. 2, T. 27 N., R. 28 W. This vertical vein in the Libby formation strikes N. 80° E. Libby beds in the area strike N. 15° W. and dip 40° SW. Gouge and breccia from post-mineral faulting parallels the south side of the vein. Another 6-inch quartz vein is sampled in sec. 11, T. 27 N., R. 28 W. The vein assayed a trace of gold and silver.

Quartz float from veins was observed at 2 localities in the Swamp Creek area. Along a road cut in the NE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 15, T. 28 N., R. 30 W., sparse chalcopyrite, pyrite, siderite, and ankerite (?) was found in medium to large pieces of quartz float. In the NW$\frac{1}{4}$ sec. 35, T. 28 N., R. 30 W. along a talus slope north of Swamp Creek, quartz float up to 6 to 10 inches thick contains chalcopyrite, siderite, and ankerite. Specimens of float assayed 0.46 percent copper, 0.50 percent lead, 1.50 percent manganese, 2.6 percent iron, and a trace of zinc.

Other small quartz veins from 2 to 4 inches wide were found in the NE$\frac{1}{4}$ sec. 17, T. 28 N., R. 28 W., and in sec. 33, T. 29 N., R. 27 W. At both localities white massive iron-stained quartz had iron and manganese oxides filling the vugs.

Miller Placer

During the 1930's Mr. O. V. Miller and Mr. P. Church of Libby staked 1,200 acres of potential placer ground in secs. 4 and 5, T. 26 N., R. 30 W. in West Fisher Creek. All placer claims were subsequently dropped with the exception of a 20-acre claim in the SE$\frac{1}{4}$ sec. 4. Development work on this latter claim consists of an inaccessible shaft to a depth of 100 feet and a nearby churn drill hole to a depth of 110 feet. No production has been reported from the property.

Mr. Miller reports gravels, sands, and silts in the shaft average $0.12 to $0.16 per cubic yard in gold. He stated the gravels in sec. 3 (Northern Pacific Railway section ?) may run higher. The shaft, sunk in unconsolidated sand and gravel, encountered one 10-foot horizon of silt between depths of 15 to 25 feet.

Color can be panned from most creek gravels in upper West Fisher Creek and its tributaries.

Tideman Placer

This placer was located by Mr. Knut Tideman around 1900 in the NE$\frac{1}{4}$ sec. 17, T. 29 N., R. 27 W. The most extensive workings are near the junction of Atlanta and Wolf Creeks. This section of the claim is developed by fairly extensive pits averaging 3$\frac{1}{2}$ feet deep over about a half an acre. The pits are at a slightly higher elevation than Wolf Creek. The ground is presently owned by the J. Neils Lumber Co.

Gold occurred as medium to coarse nuggets from surface to a depth of 2 feet. During the depression, Mr. Albert Johnson reported recovering an ounce of gold a month. Some of the better gravel ran $1.00 to $1.50 a wheelbarrow load. No accurate record of production is available; however, an estimated production of 15 ounces gold between 1930 to 1931 is believed probable.

Big Eight Placer

The Big Eight placer claim was located in June 1902 by Messrs. J. R. Listle, W. F. Mulaney, F. C. Sauerbier, K. Tideman, S. J. Jaqueth, J. J. Hibbard, F. L. Gray, and W. H. Griffin. The patented claim was later acquired from the Listle Estate by the J. Neils Lumber Co. The property consists of 160 acres of which 31.10 acres is in sec. 17, T. 29 N., R. 27 W.; 80.17 acres in sec. 18; and 49.04 acres in sec. 13, T. 29 N., R. 28 W. (see fig. 4).

The ground was worked along Wolf Creek, although no record of production or development is available to the writer's knowledge.

Darling Placer

One 20-acre placer claim was located by Mr. Art Darling in sec. 21, T. 29 N., R. 27 W. in 1929. Development work consists of several pits and trenches. Remnants of old sluice boxes remain to mark the site of operations.

Mr. Darling reports that coarse gold was associated with black sand, small garnets, and pyrite cubes from the surface to bedrock. Placer gold was spotty and ran from a few cents to $1 a cubic yard. A small amount of gravel yielded $1 per pan in gold. Production from the claim amounted to about 20 ounces over a period of 2 years.

Getner Placer

The Getner placer was located by Mr. J. S. Getner and associates on Libby Creek in sec. 5, T. 28 N., R. 20 W. The property was active in 1929 when Gibson (1948, p. 128) was mapping the Libby quadrangle. Stream gravels near creek level a short distance below Crazyman Creek were sluiced for gold. The property has been inactive for 30 years, and no record of production is available.

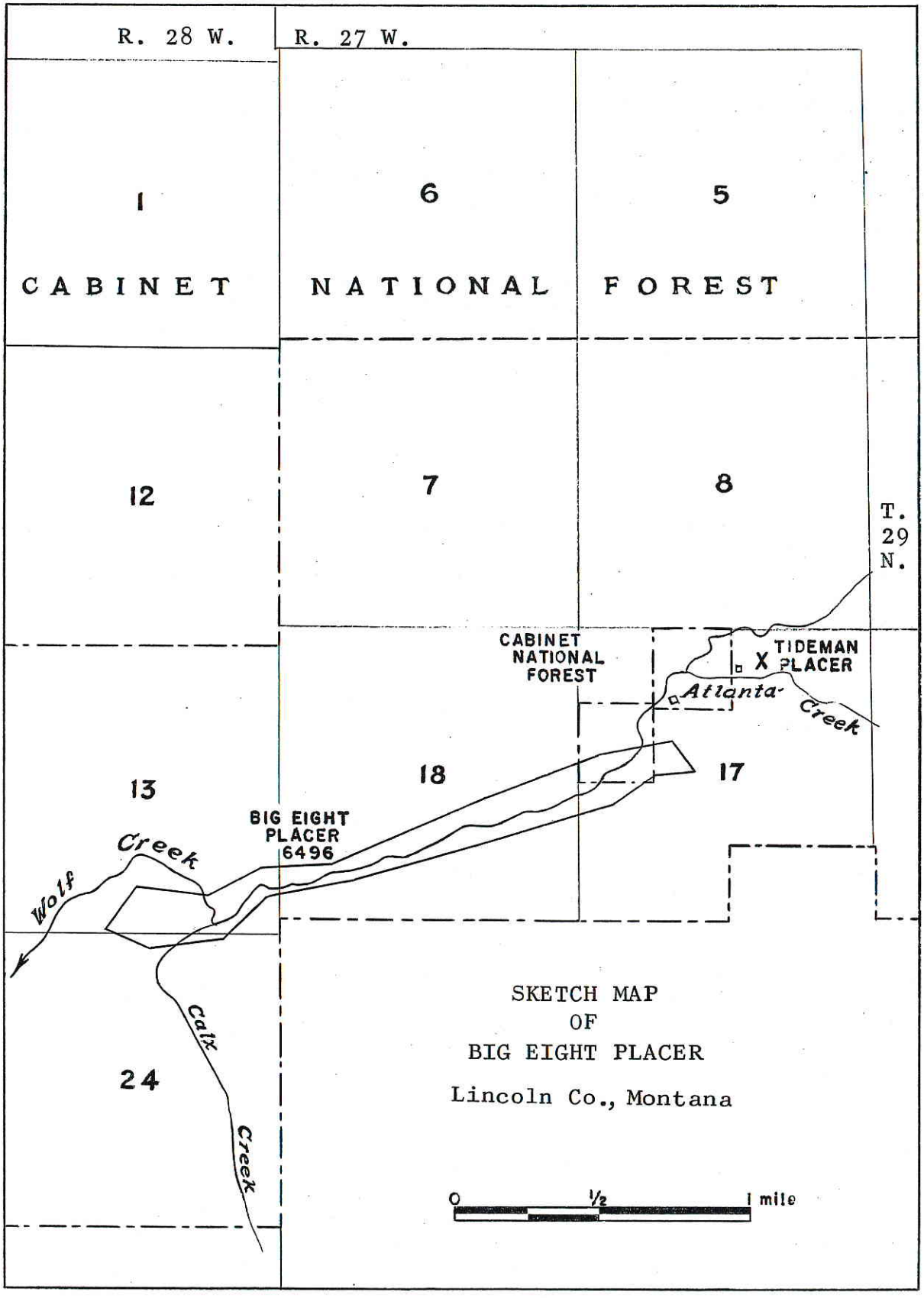

Figure 4.--Map of the Big Eight placer in T. 29 N., Rs. 27 and 28 W., Lincoln County, Montana

Other Placers

Two abandoned placers were noted in sec. 9 on Libby Creek a short distance above the Getner placer. Considerable sluicing of gravels is indicated by tailings dumps in the area.

Color can be panned* from the gravels near the mouth of Cow Creek in sec. 6, T. 28 N., R. 28 W.

NEARBY PROPERTIES, LIBBY QUADRANGLE

During the field season of 1958, considerable activity in the Libby quadrangle suggested that a brief description of new properties or new activity at older properties should be included in the progress reports on Lincoln County. With this in mind the writer described new activity in the Troy-Libby area in Bulletin 12, and has included mines and prospects in the southeastern part of the Libby quadrangle near the head of West Fisher Creek and its tributaries in the report (see fig. 5).

Many workings described by Gibson (1948) are presently inaccessible, and his descriptions of properties in the Libby quadrangle has been freely used.

Midas

The Midas mine, in the Libby quadrangle near the center of sec. 19, T. 27 N., R. 30 W., lies half a mile west of the Waylett group and 2 miles north of the Montezuma prospect. The property has produced gold and tungsten, scheelite being first reported in the ore in 1916. The mineral stolzite was reported** identified at the mine by U. S. Bureau of Mines engineers. The property has been inactive since 1933. Two shafts (one of which is inclined and sunk to a depth of 125 feet) and other underground workings are presently inaccessible. The mill building, ore bins, and most other surface buildings have collapsed or were dismantled.

Gibson (1948, p. 86) reported the property in 1932 had 8 unpatented lode claims and 1 placer claim. In recent years 3 claims have been patented.

The property was originally located in 1905 and later acquired by the Midas Gold Mining & Milling Co. to be later merged with the Spokane-Idaho Copper Co. of Spokane, Wash. During the 1950's the property was leased to Mr. O. V. Miller. Mr. Miller has relocated the placer claim and several quartz claims in the vicinity. During the summers of 1958 and 1959 he sluiced tailing dumps for gold and scheelite and reported recovering 16 ounces of gold and considerable scheelite.

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* Darling, Art, personal communication.
** Miller, O. V., personal communication.

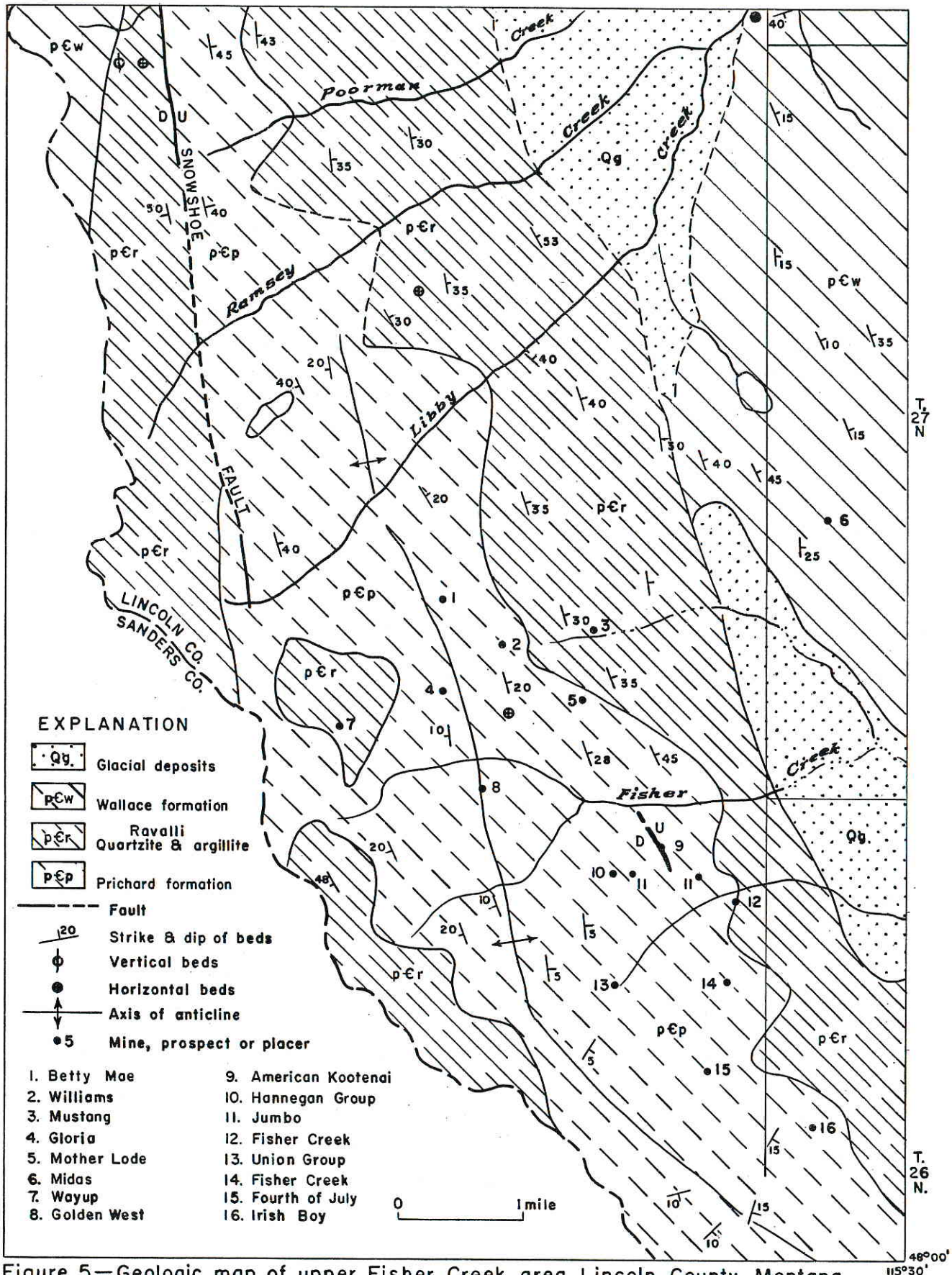

Figure 5—Geologic map of upper Fisher Creek area, Lincoln County, Montana

Gibson (1948, p. 87) describes the Midas vein as a bedding vein, ranging in thickness from a few inches to 6 feet and averaging about 1 foot. The vein strikes N. 20°-30° W. and dips 40°-60° NE. The well-defined vein is in Wallace calcareous grey shales, sandy shales and sandstones, and banded and contorted buff-weathering grey limestones.

Quartz, scheelite, and carbonates are the most abundant minerals in the vein. Sparse amounts of galena and tetrahedrite are present. Some sericite, chlorite, and native gold are associated with iron oxides. The gold is a deep-yellow color and is gnarled and wirelike. Within the developed vein the ore is incompletely oxidized.

Brecciated fragments of limestone and hanging-wall rock silicified with vein quartz points to faulting before or contemporaneous with the introduction of vein quartz. Gibson (1948, p. 87) reports the vein may have occupied a fault. Post-mineral faulting took place along north or northeast-trending fractures. Mr. Jack Larue* believed the vein was displaced at the main shaft and at a point 200 feet south of the main shaft by east-trending faults. The displacement on the latter fault may amount to as much as 450 feet. Mr. Miller has been active in attempting to locate this faulted south extension of the vein.

Gibson reports a production of $59,000 from 1905 to 1933, and total production to date may not exceed $60,000. Total development exceeds 3,000 feet of crosscuts, drifts, and raises which are all inaccessible.

Fisher Creek

This property was formerly known as the Brannigan which was one of the early producers in the Libby quadrangle (see figs. 5 and 6). The claims are located in secs. 1 and 12, T. 26 N., R. 31 W. on both sides of Bramlet Creek, which is a tributary of West Fisher Creek. A total of 8 patented claims comprise the group. Most surface buildings have collapsed and only 2 cabins remain standing.

The reader is referred to Gibson (1948, p. 83) and Johns (1959, p. 43) for a more complete description of the property.

Jumbo

The Jumbo group includes 4 unpatented claims on the north side of Bramlet Creek in secs. 1 and 2, T. 26 N., R. 31 W. (see figs. 5 and 6). The group was formerly known as the Tip Top and Blacktail. The prospect is presently owned by Mr. L. W. Bolyard of Libby. An aerial tramway and surface buildings, including a stamp mill and ore bin, are either collapsed or in poor condition.

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* Personal communication.

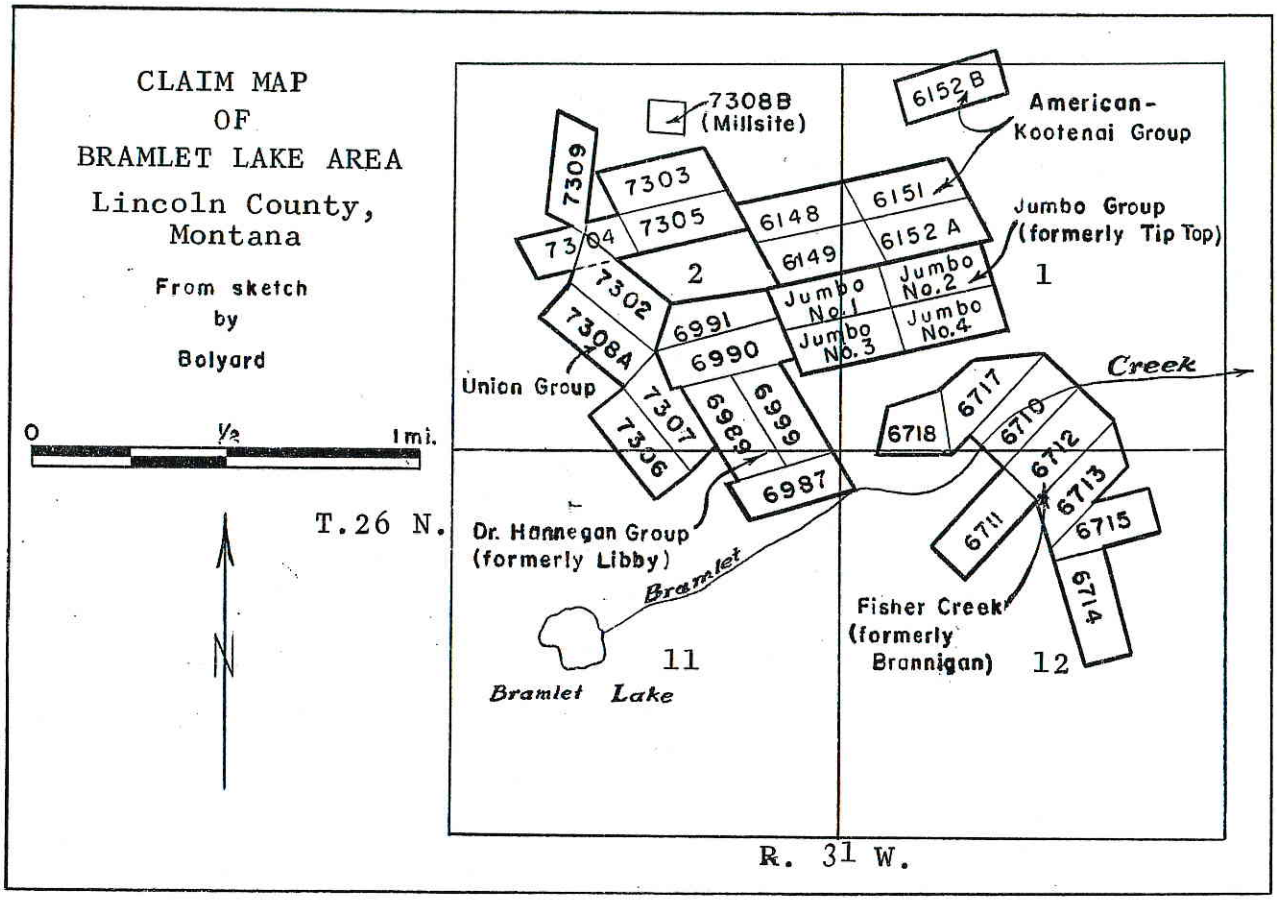

Figure 6.--Claim map of the Bramlet Lake area, Lincoln County.

The claims are developed by cuts, trenches, and adits, the longest adit not exceeding 300 feet in length.

Numerous quartz veins from a fraction of an inch to 2 feet wide conform to sedimentary bedding or cross bedding at slight angles. A few cross veins are nearly perpendicular to the bedding. The veins are irregular and form podlike lenses which pinch and swell along strike. Adjacent to the vein tiny veinlets of quartz have impregnated the country rock. The wall rock in many instances is gold impregnated.

All development work on the property has been in the oxidized zone where some enrichment of native gold is expected. An accurate thickness of the zone of oxidation is not known; however, it is probably in the tens of feet.

Visible native gold occurs in some veins on the property. The gold particles are irregular shaped, vary in size, and are gnarled and rough. Sulfides are scarce within the veins, and where they are found they are sometimes partially replaced or more often only represented by their alteration products. Pyrite, pyrrhotite, and sphalerite were identified in a gangue of quartz, iron oxides,

and sericite. The quartz contains voids and pits formerly occupied by sulfides that are now filled with alteration minerals (largely iron oxides).

The prospect is in blue-grey to medium-grey argillite and sandstone of the Prichard formation striking north to N. 20 W. with gentle eastward dips. An important structural feature in this and nearby areas is an anticline whose axis strikes slightly west of north. Quartz veins occur on both flanks of the fold, although most of the productive properties are on the east flank. A favorable horizon for productive veins is in a sericitized light-grey argillite or white sandstone. In one such bed quartz veinlets, over a thickness of several feet, assayed from $1 to $7 a ton in gold. Gold-bearing quartz veins up to 2 feet thick assay from $15 to $60 a ton. The average gold content of ore lenses in these veins is about $28. One selected specimen was reported to assay 4.90 ounces gold and 1.39 ounces silver a ton.

Production figures for the property are not available. Gibson (1948, p. 88) gave a figure of $2,300 for ore produced in test runs prior to 1934. The property was active as late as 1938.

American Kootenai

This group of claims is north of and contiguous with the Jumbo group (see figs. 5 and 6). They are located in secs. 1 and 2, T. 26 N., R. 31 W. on the south side of West Fisher Creek. The property has 5 patented claims owned by Mr. L. W. Bolyard.

The claims are developed by 3 adits which total 600 feet in length. Bedded veins are from a few inches to 5 feet thick in white sandstone and argillite of the Prichard formation. A bedded vein whose thickness varied from 1 to 5 feet was stoped for a short distance. Some cross cutting veinlets in a $1\frac{1}{2}$-foot sandstone bed are present. The lodes are very irregular with a tendency to narrow and widen within short distances.

Quartz, pyrite, iron oxides, and some gold are present in the oxidized zone. Post-quartz faulting has fractured the vein material.

Union

The Union group (formerly Olsen and Switzer?) has 8 patented claims in secs. 2 and 11, T. 26 N., R. 31 W. (see figs. 5 and 6). The claims are on the north slope near the head of Bramlet Creek. The ground was acquired by Mr. L. W. Bolyard. Development amounts to several short adits and trenches.

Quartz veins from 6 inches to 4 feet wide parallel greyish-blue and light-grey argillites of the Prichard formation. The argillite strikes N. 10° W. and dips 5°-10° E. Bedding faults have fractured vein quartz and created gouge zones along the lodes.

The predominant sulfide mineral is galena with some sphalerite, pyrrhotite, chalcopyrite, and pyrite in quartz gangue.

Hannegan

This property, formerly known as the Libby, has 5 patented claims contiguous with the Jumbo group to the east (see figs. 5 and 6). The property is owned by Dr. Hannegan of Libby. The claims are developed by 5 short adits driven in a southerly direction to explore veins and closely-spaced veinlets in Prichard sediments.

Quartz veins up to 2 feet wide follow bedding planes in medium-grey sericitic sandstone and argillite. The argillite is frequently a reddish-brown color with small blebs of iron oxide derived from the oxidation of small grains of pyrite. Numerous quartz veinlets both parallel and traverse sedimentary beds. Veins and veinlets are irregular, and veins may finger into smaller ones within short distances.

Galena, anglesite, cerussite, and native gold are present in the lodes. Quartz and iron oxides are the gangue minerals. Selected specimens assayed about 0.50 ounce in gold a ton.

The claims are on the east side of the major anticline. Prichard sediments strike N. 5^{o}-10^{o} W. and are either horizontal or dip gently east. Much shattering of sediments during folding took place providing channelways for quartz-bearing solutions.

Irish Boy

This prospect is on the south slope of Lake Creek several hundred feet above creek level. It is reached by a hazardous road which follows Lake Creek and then ascends the south slope to the property. The claims are in sec. 18, T. 26 N., R. 30 W. The property is developed by an accessible adit and several cuts. The prospect has been inactive for some time.

Both bed and crosscutting veins up to 6 and 12 inches wide respectively are exposed in cuts and in the adit. Country rock of the Prichard formation is a brown-colored sandstone and argillite striking N. 20^{o} W. and dipping 15^{o}-30^{o} E.

Sparse galena, anglesite, sericite, and iron oxides occur in a quartz gangue. A sample of galena-rich material analyzed by Gibson (1948, p. 95) assayed a trace of gold and 5 ounces of silver per ton.

Gloria

The Gloria or Little Annie was formerly one of 2 properties comprising the Golden West Mining Co. near the headwaters of West Fisher Creek. The Gloria is located on the north side of the creek, whereas the Golden West lies south of this drainage. The Gloria has been recently located by Messrs. A. Templin and R. Siefkie of

Libby, and A. C. Lewis of Dayton. One claim was relocated by the 3 men. Mr. Lewis also staked several other claims in this vicinity. The adits on the property are accessible, although both are partially caved at the portals. The property is near the boundary between secs. 27 and 34, T. 27 N., R. 31 W. Two adits, amounting to more than 300 feet of development, were driven in a northeast direction on quartz veins. The adits are connected by a crosscut.

Bedding veins up to 2 feet wide are horizontal or dip at slight angles to the west. The property is a short distance west of the major anticline that is an important structural feature in this part of the Libby quadrangle. The quartz lodes contain some visible native gold, galena, sphalerite, chalcopyrite, pyrrhotite, pyrite, and siderite. Sericite is also present.

Visible native gold, commonly in quartz or associated with sulfides, is a pale- to bright-yellow color. It is found as very small particles nearly invisible to the naked eye or as irregular-shaped visible particles that are both smooth and gnarled or wire-like. Some particles are round. In 1 specimen visible native gold was associated with very fine-grained pyrite and a grey-colored mineral believed to be tetrahedrite.

Gibson (1948, p. 86) reports that the ore being mined at the time of his visit was little oxidized; at other properties in the quadrangle ore mined primarily for gold content was not regarded as workable below the zone of oxidation.

A recent sample taken by Mr. Lewis across a 16-inch width assayed 4.88 ounces gold, several ounces silver, and some lead and copper. One shipment of 39 tons yielded 3.874 ounces gold and 1.05 ounces silver a ton. Small shipments of ore have been reported mined in the early 1930's that assayed between 8 and 9 ounces a ton in gold.

Way Up

The Way Up prospect is near the base of Twin Peaks at elevations of 5,600 to 5,800 feet. The claims are on the north slope of West Fisher in secs. 28 and 33, T. 27 N., R. 31 W. They are reached by a road up West Fisher Creek, the last mile of which was inaccessible in late June 1959, because of unmelted snow. Mr. John Malloy of Libby and 2 associates from Avon, Idaho, are presently leasing the property. The prospect has been active for the past several years.

A 4-foot sheared zone is developed by 3 accessible adits, one above the other, for distances totaling more than 600 feet. Quartz veinlets up to 2 inches wide are irregulary distributed throughout the sheared zone. The zone strikes about N. 25° W. and dips 65°-80° NE.

Sparse amounts of galena, pyrite, and native gold occur in the sheared zone. This zone is the contact between Ravalli

beds to the east and Prichard argillite to the west. The beds strike N. 10°-20° W., Prichard beds dip steeply to the southwest, whereas Ravalli sediments dip northeast. Prichard country rock is a brown-colored laminated shale and argillite. Ravalli horizons are slightly calcareous white sandstone.

Selected samples of dump material assayed 0.50 ounce gold and 0.50 ounce silver to the ton.

Williams

This prospect is at the head of a tributary of Libby Creek west of Great Northern Mountain in sec. 27, T. 27 N., R. 31 W. A steep road, via Standard Creek which can only be traveled by 4-wheel drive equipment, terminates at the top of Great Northern Mountain. The property is reached by trail from this point. Eight unpatented claims, some of which are on a ridge between Great Northern Mountain and Twin Peaks, comprise the property. The property is developed by trenches and 4 adits; the adits are all partially caved at their portals. There has been no activity on the claims for many years.

One accessible adit, about 300 feet long, has been driven on a bedded 2-foot vein of galena-bearing quartz. Oxidation products derived from galena are anglesite, cerussite, and iron oxide psuedomorph after pyrite. Some sericite is present. Crosscutting galena-rich quartz veins up to 2 feet thick strike in a northeast to east direction. Anglesite, cerussite, sparse chalcopyrite, and hematite are present in the cross structures which dip south or southwest at high angles. The veins are irregular in width with a tendency to pinch and swell along strike.

The country rock is Prichard argillite which is horizontal in attitude.

A galena-rich specimen containing sparse chalcopyrite was reported to assay 0.04 ounce gold and 8.71 ounces silver a ton.

Mustang

This prospect lies 2 miles southwest of the Midas mine on the south side of Standard Creek in sec. 26, T. 27 N., R. 31 W. A road, accessible to 4-wheel drive vehicles, parallels Standard Creek and a small tributary to the property. The prospect comprises 4 unpatented lode claims which have been inactive for some time. The property is developed by a 700-foot accessible adit and an open cut.

The adit is on a $1\frac{1}{2}$-foot quartz vein which splits into a zone of closely-spaced quartz veinlets up to a few inches thick. The quartz vein parallels the bedding and in places dips steeper than the bedding. A surface exposure above the adit, believed to be lode outcrop, is $2\frac{1}{2}$ feet wide. Some sections of the vein show a ribbon quartz structure which may have partially replaced the sheared and shattered wall rock. Metallic lode minerals are galena, pyrite, and pyrrhotite in a gangue of quartz and iron oxides. Pre-mineral

faulting and shearing was followed by contemporaneous quartz-sulfide mineralization in permeable sections of the broken and shattered area. Post-quartz movement is indicated by fractured and brecciated vein quartz. The adit is largely in the oxidized zone and conspicuous iron oxide-staining is present.

Country rock is a grey to light-grey and white shaly calcareous argillite and sandstone of the Ravalli formation. Pyrrhotite is abundantly distributed throughout some sandstone horizons. The general bedding strikes N. 20°-30° W. and dips 30° NE.

No production has been reported from the property and the present status of ownership is unknown.

Betty Mae

The Betty Mae group of 6 unpatented claims is in secs. 22 and 27, T. 27 N., R. 31 W. on Goat Creek, a northwest-flowing tributary of Libby Creek. The inactive property has been developed by several shallow cuts and pits.

Thin veins and veinlets of galena-bearing quartz conform to horizontal or gently dipping grey argillite and sandstone beds of the Prichard formation. The veins are irregular and tend to pinch out within short distances. Other metallic minerals in the lodes are chalcopyrite, sphalerite, and pyrrhotite. Oxidation products of galena which are present in the vein are anglesite and cerussite. Some melanterite and native copper has also been reported. Post-quartz movement prior to deposition of sulfides is indicated by shearing and shattering of quartz. Additional post-sulfide movement has shattered the sulfides to a small extent. A representative sample of vein material also assayed a trace of gold. Gibson (1948, p. 93) reports a selected sample contain 10 percent copper, 20 ounces silver, and 0.50 ounce gold a ton.

NONMETALLIC DEPOSITS

Vermiculite

The largest vermiculite deposit in the United States is located in Rainy Creek 8 airline miles northeast of Libby. The property, discovered in 1915, has been producing vermiculite under the trade name "Zonolite" since 1948. It is shipped as an unexpanded product to processing plants in United States and Canada.

Vermiculite is similar in appearance to biotite, and upon heating under controlled conditions expands about 12 times its original size. It has a variety of uses in the agricultural, chemical, automotive, and building and paint industries in this country.

For more-detailed descriptions of the property the reader is referred to reports by Pardee and Larsen (1928, p. 12-26), Perry (1948, p. 24-28), and Johns (1959, p. 38-39).

Another vermiculite occurrence of undetermined extent is located north of Fleetwood Creek in secs. 10 and 15, T. 31 N., R. 30 W. toward the northern part of the Rainy Creek stock (see fig. 7). Eight unpatented claims, the Last Chance and Last Chance nos. 1 to 7 were staked by George Ottoway and Mr. Fleetwood in 1925. The property was acquired by Messrs. H. J., H. L., and U. L. Poston of Kalispell in 1932. Mr. H. J. Poston has recently assumed complete ownership of the group. During the 1950's the property was leased and optioned by the F. & S. Construction Co. of Butte.

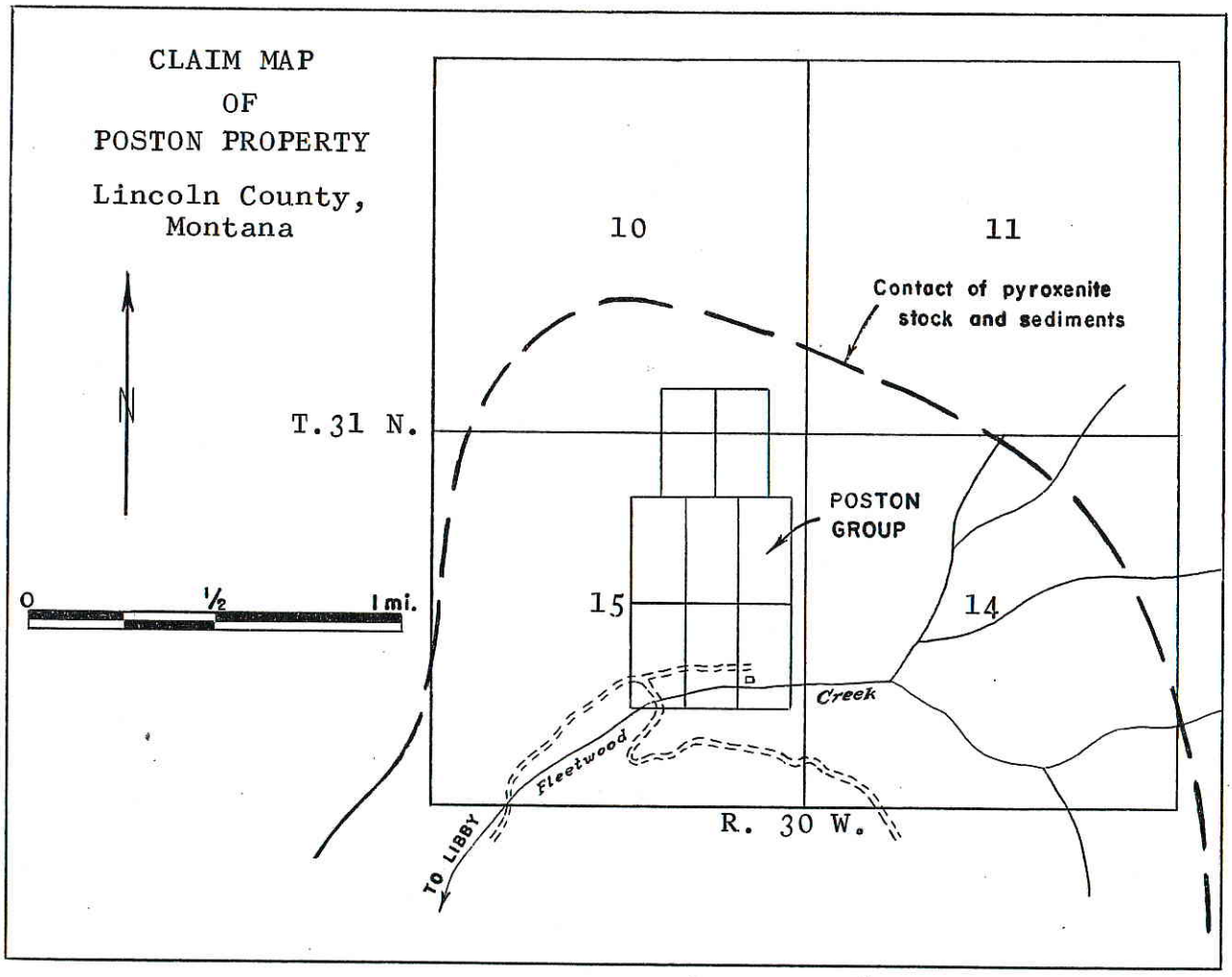

Figure 7.--Claim map of the Poston property, Lincoln County

The property is developed by 3 inaccessible adits totaling 150 feet in length,* three-quarters of a mile of trenching, and several bulldozer cuts. Vermiculite, biotite, and tremolite (amphibole asbestos) are exposed in cuts and trenches in the Rainy Creek pyroxenite stock. Quartz veins up to 14 inches wide carry sparse amounts of galena.

Mr. U. L. Poston reports that expansion tests of the vermiculite indicate that the mineral expands through a range of 20 to 27 percent.

No production has been reported from the property.

Wollastonite

Two wollastonite ($CaSiO_3$) veins striking N. 30° W. were mapped near the center of sec. 3, T. 30 N., R. 30 W. on the south side of Kennedy Gulch. The two poorly-exposed and unexplored veins, about a quarter mile apart, are each at least 2 feet wide.

A sample of material from the outcrop assayed 42 percent calcium oxide, 45.80 percent silica, 3.90 percent alumina oxide, 5 percent carbon dioxide, 1.20 percent ferric oxide, and 0.50 percent ferrous oxide. Magnesium oxide content was nil in the sample.

Clay

Clay and silty clay (samples nos. 1-8 in Appendix) of glacial lacustrine origin are mapped on the Fisher and Kootenai Rivers and their tributaries. Lacustrine clays also occur north of Crystal, Loon, and Thompson Lakes. The upper elevation of clay deposition along Fisher River is approximately 3,500 feet.

The silica content of the clays and silts which were assayed ranged from 50 to 65 percent. The alumina oxide content was between 9 and 22.50 percent. The sampled thicknesses of these horizons were from 1 to 18 feet.

Limestone

Limestones and dolomitic limestone beds of the Precambrian Wallace and undifferentiated Middle Cambrian formations were sampled for nonmetallic oxides and silicates. No calcareous tuffa deposits of spring-fed origin were found.

The sampled horizons of Wallace limestone are often characterized by pods and swirls of calcite which had been partially removed giving the rock a molar tooth structure. Ross and Rezak (1959, p. 414) believe some or all the molar structures may be of organic origin resulting from algal.

The calcium and magnesium oxide content of Wallace limestone (nos. 9, 11, 12, and 15 in Appendix) are variable. The former ranges from 13 to 30 percent; magnesium oxide and silicon

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*Poston, U. L., personal communication.

dioxide content is from 1 to 43 percent and 34 to 51 percent respectively. Two samples of Middle Cambrian (?) beds (nos. 13 and 14 in Appendix) were low in silica and alumina and had higher percentages of calcium and magnesium oxides than other Belt limestone samples.

The limited sampling of Precambrian and Cambrian limestones is, of course, not conclusive evidence for separating the 2 limestones in the field. However, there is a decided difference in calcium, magnesium, alumina, and silica content, which when coupled with field and fossil evidence, makes the tentative field identification more valid.

Quartzite

Impure medium-grey to light-grey quartzites in the Ravalli formation contain from 65 to 77 percent silica, and 2 to 5 percent iron oxides. White Ravalli quartzites near the top of the formation in Dunn and Wolf Creeks are characterized by white pods which give the beds a "hieroglyphic-writing" effect. These beds assay up to 84.40 percent silica and 1.70 percent ferric oxide.

A sample of medium-grained grey quartzite of the Striped Peak formation from the S½ of the Yaak River quadrangle assayed 80 percent silica and 2.70 percent combined iron oxide.

C O N C L U S I O N S

The mapped area is underlain by Precambrian (Algonkian ?) rocks of the Belt series whose minimum thickness is 32,000 feet. The lower Pre-Ravalli group, the Prichard formation, is dark-, medium-, and light-grey argillite. In the upper part of the section banded greyish-blue beds are from 1/16 inch to 1/4 inch thick. The Ravalli group is essentially quartzitic throughout; the quartzite and argillaceous quartzite beds are medium grey to light grey and white. The Wallace formation of the Piegan group is mostly argillite with some limestone and dolomite with molar tooth structure. Various shades of grey, green, and yellow argillite and shaly argillite are most common. Some beds are fine to medium banded. The Striped Peak of the Missoula group is dominantly a greyish-red and grey sericitic quartzite and shale with abundant mud cracks, ripple marks, and an occasional algal bed. The Libby formation of the Missoula group is composed mainly of green and yellow-colored argillites and sandy argillites. Occasional yellow to yellowish-brown limestones are mapped. Several algal horizons are present in the formation.

Changes in lithology and color take place in the mapped area, along the strike of the Wallace and Striped Peak formation (northwest-southeast).

The quadrangle is moderately folded into synclines and anticlines trending northwest. The major fold in the area is the Wolf

Creek anticline located in the northeast and eastern part of the mapped area.

Two main fault groups trend northwest and east-west while 2 subsidiary fault systems are northeast and north-south. Northwest faulting has been displaced by east-west faults, and both groups displace the folds. Northeast and north-south striking faults displace east-west faults. The major fault in the quadrangle, the Pine Creek-Thompson Lakes fault, closely follows the crest of an anticline. The fault is mapped for a distance of 40 miles in the quadrangle.

Ore deposits containing sparse mineralization are classified as lode and placer deposits. Lodes include gold-quartz, tungsten-quartz, silver-lead-zinc, and copper deposits. Vein widths range from a few inches to about 3 feet wide. Fissure-filled veins and sheared zones occupy former faults or shears in which post-mineral movement has fractured quartz or created gouge zones.

SUGGESTIONS FOR PROSPECTING

The Waylett vein, which is probably continuous for a distance of 3 miles, should be more adequately explored northwest and southeast of Teeters Peak. A few bulldozer cuts across the vein would determine the vein width. The presence of smaller parallel-trending veins may be disclosed by bulldozer trenching.

Copper-bearing quartz float in Swamp Creek in the NE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 15 and NW$\frac{1}{4}$ sec. 35, T. 28 N., R. 30 W., has undoubtedly originated from veins. More adequate exploration in the vicinity of these locations is warranted.

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APPENDIX.--Analyses of clays, limestones, and quartzites in Lincoln County, Montana.

Sample No.	Location	*CaO %	MgO %	CO_2 %	Al_2O_3 %	FeO %	Fe_2O_3 %	Fe %	SiO_2 %
1.	Surface, silty clay, SE¼ sec. 4, T. 26 N., R. 30 W.	0.60	1.20	1.00	22.50	---	---	4.50	56.40
2.	Surface, silty clay, SE¼ sec. 4, T. 26 N., R. 30 W.	0.50	1.40	0.80	20.50	---	---	---	59.20
3.	Surface, 12' bed, silt and clay, SE¼ sec. 34, T. 28 N., R. 29 W.	3.10	Nil	1.80	9.60	---	---	4.30	61.60
4.	Surface, 18' bed, silty clay, sec. 20, T. 29 N., R. 28 W.	2.00	1.60	2.60	18.20	0.90	2.70	---	63.00
5.	Surface, 14' bed, sandy clay, NW¼ sec. 26, T. 28 N., R. 29 W.	3.20	1.30	2.40	14.50	---	---	---	65.80
6.	Surface, 5' bed, clayey silt, sec. 4, T. 29 N., R. 27 W.	3.30	Nil	2.00	18.50	1.10	2.90	---	64.70
7.	Surface, 8' bed, clayey silts, sec. 33, T. 30 N., R. 27 W.	3.70	1.90	1.00	19.00	1.10	3.30	---	59.80
8.	Surface, clay and silt, SE¼ sec. 33, T. 30 N., R. 29 W.	2.80	0.30	1.20	8.70	---	3.30	---	77.00
9.	Surface, 20' bed of calcareous, sandy argillite, NW¼ sec. 4, T. 27 N., R. 29 W.	2.50	0.40	1.00	18.20	---	---	2.80	67.20
10.	Surface, 40' limestone bed, sec. 9, T. 36 N., R. 29 W.	30.60	21.60	43.50	0.60	---	---	0.80	1.70
11.	Surface, 25' limestone bed, sec. 17, T. 27 N., R. 27 W.	13.60	3.50	11.00	12.40	1.40	3.60	---	51.00
12.	Surface, grab sample of limestone, sec. 28, T. 29 N., R. 29 W.	27.00	1.60	19.00	9.80	1.20	1.50	---	34.00

APPENDIX.--Analyses of clays, limestones, and quartzites in Lincoln County (Cont'd).

Sample No.	Location	*CaO %	MgO %	CO_2 %	Al_2O_3 %	FeO %	Fe_2O_3 %	Fe %	SiO_2 %
13.	Surface, magnesian limestone, NE¼ sec. 15, T. 28 N., R. 30 W.	32.00	4.50	0.40	Nil	---	---	21.50	0.20
14.	Surface, calcareous limestone, SE¼ sec. 4, T. 28 N., R. 30 W.	39.00	8.10	41.20	4.20	---	---	0.70	4.20
15.	Surface, Wallace limestone, sec. 20, T. 31 N., R. 29 W.	18.10	1.20	16.80	13.20	---	---	2.50	39.00
16.	Surface, 15' quartzite bed, sec. 21. T. 30 N., R. 28 W.	0.30	Nil	---	9.20	0.80	2.00	---	82.60
17.	Surface, 20' quartzite bed, sec. 28, T. 29 N., R. 28 W.	1.00	Nil	--	13.10	1.20	3.00	---	73.20
18.	Surface, 3½' bed of clean sand, sec. 18, T. 29 N., R. 27 W.	2.30	1.30	---	15.90	1.90	3.20	---	65.00
19.	Surface, quartzite bed, sec. 18, T. 30 N., R. 28 W.	0.80	0.20	---	11.50	0.60	2.40	---	76.50
20.	Surface, quartzite bed, sec. 3, T. 30 N., R. 29 W.	0.50	Nil	0.20	7.50	---	1.70	---	84.40
21.	Surface, quartzite bed, sec. 36, T. 32 N., R. 33 W.	1.10	1.20	---	7.20	1.00	1.70	---	80.00

* CaO = Calcium Oxide
MgO = Magnesia
CO_2 = Carbon Dioxide
Al_2O_3 = Alumina
FeO = Ferrous Iron Oxide
Fe_2O_3 = Ferric Iron Oxide
Fe = Iron
SiO_2 = Silica