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PROGRESS REPORT ON

GEOLOGIC INVESTIGATIONS IN THE KOOTENAI-FLATHEAD AREA

NORTHWEST MONTANA

4. SOUTHWESTERN FLATHEAD COUNTY

By

Willis M. Johns

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

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ABSTRACT

The 30-minute Pleasant Valley quadrangle occupies 816 square miles in the east Salish Range, and, in part, borders the Rocky Mountain Trench in the Stillwater and Flathead Valleys north of Kalispell, Montana.

The quadrangle is underlain by conformable Belt Series strata of Precambrian age, which outcrop over extensive areas in northwest Montana, north Idaho, and southeast British Columbia. The Belt rocks present in the map area are the basal and middle members of the Series, which in ascending order are Prichard Formation, Ravalli Group, and Piegan Group. Missoula Group beds, not present in the quadrangle, have been removed by erosion. A +350-foot calcareous argillite and limestone marker bed in upper Ravalli quartzite was mapped approximately 2,000 feet below the Ravalli-Piegan Group contact. The marker bed is exposed intermittently for over a distance of 15 miles.

Moderate symmetrical folding and tight asymmetrical folds transverse the quadrangle in a northwesterly direction. The largest structure mapped is a tightly-folded asymmetrical anticline, overturned northeastward, that passes through Little Bitterroot Lake and west of Sylvia Lake, crossing the map area from the southeast border to the northwest border.

Two large northwestward-striking and westward-dipping high-angle reverse faults parallel fold axes and are displaced by later eastward-striking vertical faults. These two northwest faults may have displacements amounting to as much as several thousand feet; whereas eastward-striking faults have shorter strike lengths and much smaller displacements.

Eastward and northeastward-striking veins, containing chalcopyrite and small amounts of other base metals in a gangue of quartz, calcite, and siderite, are present in the Star Meadows district of the Pleasant Valley northeast quadrangle west of Tally Lake. Production of copper from several of the properties in the district has been intermittent and small.

INTRODUCTION

During the past three years, the Montana Bureau of Mines and Geology published Bulletins 12, 17, and 23 on (1) Western Lincoln County, (2) Southeastern Lincoln County, and (3) Northern Lincoln County. These covered mapping progress on the Kootenai-Flathead project. This report is a summary of the results of field work in the Pleasant Valley quadrangle of Flathead County, and describes the geology and mineral deposits of the area. Some mines and prospects of the Star Meadows district were described previously in Bulletin 23.

The Kootenai-Flathead mineral survey is a program jointly sponsored by the Pacific Power & Light Company and the Great Northern Railway Company, under the direction of the Montana Bureau of Mines and Geology, with the dual purpose of assisting in the location and development of mineral resources, and encouraging prospecting activity in the area through a minerals-identification service at the Kalispell office.

Preliminary field mapping in the northern part of the Thompson Falls quadrangle was done in conjunction with field work in the Pleasant Valley quadrangle. In addition, mapping and revision were continued in the Yaak River southeast quadrangle. Results of this work will be included in the next published progress report, and a final report will be issued summarizing all project data upon completion of the program.

The Stryker northeast and northwest quadrangles have been mapped by Princeton University graduate students, William Barnes and Alan Smith, and the geologic maps of their areas will be published in the 1963 Kootenai-Flathead progress report.

SCOPE OF REPORT

Data for this report were assembled by a Bureau field party of 4 in a 4-month period, during which the group mapped an area of approximately 816 square miles or 22½ townships. (See pls. 1 to 4 in pocket.) Also included in this report are descriptions of mines and prospects in the Lincoln County portion of the Thompson Falls quadrangle and 4 properties in Sanders County. The geology of the mapped area was plotted on U.S. Forest Service planimetric maps with additional control obtained from Soil Conservation Service aerial photographs.

ACKNOWLEDGMENTS

The author is indebted to Mr. W.S. March, Jr., Associate Director, and Mr. U.M. Sahinen, Chief Geologist, Montana Bureau of Mines and Geology, for supervising project planning and editing the manuscript. Mr. G.A. Duell, Staff Geologist, Pacific Power & Light Company, and Mr. R.A. Watson, Geologist, Mineral Research and Development Department, Great Northern Railway Company, contributed to project planning and provided advice concerning the program.

The Pleasant Valley northwest and southwest quadrangles were mapped by Frank W. Hall and Felix V. Latuszynski of Montana State University. The lithology, structure, and economic geology of these quadrangles were taken from their monthly progress reports, submitted during field mapping. Their geologic mapping was checked by Drs. A.J. Silverman and R.M. Weidman of Montana State University.

The writer was ably assisted in the field by Arthur L. Boettcher, now a graduate student at Pennsylvania State College. Ore and mineralized rock samples were assayed by C.J. Bartzen, Bureau Analyst, and rock specimens were analyzed by the Anaconda Company laboratory. All drafting was done by R.B. Holmes, Bureau draftsman.

The writer is indebted to many residents of the Flathead-Lincoln County area for their information and services. Some of these include Glen Bauska, Harold and Carl Luke, Uriah and Herb Poston, Frank Bauer, Ben Trosper, Jim Whilt, Barry Adkins, Marion Fishel, Guy Maycumber, Al Harvey, Herbert and Robert Bear, O.G. Tiegan, Barton Pettit, and Thain White. From their knowledge of the area, Fred, Frank, and Louis Sproul of Star Meadows, provided locations and data on several mining properties. Albert Thayer of Vermilion River supplied information on properties in northern Sanders County.

PREVIOUS WORK

Previous work in the Pleasant Valley quadrangle is limited to reconnaissance mapping of the Belt Series in Flathead and Lincoln Counties by G.S. Lambert and associates, and a study of glacial geology by W.C. Alden (1953). During the period 1921-1924, a group including G.S. Lambert, A. Bevin, and C.H. Clapp mapped 25,000 square miles in western Montana to be later used as a base for the State Geologic Map of Montana, compiled by C.P. Ross in 1955. Alden's study of glacial geology in the Kalispell area is mainly confined to Flathead Valley and adjacent valleys east and west of Kalispell.

G E O G R A P H Y

LOCATION AND ACCESSIBILITY

The Pleasant Valley quadrangle occupies the central part of the Salish Range within lat 48°-48°30' and long 114°-114°30' (fig. 1). The eastern border of the map area abuts the west side of the Flathead Valley. The valley of the Flathead River and those valleys occupied by the Stillwater and Tobacco Rivers form part of a linear topographic feature that Daly (1912) named the Rocky Mountain Trench.

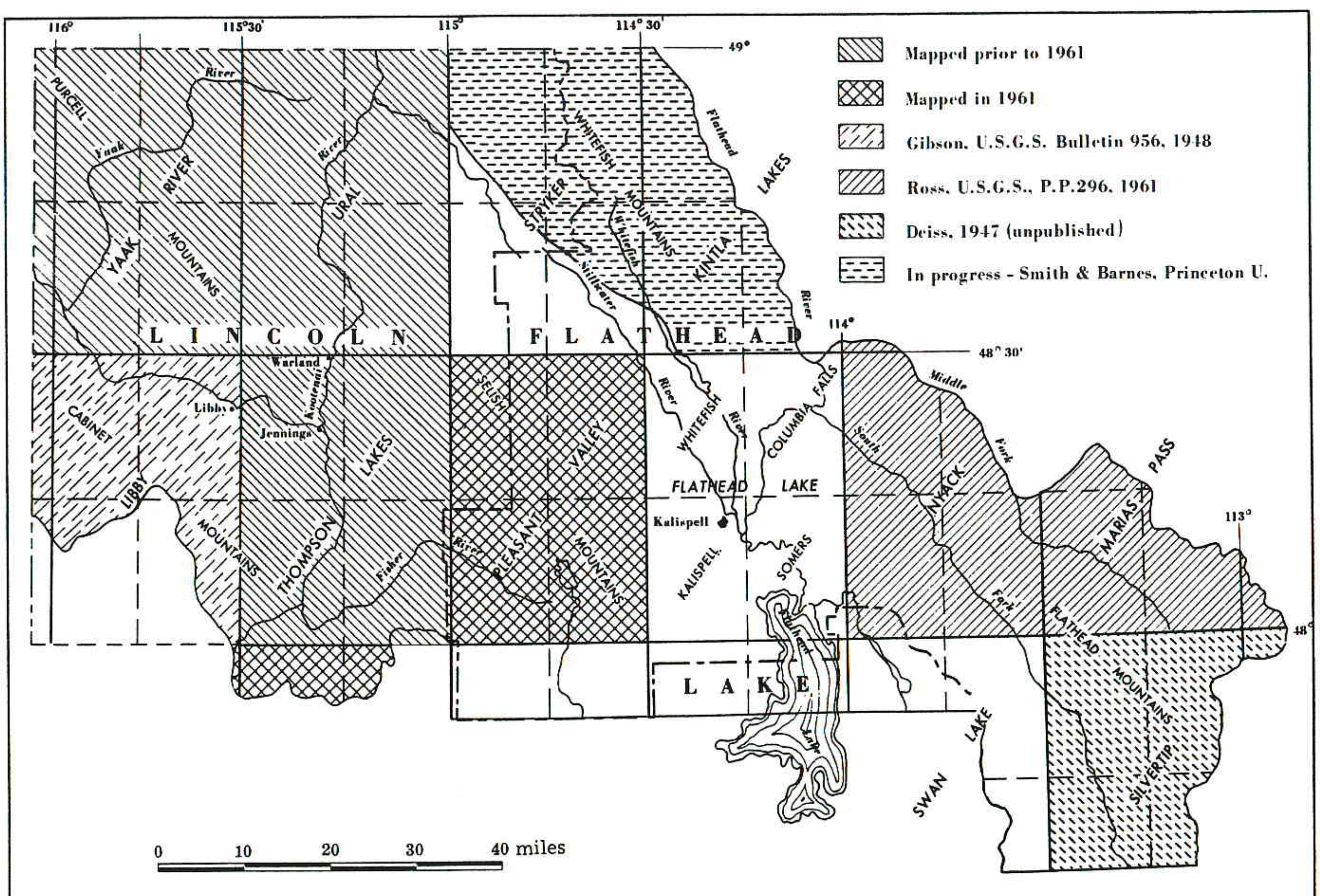

Figure 1.--Index map of northwest Montana showing location of quadrangles being mapped.

The west boundary of the map area borders part of Pleasant Valley and the north boundary approximates the position of Good Creek. No topographic features, which can be easily recognized, approximate the position of the southern map border since drainages and valleys and adjoining ridges trend southward and about perpendicular to the southern east-west boundary line.

The quadrangle is, in part, accessible from U.S. Highway 2 traversing the south half of the area, and the northern part of the map area is accessible by county and forest service roads from U.S. Highway 93. Highway 93 follows Flathead Valley northward to Whitefish Lake and beyond to the Canadian border. County roads to the north from U.S. Highway 2 at McGregor Lake and Marion via Haskill Pass are main access routes to Lost Prairie and Pleasant Valley. The Marion road between Libby and Kalispell follows the grade of the abandoned Great Northern Railway, which was in operation prior to 1904. Other county roads by way of Hubbart Reservoir and Thompson River from U.S. Highway 2 provide access to the southwest part of the Pleasant Valley quadrangle. County roads to Rogers Lake and Mount Creek from Highway 2 and other county roads are open to passenger car travel.

Forest service roads up Sheppard and Good Creeks in the Tally Lake area merge to cross a divide to join the Marion-Wolf Creek-Trego road. Forest service logging spurs, sometimes only passable to pickups and 4-wheel drive equipment, follow subsidiary drainages to all but a few areas within the quadrangle. The headwaters of Griffin and Logan Creeks are reached by Forest Service Trails 150 and 208, and 156, respectively.

TOPOGRAPHY AND DRAINAGE

Topography within the quadrangle is locally either precipitous or subdued with elevations of peaks ranging from 5,500 to 6,600 feet in the east half of the area; whereas somewhat lower topography is encountered in the west half. The highest peaks in the quadrangle are Meadow Peak and Elk Mountain, which attain elevations of 6,647 and 6,581 feet, respectively. Elevations of valleys range from about 3,400 to over 4,000 feet. These valleys, the most important being Stillwater Valley, Pleasant Valley, and Lost Prairie, are relatively broad and enclosed by mountains.

A major feature in the area is a northward-trending divide extending from west of Little Bitterroot Lake to the north boundary of the map area and beyond to cross U.S. Highway 93 at Stryker. This divide continues through the Whitefish Range to and beyond the international border. The highest elevations of peaks and ridges, with the exception of Meadow Peak in the southwest corner of the quadrangle, are attained along this divide within the map area.

East of the divide described in the previous paragraph, drainages such as Good, Sheppard, and Ashley Creeks flow eastward to the Stillwater and Flathead Rivers. Drainages west of the divide including Wolf, Little Wolf, and Coniff Creeks, and Pleasant Valley River flow westward and southwestward into the Kootenai by way of Fisher River. Little Bitterroot River, draining the south-central part of the quadrangle, flows southward to enter the Flathead River in eastern Sanders County.

The eastward and westward-flowing drainages are consequent streams, which flow nearly perpendicular to the strike of Belt strata. Their development is dependent on the slope of the terrain. Southward-flowing streams in the south-central part of the quadrangle are subsequent drainages whose courses were established in softer sedimentary rocks and may have been further entrenched by action of continental ice.

CLIMATE AND VEGETATION

Temperature and precipitation records from the Kalispell County Airport for Flathead Valley and adjacent areas were described previously in Montana Bureau of Mines and Geology Bulletin 23. A summary of this description gives the annual precipitation as being 16.38 inches over a 29-year period, annual mean temperature for a 30-year period as 43.2°F, and seasonal snowfall as 68.3 inches for an 11-year period.

Both evergreen and deciduous trees are found throughout the map area. The trees are largely confined to mountain slopes, whereas native grasses including timothy, white clover, quack grass, and fescue provide grazing for a thriving cattle industry in the valleys. Sedges and rushes are confined to lakes and marsh areas.

GLACIATION

Throughout parts of the quadrangle evidence of glacial action is present in the form of striae and fluting of rock outcrops, drift and till, erratics, small cirques, and U-shaped and dissected hanging valleys, indicating the land surface was overlain by an ice sheet and possibly some valleys were later occupied by alpine glaciers. That the ice sheet attained a thickness of at least 2,500 feet is evident from southeastward-trending glacial striae recorded on the higher peaks and ridges between Elk and Sanders Mountains at elevations between 6,000 and 6,500 feet, and on the summit of Johnson Peak at 6,100 feet. Several lakes in the quadrangle are impounded by glacial deposits at their southern terminus.

Glacial striations and fluting and polishing are often found in the more resistant Ravalli quartzite throughout the west half of the map area. Only a few scattered striae were recorded in softer Piegan Group beds. Striation trends (fig. 2) range from S. 20°-30° E. swinging to about S. 50° E. in that area west of Little Bitterroot Lake in the Pleasant Valley-Lost Prairie sector. The upper Pleasant Valley-Fisher River parallels this latter striation trend.

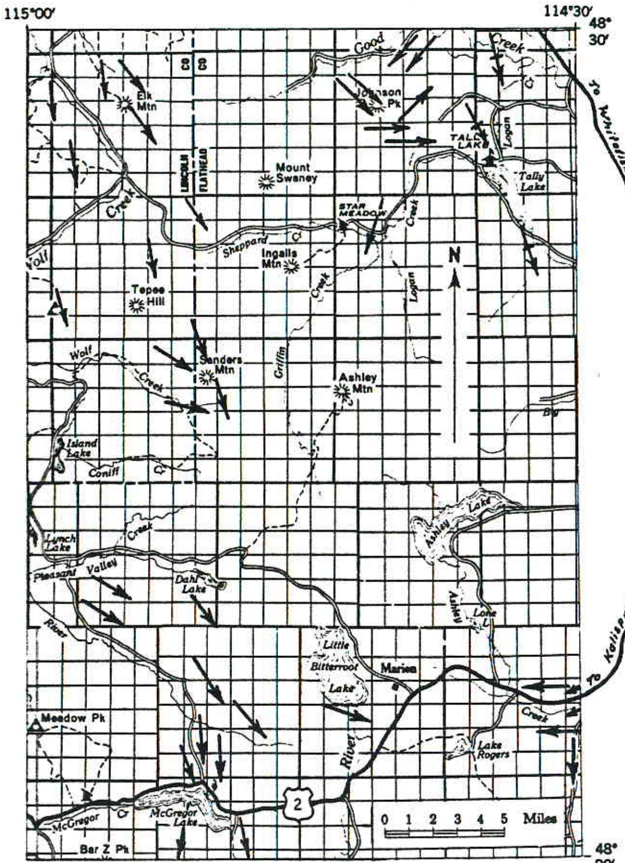

Figure 2.--Map showing direction of movement of Cordilleran ice sheet, Pleasant Valley 30-minute quadrangle.

Striae striking S. 50°-60° E. were recorded on Johnson Peak, and a short distance southeast of this location, glacial scratches trend east. This easterly striation direction is about parallel to Sanko Creek and nearly perpendicular to present hill slopes in the region.

It is believed glacial ice from Flathead Valley extended up Good Creek at the north border of the quadrangle, up Evers Creek which is a tributary of the Stillwater River, and up Ashley Creek for some distance along U.S. Highway 2 east of Marion. Striae trending S. 45° W. were noted on both flanks of Good Creek, and deep semicircular grooves, beveled outcrops, and shallower scratches trending S. 60° W. were recorded along the Great Northern Railroad grade in the S$\frac{1}{2}$ sec. 13, T. 27 N., R. 22 W. Alden (1953) observed southward-trending striations in the valley of Mount Creek south of U.S. Highway 2, which he believed resulted from a small southward-diverging branch of the glacier extending up Ashley Creek Valley.

In low-lying topography north and northeast of Tally Lake near the northeast map border, glacial lineations in the foothills west of Stillwater Valley (observed on aerial photographs) trend S. 22° E. These lineations are truncated by others trending S. 15° E. The low hills are covered by glacial material and the lineation trends may indicate 2 southeasterly advances of ice down Stillwater and Flathead Valleys.

Glacial moraines, one of which is responsible for the damming of Lake Rogers, are present south of Little Bitterroot Lake (Alden 1953, p. 118). Tally Lake, Sylvia Lake, and other small lakes and ponds throughout the quadrangle are also dammed by terminal moraines. Outwash deposits are present below Little Bitterroot and Sylvia Lakes. Hummocky surfaces and pothole topography were observed in Little Bitterroot Valley 2 miles south of Little Bitterroot Lake.

At the south end of Tally Lake a low moraine dams the lake, changing the earlier southeast-flowing outlet to north-flowing. In the SW$\frac{1}{4}$ sec. 9, a quarter of a mile south of Talley Lake, an elongated drumlin-like deposit trends S. 30° E. The small valley below the terminal moraine is occupied by glacial fill and the low moraine may have been deposited by the southeasterly advance of a valley glacier, whereas the drumlin-like deposit possibly indicates a previous advance of ice in a southeasterly direction past Tally Lake toward Flathead Valley. The central and southeast shores of Tally Lake are bounded by near-vertical cliffs both above and below shoreline; a measured depth of 200 feet was determined at a point 650 feet from shore at the south end of the lake. Near the center of the lake on an east line separating the NE$\frac{1}{4}$ and SE$\frac{1}{4}$ sec. 5, a depth of 343 feet was measured without reaching bottom. The excavating of such a depression may have been accomplished by the ice sheet which covered higher elevations to the west, and the excavated material was removed and deposited to the southeast in Flathead Valley. A postglacial landslide extends for some undetermined distance into the lake from the adjoining east slope in the center of the W$\frac{1}{2}$ sec. 4, T. 30 N., R. 23 W.

Hall reports that Sylvia Lake is blocked by a moraine in the valley which extends for half a mile in a southerly direction. Glacial material is present below this terminal moraine as outwash deposits where the valley becomes less constricted. Hall believes a valley glacier was responsible for the deposit athwart the valley.

In the north-central part of sec. 30, T. 31 N., R. 23 W., a sinuous eskerlike moraine blocked a small lake which is now drained. Other ponds on Listle Creek of the Pleasant Valley northwest quadrangle are reported by Hall to be dammed by moraines. Latuszynski states small lakes related to cirques and dammed by moraines are present in sec. 35, T. 27 N., R. 26 W. and secs. 9 and 10, T. 28 N., R. 26 W. He believes they are of the mountain type and are probably related to the receding stages of the ice sheet. In the Pleasant Valley northwest quadrangle a cirque was noted at the head of Listle Creek and several smaller cirques surround Dunsire Point giving it a horn appearance. Typical U-shaped valleys scoured by ice are found in the upper part of Wolf Creek trending S. 30° E., the valley occupied by Sylvia Lake trending S. 40° E., and Dunsire Creek trending S. 20°-30° E.

From recorded striations it seems probable that the Cordilleran ice sheet advanced in a southerly direction from the international boundary to the northwest corner of the Pleasant Valley quadrangle, where one lobe continued southeastward across the quadrangle with axial flow controlled by the valleys in the Purcell Trench, while another lobe advanced southwestward with axial flow controlled by the valley of the Kootenai River. The long axes of Little Bitterroot, Tally, and Sylvia Lakes, and the southwest lobe of Ashley Lake have parallel trends in the direction of ice flow.

The most southerly advance of ice recorded in the quadrangle was a short distance south of McGregor Lake where striae trend N. 10° W. and N. 10° E. in secs. 3 and 7, T. 26 N., R. 25 W., respectively. Glacial erratics of Purcell Basalt were observed atop peaks and ridges in parts of the Pleasant Valley southeast quadrangle. It seems likely that most of the map area was covered by the Cordilleran ice sheet during its maximum stage of development, and this sheet attained a minimum thickness of 2,500 feet in lower valleys within the quadrangle. Since the divide occupied by Tepee Hill and Elk and Sanders Mountains is between 6,000 to 6,500 feet high, the ice may have attained a thickness of 3,000 feet in Flathead Valley near Kalispell which is at an elevation of about 2,955 feet.

Moraine-like drift deposits, kettle holes, and hummocky drift were noted south of Little Bitterroot Lake, and hummocky drift was noted in Evers Creek in secs. 14 and 23, T. 31 N., R. 24 W. Alden (1953, p. 118), in addition to describing the terminal moraine which dams Lake Rogers, mentions drift fills below Ashley Lake and a low moraine-like crest north of Monroe Lake (south of Ashley Lake) at about 3,650 feet above sea level.

Valley glaciers advancing down tributary valleys during receding stages of the ice sheet may be responsible for deposition of terminal moraine across valleys impounding Sylvia and Tally Lakes; however, glacial deposits south of Little Bitterroot, Ashley, and Lake Rogers are believed to have been deposited by advanced lobes of the Cordilleran ice sheet during the early Wisconsin stage of glaciation. The ice lobe from Flathead Valley may have only advanced westward to or a little beyond where Ashley Creek swings northward from U.S. Highway 2.

R O C K   T Y P E S

Rocks of the Beltian System of Precambrian age, named the Belt Series for exposures in the Little and Big Belt Mountains east of Helena, Montana, were first described by Hayden (1869) and Peale (1873) as Paleozoic strata. The first subdivision was attempted by Dawson (1875, 1885). Peale (1893) was the first to correctly assign these rocks to the Precambrian based on his study in the vicinity of Three Forks, Montana. Walcott (1899) made the first satisfactory subdivision of the Belt Series in the vicinity of Helena. Since these early workers much data has been assembled on the Belt Series, the most recent by Ross (1959, 1960), Campbell (1960), and Nelson and Dobell (1961).

The Belt System is a group of thick clastic and carbonate strata conformably deposited in shallow seas and later subjected to regional metamorphism. Rocks in the Series range from quartzites to argillites and impure limestones containing no fossils except a primitive form of life called algae and rare worm trails.

Algae secreted calcium carbonate by which cabbage-like masses and other forms called stromatolites came into existence. Rezak (1957) in his study of stromatolites in the Belt Series in Glacier Park described eight stromatolite zones occurring in the Ravalli, Piegan, and Missoula Groups.

THE BELT SERIES (PRECAMBRIAN)

Ross (1949) discussed the Belt "problem" and later proposed a plan to facilitate regional correlation by subdividing Belt strata into formations and groups which could be recognized in broad aspect from area to area. In northwest Montana these units in ascending order are: Prichard Formation, and Ravalli, Piegan, and Missoula Groups.

In the Pleasant Valley quadrangle the Prichard, Ravalli, and Piegan sedimentary rocks are present, the Missoula Group having been removed by erosion. Throughout eastern Lincoln and western Flathead Counties the Prichard is dominantly an argillite, the Ravalli a quartzite and argillite, and the Piegan Group an impure limestone and argillite.

Prichard strata rarely show ripple marks and mud cracks, the Ravalli quartzites occasionally show cross laminations and frequent numbers of ripple marks and mud cracks pointing to deposition in shallow water. Both mud cracks and ripple marks are locally abundant in the more argillaceous members of the Piegan Group, the mud cracks indicating subaerial exposure possibly as flood-plain type deposits existing for periods of time above sea level. Cross laminations, ripple marks, and mud cracks are locally abundant in basal Missoula sediments, and rain drop imprints and occasional salt crystal casts have been identified in this upper Belt Group in the Ural northeast quadrangle.

Pre-Ravalli Rocks

Prichard Formation.--Sedimentary rocks older than the Ravalli Group are mapped as the Prichard Formation of which only the uppermost strata are present in the Pleasant Valley quadrangle. In western Lincoln County the greatest thickness of this unit is exposed, and as mapping was continued eastward into Flathead County the formation disappeared beneath the Ravalli except where thrust movements along northwest faults bring these strata to the surface. The Prichard in the map area is exposed along the west-central border of the 30-minute quadrangle with the exception of limited exposures along two thrust faults. Latuszynski reports only the upper 2,500 feet of the formation is present in the Pleasant Valley southwest quadrangle (fig. 3).

The Prichard exposed is a homogeneous sequence of alternately banded medium dark-gray, medium-gray, and light-gray thin- and medium-bedded argillite, and some argillaceous quartzite, all containing fine- to coarse-grained disseminated biotite, sericite, and pyrite. The beds weather to a distinct red-brown color that aids in identifying the formation. Bluish hues in biotite-bearing argillites are common in upper horizons. The occurrence of mud cracks in outcrops in the Prichard Formation are rare and ripple marks absent.

	Libby quadrangle Gibson	South Yaak River quadrangle Johns	Thompson Lakes quadrangle Johns	Ural and North Yaak River quadrangles Johns	Pleasant Valley quadrangle (this report)	British Columbia Leech
Missoula Group	Top eroded Libby 6,000+	Top eroded Libby 9,000	Top eroded Libby 7,600	Top eroded Gateway mapped above Purcell lava west of Kootenai River and Sheppard and Kintla east of Kootenai River above lava 1,700		Roosville 1,740 Phillips 400
	Striped Peak 2,000+	Striped Peak 2,000	Striped Peak 3,500	Purcell Basalt 550		Gateway 2,000(?)
Piegan Group	Wallace 12,000	Wallace 14,500	Piegan Group (Wallace) 13,000	Piegan Group 8,000+	Top eroded Piegan Group 8,200+	Purcell andesitic lava mapped at top of Siyeh Siyeh and Kitchner 4,700 to 7,000
Ravalli Group	Ravalli 10,000	Ravalli Group 12,000	Ravalli Group 11,000	Ravalli Group 7,000	Ravalli Group 10,000	Creston 6,000
Pre-Ravalli rocks	Prichard 9,700+	Prichard 9,000	Prichard 6,000	Prichard 12,000+	Prichard 2,500	Aldridge 8,000+
						Fort Steel 6,000

Figure 3.--Correlation of Belt Series in Pleasant Valley quadrangle with nearby areas.

Toward the Prichard-Ravalli gradational contact zone that is between 200 to 500 feet wide, the gray argillites acquire a brownish hue and become more quartzitic and the lithologic changes are accompanied by a small increase in the thickness of bedding. A 50-foot calcareous medium and light-gray argillite and impure limestone member was observed continually along the Prichard-Ravalli contact zone in the Pleasant Valley southwest quadrangle, whereas only local thin carbonate-bearing horizons were noted in uppermost Prichard beds in the Pleasant Valley northwest quadrangle. Within the contact zone medium and medium light-gray, moderate-to thick-bedded argillites with some darker gray argillite bands are interbedded with medium-and light-gray quartzites. Considerable amounts of biotite are present. The biotite content decreases and becomes more finely disseminated below the contact within the Prichard.

In the Pleasant Valley southeast quadrangle south of Haskill Pass and along the west flank of an overturned anticline (Little Bitterroot anticline), whose axial trace passes through Little Bitterroot Lake, interbedded gray argillites and medium-and light-gray quartzites contain biotite and resemble strata of both upper Prichard and lower Ravalli horizons. It is believed that in the Haskill Pass vicinity and bordering the west shore of Little Bitterroot Lake, the Prichard-Ravalli contact zone has been exposed by erosion. Since no Prichard outcrops of appreciable size and extent were noted, the sedimentary rock was mapped as basal Ravalli.

Ravalli Group

The Ravalli quartzites, argillaceous quartzites, and argillites outcrop throughout the north-central, south-central, and middle parts of the 30-minute Pleasant Valley quadrangle. Where these resistant strata outcrop they are reflected by the presence of rugged cliffs and ridges to form the highest topographic expression in the quadrangle.

Latuszynski reports a thickness of 10,000 feet for the group in the Pleasant Valley southwest quadrangle, whereas Hall, from cross sections, measured a minimum thickness of 7,000 feet for the group from the Piegan-Ravalli contact to the westernmost northwestward-striking thrust fault. This section, measured at Elk Mountain, is the greatest exposed thickness for the Ravalli Group in the Pleasant Valley northwest quadrangle. In the Pleasant Valley southeast quadrangle, from 9,000 to 11,500 feet of Ravalli strata outcrop between Little Bitterroot Lake and Piegan-Ravalli contact.

The Ravalli is a thin-and medium-bedded biotite, sericite, and magnetite-bearing medium- to light-gray, white, and purple-hued quartzite, argillaceous quartzite, and argillite whose outcrops contribute to large talus slopes, and form cliffs and resistant ridges. A calcareous argillite and impure limestone member, about 250 to 500 feet thick, lies below the Piegan-Ravalli contact zone. It was not mapped south of U.S. Highway 2 in the Pleasant Valley southeast quadrangle. South of the highway a lithologic change from quartzitic to more argillaceous strata was observed.

The lower Ravalli is a thin- and medium-bedded sequence of interbedded medium- to light-gray quartzites, argillaceous quartzites, and argillites containing considerable biotite and generally sparse magnetite in octahedrons. In some places the biotite tends to be aligned in parallel layers giving the rock a banded appearance. Biotite in basal Ravalli or in other strata in the group was not observed in the Thompson Falls and Yaak River quadrangles west of the map area. Some pyrite and sericite were reported from the Pleasant Valley southwest quadrangle. Mud cracks in the more argillaceous beds of this basal member are common.

The middle part of the Ravalli is characteristically a very light-gray quartzitic rock with faint banding. The quartzite horizons are medium- to thick-bedded or massive and occasionally exhibit cross-bedding. Subsidiary amounts of interbedded medium- to light-gray thin- and medium-bedded argillites, and argillaceous quartzites and quartzitic argillites with abundant mud cracks occur. Octahedral magnetite weathering to orange-colored iron oxides filling voids is common in this member. Biotite in conspicuous amounts is rarely found within and above this middle member of the Ravalli.

The upper Ravalli consists of thick-bedded massive quartzites that are characteristically purple-banded, exhibit cross-bedding, and contain abundant mud cracks. Ripple marks are found with some thin-bedded medium-gray argillite, commonly banded a grayish-purple. Mud chips are present in the argillite. Some greenish-gray argillites with abundant mud cracks interbedded with purplish quartzites and thin bands of white quartzite occur in uppermost Ravalli. At about 2,000 feet below the Piegan-Ravalli contact a horizon from 250 to 500 feet thick consists of medium-gray calcareous argillite and subordinate medium-gray limestone. It extends in a northwesterly direction from near the ridge between Little Bitterroot Lake and Ashley Lake to north of Sylvia Lake in the Pleasant Valley northwest quadrangle.

The Ravalli-Piegan contact is gradational for several hundred feet and consists of interbedded purplish-gray and gray quartzites, and medium-gray and greenish-gray argillites grading into medium-gray calcareous argillites and dark-gray and medium-gray thin-bedded limestone. Some dark and medium-gray noncalcareous argillite is present in this zone.

Mud cracks and mud chips are abundant in upper beds. The Ravalli weathers from dark-gray to light-gray, a color which is not distinctive of fresh surfaces. Some slight red-brown weathering occurs in basal beds, the tints resulting from weathering of the biotite, magnetite, and sparse pyrite.

Piegan Group

The Piegan Group is exposed in the southeast corner, east-central, and northeast part of the 30-minute Pleasant Valley quadrangle from Haskill Mountain through the Ashley Lake vicinity to the upper tributaries of Good Creek at the north boundary of the map area. Piegan strata, except for limited exposures in the southwest corner of the quadrangle, occupy generally the eastern part of the map area.

Lower Piegan argillites, calcareous argillites, and subordinate limestone are 2,500 feet thick in the Pleasant Valley northwest quadrangle, an incomplete section is 2,000 feet thick in the southwest quadrangle, and about 3,200 feet thick in the southeast quadrangle. Hall estimates only 2,000 feet of middle Piegan strata are present in the northwest quadrangle, while a minimum of 5,000 feet of an incomplete section of middle molar-tooth limestone was measured from the west shore of Ashley Lake to Boorman Peak. Upper Piegan gray-green banded argillites have been removed by erosion in the Pleasant Valley quadrangle. A total exposed thickness for the lower and middle members of the group in the quadrangle amounts to +8,200 feet. The group is believed to thicken from the northwest quadrangle to the southeast quadrangle, and a lithologic change in upper Good Creek from gray and purple-gray limestones with subordinate molar-tooth limestone to dark-gray and light-gray molar-tooth limestones in the Ashley Lake vicinity takes place.

The lower member of the Piegan Group in the northwest quadrangle consists of banded gray-green argillite and calcareous argillite, whereas thin-bedded gray-weathering medium-gray calcareous and noncalcareous argillite and pale green-gray calcareous and noncalcareous argillite with abundant and well-developed mud cracks are present in the southeast and southwest quadrangles.

The basal member grades into the middle unit, but the middle Piegan is dominantly a medium dark- to light-gray limestone and molar-tooth limestone containing grains and pyrite cubes. On surface exposures psuedomorphs of limonite (after pyrite) are common. Locally, minor amounts of medium-gray and gray-green banded argillite and calcareous argillite are interbedded with the limestone.

In the Pleasant Valley northwest quadrangle, Hall reports that middle Piegan limestone exposed in this area has decided purplish tones, and that greenish-gray and gray-yellow-green argillite and calcareous argillite are associated with the purple-hued molar-tooth limestone horizons.

Toward the top of the middle Piegan thin bands of white siliceous limestone and calcareous quartzite are associated with other beds containing elongated pebbles of argillite and quartzite in a limestone matrix. Several discontinuous stromatolite zones up to a few feet thick are located toward the top of the member near the northeast border of the map area. Gray, orange-brown, and yellow-brown weathering is most common in the lower and middle Piegan units. Often well-developed cleavage is found in the basal member of the group.

Molar-tooth limestones have been mapped as the Middle Siyeh Formation in the Stryker quadrangle east of Eureka by Alan Smith and William Barnes of Princeton University.

QUATERNARY SEDIMENTS

Glacial Deposits

Glacial drift deposits present in the quadrangle include till, moraine, lacustrine stratified silts and clays, and fluvial or glacio-fluvial deposits of gravel and other fine material.

Deposits attributed directly or indirectly to glacial ice are largely heterogeneous mixtures of boulders, sands, clay, and rock flour, which are overlain by laminated silts and clays of a lacustrine origin. Lacustrine deposits are believed confined to the larger valleys at or below 4,000 feet in elevation where ponding occurred through ice blockage--it is conceivable that water from the Flathead Valley area inundated these adjacent valleys when glacial Flathead Lake was at its maximum elevation.

Recent Alluvium

Recent alluvium borders the Stillwater River and Ashley Creek, and some alluvium was mapped east of Little Bitterroot River south of U.S. Highway 2. Some crop lands mapped as Quaternary alluvium at one time may have consisted of laminated glacial silts. Wind deposition of soil, river and stream flooding, and grass growing in these areas helped to build up the humus content of the soil to a productive dark-colored loam mapped as alluvium.

IGNEOUS ROCKS

Metadiorite Dikes

Three metadiorite dikes were mapped about a quarter of a mile apart in sec. 14, T. 28 N., R. 25 W. on the North Fork of Herrig Creek. These dikes are north of the Blue Grouse prospect. (See "Description of Mining Properties, Pleasant Valley quadrangle.")

The igneous-sedimentary contacts were covered at the three locations; however, the dikes crosscut bedding at right angles and appear to be about 20 to 30 feet wide. Outcrops can be traced for 150 to 200 feet along strike. The dikes at this location are medium-grained dark-colored rocks that have been slightly altered by surface weathering. In hand specimen the rock contains hornblende, plagioclase, magnetite, biotite, and sericite. Dark-green hornblende is the dominant rock constituent in a fine-grained matrix containing gray-colored feldspar.

These dikes are later than the folding and may postdate eastward-striking faults in the area. A covered metadiorite intrusive was indicated by the presence of float and mantle rock(?) a short distance north of the Yukon property in sec. 1, T. 30 N., R. 25 W.

Other Igneous Rocks

On a ridge top in the north-central part of sec. 19, T. 31 N., R. 24 W., some igneous mantle rock megascopically identified as hydrothermally(?) altered quartz diorite was found at the base of an uprooted tree. The specimens were believed derived from underlying bedrock in the immediate area.

The rock constituents are plagioclase(?), feldspar, quartz, a dark-green to black ferromagnesian mineral (hornblende?), and moderate amounts of sericite and sparse iron oxides. Monzonite-looking,strongly weathered, and iron-stained mantle rock containing medium-grained plagioclase feldspar, ferromagnesian minerals, and considerable accessory magnetite was found along the road in the NE$\frac{1}{4}$ sec. 22, T. 26 N., R. 24 W. Glacial erratics of Purcell Basalt and quartz manzonite porphyry are found on ridges within the quadrangle.

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

SEDIMENTARY ROCK STRUCTURE

Folding in the quadrangle amounts to simple symmetrical and asymmetrical anticlines and synclines striking northward to northwestward. Both broad and tight folds plunge northwestward or southeastward. One major anticline, hereafter referred to as the Little Bitterroot anticline, was mapped from sec. 23, T. 26 N., R. 24 W. through Little Bitterroot Lake to sec. 31, T. 32 N., R. 26 W., a distance of 39 miles.

In the west half of the 30-minute quadrangle (pls. 2 and 3), folding west of the Little Bitterroot anticline includes two anticlines and two synclines in Prichard and Ravalli rocks. The fold axes strike northward in the Pleasant Valley southwest quadrangle and swing to a northwest strike in the Pleasant Valley northwest quadrangle. These folds are broad structures with gentle-sloping limbs; the westernmost anticline and syncline plunge southward. The other two folds just west of Bitterroot anticline continue in a southerly direction from sec. 36, T. 30 N., R. 26 W. past McGregor Lake entering the Horse Plains quadrangle at the southwest map border. Two faulted discontinuous south-plunging folds (an anticline and syncline) extend northward, a distance of about 7$\frac{1}{2}$ miles, from Little Wolf Creek to Wolf Creek in the northwest part of the map area.

East of Little Bitterroot anticline, folding, essentially in Piegan Group strata, consists of a north-plunging asymmetrical syncline dying out along a fault, a south-plunging anticline passing along and west of Logan Creek, and a north-plunging broad symmetrical syncline mapped from Haskill Mountain in sec. 31, T. 30 N., R. 23 W. Other smaller folds were mapped north of Sheppard Creek near Johnson Peak in the northeast 15-minute quadrangle (pl. 1).

Little Bitterroot Anticline

The Little Bitterroot anticline is a continuous structure trending northwestward from the south map border (pl. 4) to the north map border (pl. 2), a distance of nearly 40 miles. The anticline is tightly folded, asymmetrical to the east, and in places the east limb is overturned. The trace of the axial plane strikes from N. 40° W. to north. This fold is in the Prichard Formation and the Ravalli Group; the axis is displaced by longitudinal and transverse faults.

Near Sylvia Lake the east limb of the fold is overturned to the northeast. Stratigraphic criteria used to determine overturning were truncation of cross-bedding, and inverted oscillation ripple marks and mud cracks. Exposures present in the Sylvia Lake area show a continuous change of beds from right side up to vertical to overturned.

The fold axis, faulted north and south of Little Bitterroot Lake, follows the long axis of the lake to cross U.S. Highway 2 in the W½ sec. 33, T. 27 N., R. 24 W. into the Horse Plains quadrangle in sec. 22, T. 26 N., R. 24 W. The fold, asymmetrical to the northeast, is responsible for the near-surface position of the Prichard Formation west and northwest of Little Bitterroot Lake.

FAULTS

Description of Faults

A zone of structural deformation cuts diagonally across the center of the map area from the southeast quadrangle to the northwest map border. Within this zone that follows the Little Bitterroot anticline and the adjacent syncline to the east, two northwest longitudinal faults and several eastward-striking transverse faults displace fold axes traversing upper Ravalli and lower Piegan Group beds (pls. 1, 2, and 4). Other faults with northwest, east, northeast, and north strikes were mapped in other parts of the quadrangle.

The largest fault in the quadrangle is a northwestward-striking longitudinal fault mapped from the Little Bitterroot Lake vicinity, down Griffin Creek and past Sylvia Lake to the northwest corner of the quadrangle. This fault may be the southwest continuation of the Pinkham-Gut Creek fault traversing the Ural quadrangle (Johns, 1961, p. 29) that is believed to have a displacement exceeding 7,000 feet north of Swamp Creek.

The fault follows the axis of the Little Bitterroot anticline, but in parts of the northwest quadrangle the fault swings eastward of the axis cutting the east limb of the fold--notably on the highest points of the anticline. The fault is a high-angle reverse structure with west side up relative to the east side, striking about N. 20°-30° W. In several localities the fault cuts out part of the Ravalli section and thrusts up rocks of the Prichard Formation into fault contact with Ravalli Group beds.

Drag folding, brecciation, silicification, shearing of adjacent rocks and fracture cleavage were noted at various localities in and adjacent to the fault zone. Immediately west of Sylvia Lake, Ravalli strata are tightly folded--a local feature from fault drag. Much brecciation and shattering were observed west of Griffin Creek in SW$\frac{1}{4}$ sec. 36, T. 29 N., R. 25 W.

West of Sylvia Lake where the Prichard is in fault contact with upper Ravalli beds, the displacement exceeds 5,000 feet where lower and middle Ravalli strata have been cut out up to the marker bed. The calcareous marker horizon is between 2,000 to 2,200 feet below the Ravalli-Piegan contact. Fault displacement decreases to the southeast, where east of Little Bitterroot Lake the major structure horsetails into smaller bifurcating faults, which change dip probably to the northeast and die out north of U.S. Highway 2.

Another parallel high-angle reverse fault, with west side up relative to the east side, was mapped near the Ravalli-Piegan contact from a point southwest of Ashley Lake to the northwest border of the map area in sec. 35, T. 32 N., R. 26 W. Bedding on the west side of the break in the northwest quadrangle dips at angles of greater than 50°, while bedding east of the fault has shallower dips. Mr. Hall found considerable displacement along this fault, since, in some places, part of the basal Piegan unit has been faulted out. West of Ashley Lake the fault changes dip to 70° E., and the steep-dipping beds are west of the fault, whereas shallower dipping strata occur east of the structure. Some basal Piegan beds have been cut out in this locality--perhaps several hundred feet of argillite. Drag folding, fault breccia, gouge, shearing and fracture cleavage, and silicification occur along this fault zone, which, in the northwest quadrangle, follows a line of springs.

A near-vertical westward-dipping(?) fault, striking N. 20°-30° W., can be traced for 7 miles from the northeast end of Ashley Lake in sec. 31, T. 29 N., R. 23 W., to disappear beneath Quaternary gravels and silts near the mouth of Logan Creek. The fault may be displaced by the eastward-striking structure in Sheppard Creek, and continue northwestward to Sanko Creek, to die out west of Johnson Peak in sec. 7, T. 31 N., R. 24 W.

The fault is believed to be normal with the west side dropped and the east side upthrown. Drag folds were observed on both sides of the structure. On the crest of the anticline west of this fault, a line of springs in secs. 21 and 28, T. 30 N., R. 24 W. suggests faulting along the trace of the fold axis.

Eastward-striking vertical faults, with the north side dropped relative to the south side, were mapped half a mile north of Grubb Mountain, 2 miles southeast of Sylvia Lake in Sheppard Creek, and 1 mile north of Sanko Creek. These faults displace fold axes, northwest faults, and the Ravalli-Piegan contact.

The Yukon and Harvey properties are on or near the Sheppard Creek fault, and a spring-fed calcareous tufa deposit occurs in sec. 9, T. 30 N., R. 25 W., about half a mile south of the fault trace.

A fault striking N. 80°-85° W. was mapped north of Little Bitterroot Lake, crossing southward of Haskill Pass. At one exposure in sec. 25, T. 28 N., R. 25 W., a 6-foot breccia zone trends N. 80° W. and is believed to be vertical.

South of Lynch Lake in the Pleasant Valley southwest quadrangle, a large separation between the Prichard-Ravalli contact and shifting of the anticlinal axial trace indicates the presence of an eastward-striking fault concealed beneath Quaternary gravels in Pleasant Valley.

Age of Faults and Folds

The youngest sedimentary rocks (excluding Quaternary deposits) in the Pleasant Valley quadrangle belong to folded and faulted Piegan Group strata. Other higher Belt Series formations in the Missoula Group and Devonian limestone and Mississippian(?) quartzite (pl. 1, MBMG Bull. 23), mapped in the Ural northeast quadrangle on the east flank of the Purcell trench at the international border, have been folded and faulted; therefore, structural deformation is believed to be post-Devonian in this part of northwest Montana.

Summary of Faulting

Two northwestward-trending high-angle reverse faults (with west side upthrown) cut diagonally across the Pleasant Valley quadrangle. The west fault in Ravalli quartzite parallels and displaces the axis of the Bitterroot anticline and a calcareous marker bed in the upper Ravalli. The east fault, essentially in basal Piegan Group strata, dies out along the axis of a syncline in the northwest quadrangle.

The Ravalli-Piegan contact, fold axes, and the northwest faults are displaced by transverse faults trending eastward. The eastward-striking faults are believed to be vertical with the north side dropped relative to the south side.

A northeast high-angle reverse fault with west side upthrown was mapped crossing Sanders Mountain in the Pleasant Valley northwest quadrangle. Normal faults with a northerly trend cross Haskill Mountain and follow Lost Prairie road northwest of McGregor Lake.

O R E   D E P O S I T S

Ore deposits in the Pleasant Valley quadrangle consist of one type lode deposit and a few unproductive placer deposits in scattered localities throughout the area.

The placers on small-stream tributaries have been unproductive and test pits have yielded very small amounts of flake gold by panning. Individual water-worn nuggets and other specimens containing rough or gnarled gold have been found north of Little Bitterroot Lake and in the Star Meadows district. It is a possibility that some gold specimens were dumped with glacial ice deposits; however, the rough uneven appearance of most specimens preclude the possibility they traveled any great distance. No workable deposit of placer gold has been so far located.

Lode deposits in the quadrangle are classified as gold-quartz veins and copper-bearing quartz veins containing small amounts of lead, silver, gold, and barite. Specular hematite-siderite-quartz veins have been explored by short adits northwest of Star Meadows guard station. Barite is a constituent along with copper in a quartz vein at the Humdinger prospect northwest of Tally Lake.

Several mining properties in the Thompson Falls quadrangle were visited during preliminary field mapping in southeastern Lincoln County, initiated in 1961. These properties are described in this Bulletin in the section "Description of Mining Properties, Thompson Falls Quadrangle."

LODES

Copper-Bearing Quartz Veins

Most lode deposits in the Pleasant Valley northeast quadrangle are in the Star Meadows district west of Tally Lake, north and south of Sheppard Creek. These deposits are classified as copper-bearing quartz veins.

The greater number of veins strike eastward, are vertical or near vertical, and are from a few inches to 4 feet wide. A few copper-bearing quartz veins strike northeastward and northwestward. The veins occupy fault fissures, and postmineral faulting has displaced veins at several properties. Postmineral faulting may be more extensive throughout the district since only limited amounts of development at shallow depths has been done on the properties.

Gold-Quartz Veins

Very small amounts of gold at the Blue Grouse prospect has been reported in quartz veins containing pyrite, sericite, and iron oxides. No deposits to date in the area have produced gold in commercial amounts. Small amounts of silver are also associated with gold and quartz.

Barite

Barite veins in the north Stryker and Ural northeast quadrangles were described in Montana Bureau of Mines and Geology Bulletin 23, and in Bulletin 12 covering work in the Yaak River area. A barite vein in sec. 34, T. 27 N., R. 28 W., in the Thompson Lakes quadrangle, was developed in 1961 by Gerald Kenelty of Libby, Montana. Within the Pleasant Valley quadrangle, barite occurs in small quantities with copper minerals in quartz veins. No significant amounts of this nonmetallic mineral have been found so far in the Pleasant Valley quadrangle.

DESCRIPTION OF MINING PROPERTIES, PLEASANT VALLEY QUADRANGLE

West Virginia

The West Virginia was the first property discovered in the district and the first producer of a small shipment of high-grade ore, which had to be packed out by horses. The property is on the west side of Sullivan Creek in the NE$\frac{1}{4}$ sec. 19, T. 30 N., R. 24 W., and was discovered by John Sullivan prior to 1900. The mine is near the top of a small ridge separating Sullivan and Griffin Creeks. According to Art Stahl of Cranbrook, British Columbia, the property was first worked by John and Mike Sullivan and Bill Doyle, with financing supplied by Charles Conrad of Kalispell. The near-vertical ore body terminated a short distance underground against a small flat-dipping northwestward-striking fault. Total production from the property amounted to 60 tons of ore.

Two veins exposed on the surface are developed by 2 shafts, an adit, a cut, and some trenching. The veins, about 65 feet apart, are near-parallel veins or one may be the displaced segment of the other. The West Virginia vein strikes N. 65°-75° E., and dips 75°-81° SE. This vein is developed by a shaft from which ore was stoped along the vein, and a 210-foot adit. Some trenching northeast and southwest of the shaft has exposed the vein for short distances. Surface exposures of the vein vary from 4 to 13 inches wide; however, the stoped area is up to 4 feet wide. The other vein strikes N. 70°-80° E., is vertical, and is developed by an 8- to 10-foot water-filled shaft and a 4 by 6 foot cut. This latter vein is 12 inches wide.

Vein minerals identified from samples in a small stockpile were chalcopyrite, some azurite, and a few flecks of bornite in a hematite-stained quartz-siderite gangue. A small pillar of low-grade ore, left on the north side of the West Virginia shaft near the surface, contained small amounts of chalcocite-bornite intergrowths in quartz. Portions of the quartz vein have been leached of sulfides leaving masses of reddish iron oxides. The ore body at the West Virginia may have been formed by secondary enrichment through conversion of primary copper sulfides to chalcocite.

For additional information, the reader is referred to Montana Bureau of Mines and Geology Bulletin 23.

Foolsburg

The Foolsburg copper property is in the SE$\frac{1}{4}$ sec. 19, T. 30 N., R. 24 W., east of Griffin Creek at the head of Sullivan Creek in the Star Meadows district. It is owned by Bill and Jess Stubbs of Kalispell. The property was first developed in 1920 and the Foolsburg claim patented in 1955. Principal development is by adits 240 and 300 feet long on a 16- to 54-inch chalcopyrite-bearing quartz vein that strikes about N. 80° W., and dips 80° SW.

Chalcopyrite, tenorite, malachite, and azurite occur in a gangue of quartz, siderite, and calcite. In the leached portions of the vein red-colored slightly brown-toned masses of limonite are abundant, suggesting the possibility that secondary enrichment may occur at shallow depth where iron oxides are most abundant.

A chip sample 38 inches wide across the ore shoot in the upper adit assayed 4.87 percent copper, 0.80 ounce silver, and 0.05 ounce gold per ton. The property has been inactive for some time.

A more complete description of this property was presented in Montana Bureau of Mines and Geology Bulletin 23, published in 1961.

Copper King

The Copper King prospect is on a ridge top in the SE$\frac{1}{4}$ sec. 20, T. 30 N., R. 24 W., in the Star Meadows district. The property was located by Lee Bigland in 1946, but was subsequently allowed to lapse.

A 12-inch vertical eastward-striking quartz vein containing sparse amounts of chalcopyrite is developed by two shallow pits. The property is on the west limb of an anticline in thin- and medium-bedded ripple-marked medium-gray calcareous argillite and limestone. A 12-inch chip sample assayed a trace of gold and 0.20 ounce silver per ton.

Moonlight

The Moonlight claim was located by Harold and Carl Luke of Kalispell near the center of sec. 21, T. 30 N., R. 24 W. The prospect is on the west side of Logan Creek about 1 mile south of the mouth of Oettiker Creek. Development consists of several shallow pits on quartz veins.

Three parallel closely spaced vertical veins strike eastward. A fourth parallel quartz vein lies about 300 feet south of the others. The three parallel veins are 8, 12, and 18 inches wide, and contain small amounts of chalcopyrite, malachite, azurite, and chrysocolla. Masses of red pulverent iron oxides are associated with the secondary copper minerals.

The prospect is on the east flank near the crest of a gently dipping anticline in thin-bedded medium and light-gray, gray and yellow-weathering calcareous argillite. There has been no production from the prospect.

Griffin Creek

The Griffin Creek prospect is in the northwest corner sec. 19, T. 30 N., R. 24 W., on the west side of the drainage. The property is developed by a 20-foot trench and a 12 by 4 by 6 foot pit. The workings are in gray-weathering gray-green argillite, and very pale yellow-gray and yellowish-white siliceous and calcareous argillite and dolomitic limestone. The sedimentary rocks strike N. 30° W., and dip 15° SW.

An 8- to 9-inch vuggy quartz vein strikes eastward and is vertical. Large rhombohedral casts filled with calcite and/or ferruginous carbonates are contained in rock on the dump. In the vein at the upper pit sparse chalcopyrite, tenorite, calcite, and hematite were observed.

No history of the prospect is available; however, the work appears to have been done in the 1920's or 1930's.

A selected dump sample from the upper pit assayed 1.38 percent copper, a trace of gold, and 0.30 ounce silver per ton. For additional descriptions of properties in the Star Meadows district, the reader is referred to Montana Bureau of Mines and Geology Bulletin 23, published in 1961.

Sanko

The Sanko vein was discovered by Fred Sanko prior to the 1930's and is in the center of sec. 28, T. 31 N., R. 24 W. A 4- to 6-inch vertical quartz vein with medium-sized quartz crystals and iron oxides strikes eastward and is developed by a 4 by 4 foot pit. The property is a few dozen feet north of the Sanko Creek road in thin- and medium-bedded yellow-brown, yellow-gray, and light-gray argillite striking northward and dipping about 12° E. These beds are in the Piegan Group.

Blacktail

The Blacktail prospect is on a small tributary of Sanko Creek in the NW$\frac{1}{4}$ sec. 29, T. 31 N., R. 24 W., in the north part of the Star Meadows district. The property was first discovered by Frank Lykin of Pleasant Valley after the 1936 Sanko Creek fire burned the vegetation overlying the vein. The original Blacktail claim was staked in 1938, and in 1940 Lykin brought in two additional partners, Messrs. Helmer Houghland and Andrew Briguel. Development work during this period amounted to sinking a short shaft in the creek and driving an adit of 10 feet on the vein. The claim was allowed to lapse and a Mr. Burke relocated the ground in 1945. In may and June of 1961, Marion Fishel of Kalispell relocated the Blacktail and two additional claims.

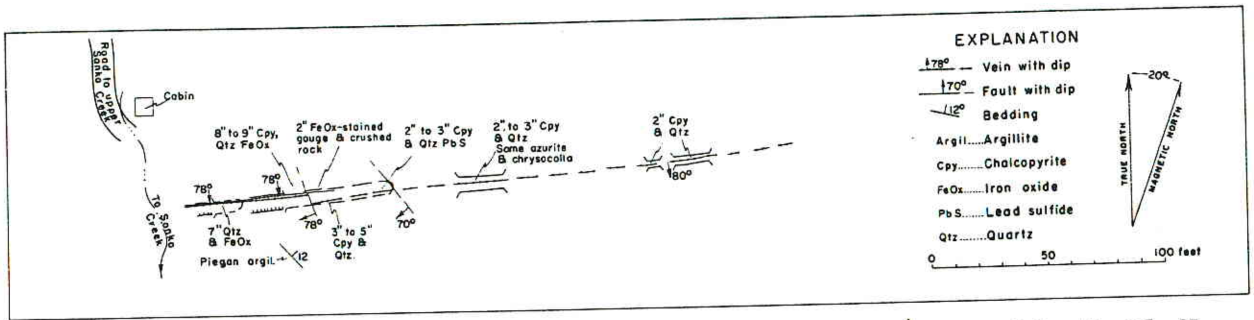

Figure 4.--Surface plan of Blacktail mine in NW$\frac{1}{4}$ sec. 29, T. 31 N., R. 24 W., Star Meadows district, Flathead County, Montana.

At the time of the writer's visit, the vein was exposed for a distance of 200 feet by 8 pits and a 20-foot adit. Recently the adit has been extended along the vein, and bulldozing has exposed the vein containing chalcopyrite and quartz for a distance of 300 feet.

The Blacktail vein strikes eastward and dips 81° S; it ranges from 2 inches to 10 inches wide. Near the portal of the adit the vein width is 9 inches. Moderate to abundant amounts of chalcopyrite, sparse galena and cerrusite, and pyrite in a quartz gangue make up the mineral assemblage in the vein. The depth of oxidation extends 4 to 6 feet below the surface, within which sparse to moderate amounts of crysocolla, malachite, and azurite were identified.

Small northeastward-trending iron oxide-filled joints or small shears on the north (footwall) side are truncated by the vein. At the face of the adit, a small northwestward-striking and southwestward-dipping high-angle fault displaces the vein a short distance. The displaced segment is not exposed in the face of the adit. The vein is in thin- to medium-bedded light-gray and yellow-gray argillite and calcareous argillite striking N. 40° W., and dipping 10° NE.

Total production from the property has amounted to 36 tons of ore, of which the initial 8-ton hand-sorted shipment assayed 13.65 percent copper. A 10-inch channel sample across the vein at the portal of the adit assayed 9.64 percent copper, 2.80 ounces silver, and 0.04 ounce gold per ton. Selected specimens of chalcopyrite assayed by Marion Fishel contained up to 18 percent copper. The writer sampled selected specimens from a 2-ton stockpile of ore, which assayed 28.40 percent copper, a trace of gold, and 4.70 ounces silver per ton.

Lucky Strike

This prospect was found by Fred and Ernie Luke between 1915 and 1918, and is in the E$\frac{1}{2}$ sec. 32, T. 31 N., R. 24 W. north of Sheppard Creek in the Star Meadows district.

An 8-to 18-inch chrysocolla-bearing quartz vein at the surface strikes eastward. The prospect is in gray-weathering yellow, yellow-green, and gray-green limestone of the Piegan Group striking N. 20° W., and dipping 8° NE. The prospect is being developed by Leroy, Carl, and Bud Luke of Kalispell.

Blue Grouse

The Blue Grouse prospect in the E½ sec. 14, T. 28 N., R. 25 W. is adjacent to and on the east side of the North Fork of Herrig Creek, about 3½ miles north of Little Bitterroot Lake. The property includes 4 claims staked by Glen, Lloyd, and Manuel Bauska, and Neil Graham. These unpatented claims were located in September 1960 and in July 1961. The side lines of the claims trend eastward.

Development work includes a 27-foot adit driven in the 1930's, a 10 by 6-foot pit, and a 4 by 4-foot pit, and several smaller pits on 3 quartz veins a quarter of a mile to half a mile north of the main workings. At the main workings 3 quartz veins, 20, 24, and 36 inches wide, outcrop adjacent to a trail bordering the east flank of the North Fork of Herrig Creek. The two smaller veins are developed by the adit and pits. The +36-inch vein was not exposed by any excavation at the time of the writer's visit. This vein outcrops about 100 feet south of the main workings. North of the main workings and adjacent to metadiorite dikes, 3 quartz veins from 3 to 6 inches wide strike eastward and northwestward, and dip steeply to the south and southwest.

At the main workings (fig. 5) the quartz veins are essentially barren except for magnetite, sericite, chlorite, and some iron oxides in vugs. Glen Bauska reports some selected samples of vuggy material assaying 3 ounces silver per ton and containing small amounts of gold. The very sparse silver mineralization in the vein appears to be spotty and usually found in vugs. The workings are in banded blue-gray biotite and magnetite-bearing argillite and very light-gray fine-grained magnetite-bearing quartzite and argillaceous quartzite of the basal Ravalli Group.

An anticlinal axis is about one-tenth mile west of the quartz veins. The trace of the axis trends slightly west of north, and it is believed the veins occupy tension faults related to folding stresses and dike intrusion.

In the general area of the Blue Grouse prospects, two high-grade specimens of native gold-bearing quartz have been found. The first specimen was found in 1914 by Charlie Ayers, U.S. Forest Service packer, near a spring in the center of the E½ sec. 14, T. 28 N., R. 25 W. The piece of float was angular and the native gold was associated with iron oxide-bearing quartz. The second specimen was found by Glen Bauska in 1929 near a spring about a quarter of a mile southwest of Pleasant Valley Mountain. This latter specimen was assayed by the Colorado School of Mines and found to contain $17,500 per ton in gold. This specimen contained wire gold in vuggy quartz. Bauska believed this specimen may have been packed in to the vicinity of the spring.

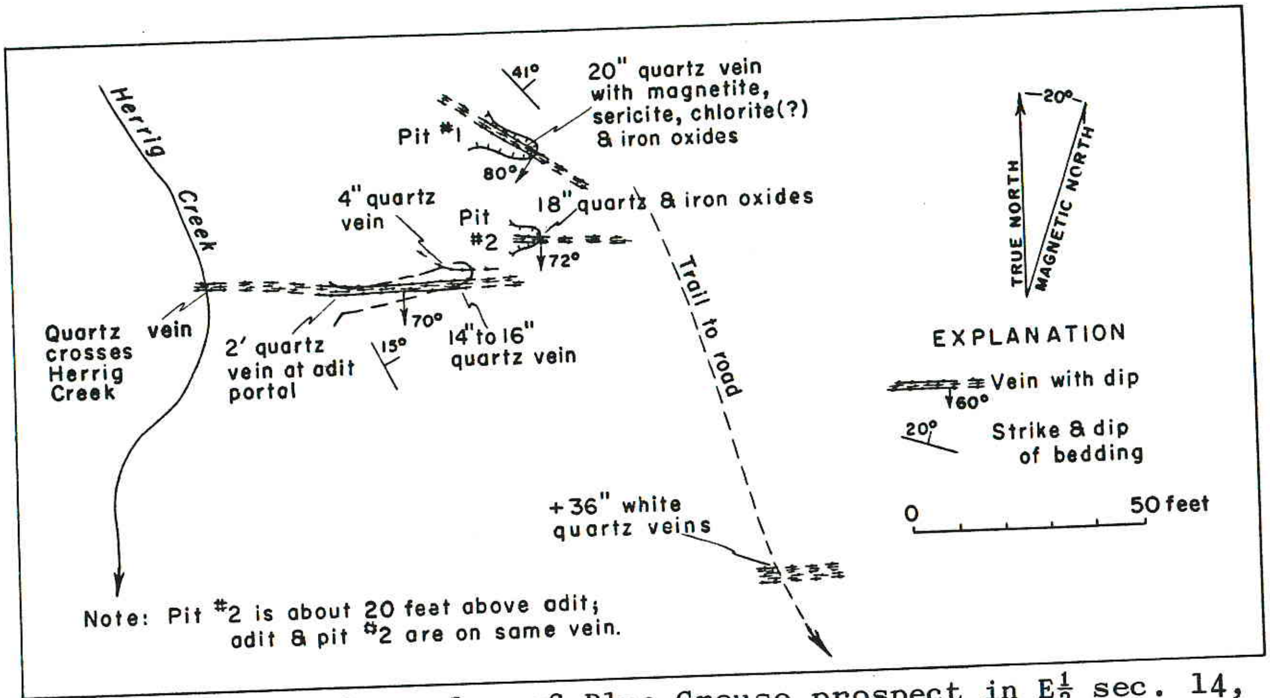

Figure 5.--Surface plan of Blue Grouse prospect in E$\frac{1}{2}$ sec. 14, T. 28 N., R. 25 W., Flathead County, Montana.

According to rumor a Mr. Foster, who was a tunnel watcher at the Haskill Pass Great Northern Railway tunnel prior to its being rerouted along the Kootenai River in 1904, found coarse native gold in quartz in the Haskill area. Several Marion residents at that time supposedly saw samples of Mr. Foster's ore. Mr. Foster is supposed to have excavated all the ore from this particular outcrop; however, he did commence working in an adjacent area which he thought might be as productive. From reported descriptions of the ore, Marion residents at the time believed the mineralization occurred in a lenselike body in a quartz vein north of Haskill Pass.

Horse Hill

In the Pleasant Valley northwest quadrangle just northwest of Horse Hill Lookout in the SW$\frac{1}{4}$ sec. 30, T. 30 N., R. 26 W., an inactive prospect is developed by a short adit and winze.

A 14-inch vein is exposed by a 50-foot adit trending S. 70° E. A few small quartz stringers parallel the larger vein. A winze at the face of the adit is now filled with water. From visual observation samples of dump and vein material appear barren. A sample of vein material assayed a trace of gold and 0.10 ounce silver per ton.

Undeveloped Surface Veins and Miscellaneous Ore Deposits

An abandoned prospect is in the NW$\frac{1}{4}$ sec. 20, T. 30 N., R. 24 W; development work amounts to a 150-foot(?) adit, now caved, that trends S. 50° E. The adit is believed to have been driven in 1930-32 by Kalsipell people. Selected specimens taken for assay from the dump contained sparse chalcopyrite and iron oxides in a quartz-siderite gangue. The specimens assayed 0.46 percent copper, 0.03 ounce gold, and 1.40 ounces silver per ton.

Considerable development has been done on a northeastward-striking vein a quarter of a mile northeast of the West Virginia in the NE$\frac{1}{4}$ sec. 19, T. 30 N., R. 24 W. An iron-stained vuggy vertical quartz vein up to 2 feet wide strikes N. 65°-70° E. (about parallel with the West Virginia vein) and has been explored by a caved adit, a water-filled shaft, and several pits and trenches. The vein quartz is iron oxide-stained, has rhombohedral cavities, and is barren of sulfide minerals and copper staining.

Two parallel quartz veins, approximately 600 and 1,000 feet respectively, south of the West Virginia property, strike N. 80° W., and dip 80° SW. The vein material is conspicuously stained with iron oxides. The veins are developed by inaccessible shafts which are 14 and 25 feet deep, and several shallow pits. The veins range in width from 6 to 14 inches, are vuggy, and hematite and siderite are present as gangue minerals.

A 4-inch vertical quartz vein striking eastward outcrops on U.S. Forest Service Trail 303 in the NW$\frac{1}{4}$ sec. 20, T. 31 N., R. 24 W. The barren quartz where exposed is stained with small amounts of iron oxides.

Carl Luke reports finding a vein of galena 3 inches wide adjacent to U.S. Forest Service Trail 161 to Ashley Mountain in SE$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 30, T. 30 N., R. 24 W. Luke also found galena float west of this location in the SE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 26, T. 30 N., R. 25 W.

An 8 by 8 by 10-foot shaft exposes a vein 10 inches wide containing rusty and vuggy brown-colored quartz. The vein is in the SW$\frac{1}{4}$ sec. 29, T. 28 N., R. 23 W. On the top of Boorman Peak in the NE$\frac{1}{4}$ sec. 21, T. 28 N., R. 23 W., an 8-inch vertical vein with vuggy quartz, hematite, and calcite is developed by a shallow pit. An adit on the north slope of Grubb Mountain in the NW$\frac{1}{4}$ sec. 29, T. 29 N., R. 25 W. is driven in a southerly direction on a quartz vein, and another small quartz vein occurs along the north side of the road to Tepee Hill in the NW$\frac{1}{4}$ sec. 24, T. 30 N., R. 26 W.

Glen Bauska of Kalispell reports finding an adit on the north side of the creek near the center of sec. 19, T. 30 N., R. 24 W, and other diggings have been noted* along U.S. Forest Service Trail 171 in N$\frac{1}{2}$ sec. 13, T. 30 N., R. 25 W. and on the east side of Ingalls Mountain.

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*Personal communication, Harold Luke.

About 1930, Mr. Rhodes, a local rancher living in Lost Creek northwest of Kalispell, discovered a lead-silver vein on an eastward-trending ridge north of Ashley Lake. Rhodes described the vein as being found at the base of an outcrop; specimens of the material assayed $96.00 per ton in lead and silver. The major value of the ore was reported to have been in silver. Rhodes spent the next several years trying to relocate this vein.

From information supplied by Glen Bauska, Rhodes appears to have found the vein at the head of the South Fork of Big Lost Creek in sec. 30, T. 29 N., R. 23 W. The writer spent a short period of time in this vicinity without positive results. In this area a tight syncline trends about N. 20° W. and a parallel-trending vein might follow the fold axes.

About 4 miles east of Boisvert's camp on McGregor Lake and 600 feet south of U.S. Highway 2, are gravels cemented by hematite and silica which assay a trace of gold, 0.10 ounce silver per ton, and 1.80 percent manganese. These gravels have been uncovered by bulldozers working in a highway department gravel pit.

Herrig Placer

A sluice box composed of several sections was once located on Herrig Creek a short distance south of the junction of Herrig and the North Fork of Herrig Creek in the SE$\frac{1}{4}$ sec. 23, T. 28 N., R. 25 W. Local residents stated some placering was done in this area prior to 1900.

Glen Bauska and U.L. Poston examined the sluice boxes in 1929 and 1940 respectively, and Herb Poston panned colors and recovered small globules of mercury from tailing piles. Parts of an old diversion dam remained at that time. The gold-bearing gravels may have been packed in since no workings were found in the immediate area. Test pits were observed by the writer in the S$\frac{1}{2}$ sec. 14, T. 28 N., R. 25 W. Evidence of placering can be found in sec. 24, T. 28 N., R. 25 W., and older residents of Marion believe the creek in the east half of this section was placered in the late 1880's.

Other Placers

Small piles of gravel believed by Glen Bauska to be placer tailings are located north of Ashley Lake near the center of NW$\frac{1}{4}$ sec. 36, T. 29 N., R. 24 W. No extensive work was done in this area and the ground, if placered, was unproductive.

DESCRIPTION OF MINING PROPERTIES IN THE NORTHERN PART

THOMPSON FALLS QUADRANGLE

Viking

The Viking property was originally located by Mark Fowler in 1934 and has operated under the management of the Viking Mining Company as the Viking Mine and as the Gold Hill Group. The property is in sec. 4, T. 25 N., R. 30 W. in upper Silver Butte Creek of the Thompson Falls quadrangle (fig. 6). The property has been inactive for some time and its present status is unknown. Data on development, ore reserves, and grade of ore have been obtained from a private report written by U.M. Sahinen, dated August 1946.

In 1946 the property consisted of 3 unpatented claims, which had been surveyed for patent (Survey No. 10,755), but not yet patented, and an abandoned mill built in 1938, which at the time of the writer's visit (1961) had collapsed. One surface building and the ore bin remain standing.

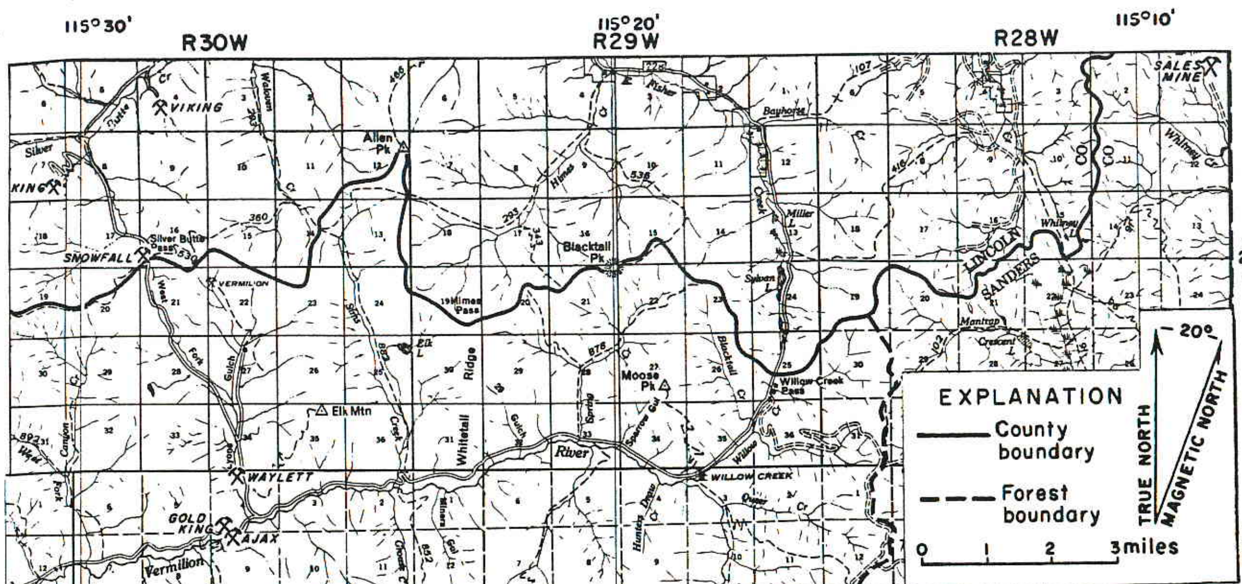

Figure 6.--Map showing location of described mining properties in the Cabinet Mountains, north Thompson Falls quadrangle, Lincoln and Sanders Counties, Montana.

The Viking mine has been developed by 2,000 feet of drifting and crosscutting from 5 tunnels of which only the lower one (Tunnel No. 1) is accessible for a distance of 175 feet. Mr. Sahinen reports this tunnel is 240 feet long. Tunnel No. 2 (above No. 1) is driven as a crosscut for a distance of 70 feet, intersects the vein at 30 feet, and a 250-foot drift explores the vein that is displaced at both ends by northwestward-striking faults dipping southwestward. Tunnel No. 4, above No. 2, was inaccessible in 1946; however, Mr. Sahinen reports no ore in this tunnel. No. 5 tunnel is 60 feet above No. 2 and is developed by about 680 feet of cross-cutting and drifting to and along the vein. Tunnel No. 3 is on Gold Hill No. 3 claim, driven through barren rock for a distance of 350 feet. Tunnel No. 5 was the main working level and produced the major part of the ore mined by the Viking Mining Company. A quartz vein outcrop contours the hill and was stoped to the surface for a distance of 175 feet at the same elevation and south of Tunnel No. 5.

Five fissure-filled bedding veins with gold-bearing quartz, galena, chalcopyrite, pyrite, and limonite and hematite range in width from a few inches to 22 inches wide. Mr. Sahinen reports the available ore in the present workings has been mined out except for very small blocks of milling-grade ore too small to be economical. However, a discovery cut 600 feet southwest of Tunnel No. 3 contains a 22-inch quartz vein which carries $19.60 per ton in gold and 0.06 ounce silver per ton.

Northwestward-striking quartz veins dipping between 33°-45° NE are displaced by west-northwest faults dipping southwestward in en echelonlike segments (fig. 7). The better ore, in part free milling, was mined above the zone of oxidation.

Sandvig (1947, p. 64) states that during excavation of the millsite a metadiorite sill containing extensive quartz veinlets was discovered. A channel sample across the mineralized zone assayed $14.00 per ton in gold. There has been no additional work at this location to the writer's knowledge.

The workings are in very light-gray magnetite-bearing quartzite, medium- to medium-light-gray weathering light-gray quartzitic argillite, and blue-green thin-bedded and medium-bedded soft argillite striking N. 35° W., and dipping 45° NE. The Prichard-Ravalli contact is believed to be a short distance southwest of the workings.

King

The King mine is in sec. 7, T. 25 N., R. 30 W. in southern Lincoln County and was discovered in 1887. It was formerly known as the Silver Butte and was first operated by the Kentucky Vermillion Company until a fire destroyed all buildings and a 150-ton mill. The mill, constructed at a cost of $150,000, was destroyed before 1905 (Calkins and MacDonald, p. 105). Reports indicate the property was idle for some time prior to 1905, and between 1910 and 1946.

In 1943 the Silver Butte Zinc-Lead Mining Company was incorporated with William Curts as president. In the 1950's the property was sold for taxes and the newly constructed mill dismantled. The property has since been inactive. The ground amounts to 10 patented claims, 2 patented millsites, and 21 unpatented claims, comprising a total of 220 acres of patented ground and 430 acres of unpatented claims which have been allowed to lapse.

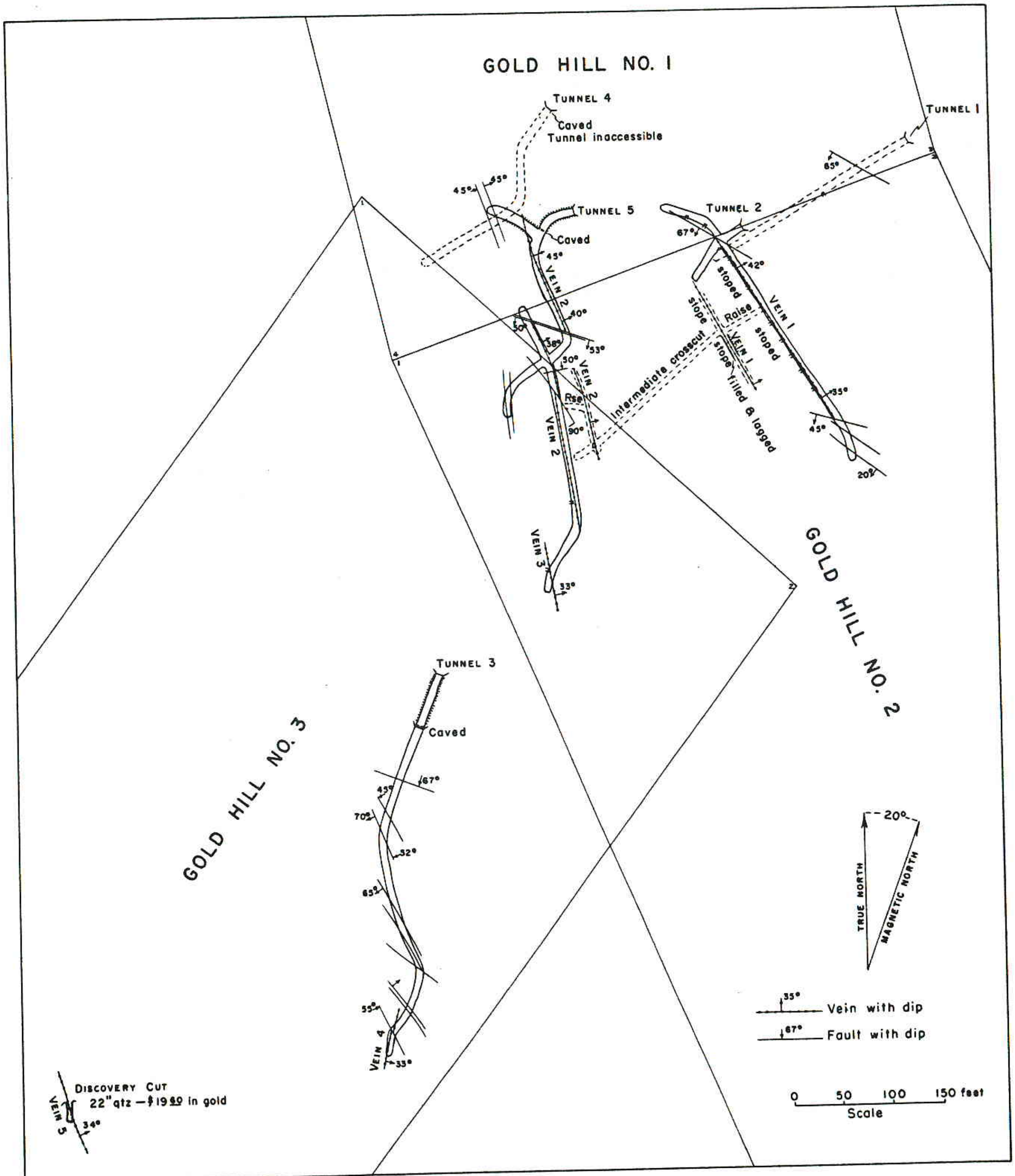

Figure 7.--Composite plan of workings on the Gold Hill claims, Cabinet district, Lincoln County, Montana.

The mine is developed by 4 adits totaling 4,300 feet, only two of which are now accessible. An 80-ton flotation mill was erected in 1946 and the equipment later removed. All surface buildings have been destroyed or callapsed. Development was done on a low-grade lead-silver-bearing quartz vein striking N. 60° W., and dipping 30° SW. The vein averages about 10 feet wide and is in gray and blue-gray banded Prichard argillite. Vein matter includes white quartz and small amounts of pyrite, chalcopyrite, and sphalerite. The outcropping quartz vein is 30 feet wide on the ridge northeast of the lower workings.

The first shipment from the mill in 1947 was valued at $2,300. Selected dump samples from the upper accessible adit assayed 0.01 ounce gold, 9.10 ounces silver, and 18.50 percent lead per ton.

Sales

The Sales mine is in the NW$\frac{1}{4}$ sec. 1, T. 25 N., R. 28 W. on the east side of Whitney Creek near the Lincoln-Sanders County line. The country rock is the Libby Formation consisting of light-gray, light-brown, and yellow and green-colored argillites striking N. 20°-40° W., and dipping 80°-85° SW. The property was inactive at the time of the writer's visit.

A caved adit enters the hillside a short distance above creek elevation, and for a distance of 1,000 feet along a southeastward-trending ridge from this adit, 9 bulldozer cuts spaced about 100 feet apart expose copper carbonate and copper silicate minerals in a near-vertical fractured zone trending S. 20° E. The first 5 cuts south of the adit (a distance of about 600 feet) contain sparse amounts of chrysocolla, azurite, and very sparse malachite. The remaining 4 cuts contain little or no copper minerals; the fracture zone was exposed in all cuts reaching bedrock. The zone decreases in width and intensity to the southeast. Material in first cut, believed to be representative of the first 5, assayed 0.82 percent copper, 0.30 ounce silver, and 0.001 ounce gold per ton across the 4-foot fractured zone.

Chrysocolla is found as blebs and masses in shattered argillite, whereas azurite is present as a surface coating on shear planes within the zone. In fresh argillite, small stringers and elongated masses of cupriferous pyrite(?), chalcopyrite, pyrite, galena, sphalerite, and possibly some chalcocite were noted within the structure. A buried intrusive below the fracture zone could be the source of the sulfides. The fractured zone, containing sparse sulfides, permitted circulating surface water to aid in converting copper-bearing sulfides to copper carbonate and silicate minerals. Recently the operators attempted to leach the low-grade material. Leaching equipment including a precipitating tank and hammer mill remain at the site.

The 1960 Montana Bureau of Mines and Geology Bulletin 20, "Directory of Known Mining Enterprises," lists the owners of the property as Mr. and Mrs. Gordon Sales and Ruth Sales, P.O. Box 464, Kalispell, Montana.

Snowfall

The Snowfall prospect is near the Silver Butte Divide in SW$\frac{1}{4}$ sec. 16, T. 25 N., R. 30 W. The property was relocated in May 1955 by Clyde Roark and Blaze and John Echo. The prospect consists of one unpatented claim.

Development includes a caved adit and a discovery pit whose dimensions are 20 by 10 by 6 feet. An eastward-striking vertical 8-inch quartz vein in the discovery pit contains chalcopyrite and pyrite in a gangue of quartz. Sparse amounts of chalcopyrite and pyrite in a quartz-siderite gangue were found on the dump of the caved tunnel. The prospect is near the Prichard-Ravalli contact. A grab sample of vein material from the discovery pit assayed 0.03 ounce gold, 2.20 ounces silver, and 1.00 percent copper.

Gold King

The Gold King prospect amounts to one unpatented claim on the north side of the Vermilion River road a short distance northwest of the Ajax placer. The prospect is on the section line between secs. 4 and 9, T. 24 N., R. 30 W. One claim was located by Ed Moreland in 1949, and the ground was relocated by Phil F. Leison in February 1961.

A 1-foot quartz vein, developed by a 30-foot adit, contains small amounts of galena, chalcopyrite, sphalerite, and pyrite, and strikes N. 37° W., and dips 50° NE. Drag folding on the footwall indicates the vein occupies a normal fault. A postmineral fault with about 1 inch of gouge follows the footwall in Prichard argillite. There has been no production from the property.

Albert Thayer reports a small galena vein a few inches wide, outcropping a few hundred feet northeast of the adit, has been covered by bank sloughing.

Undeveloped Surface Veins and Miscellaneous Ore Deposits

A 38-inch white quartz vein, striking N. 65° E., and dipping 84° NW., and a 15-foot sheared zone with quartz veins from $\frac{1}{4}$-inch to 1-foot wide are exposed in bedrock cuts on the J. Neils-Bay Horse Creek road from East Fisher River to McGinnis Creek. The vertical sheared zone strikes eastward. On an upper logging spur some red-brown limonite is associated with a 3-foot quartz vein. These veins are in sec. 12, T. 25 N., R. 29 W.

Several bulldozer cuts have been made on azurite and malachite-stained Ravalli Quartzite on the east side of Miners Gulch in sec. 1, T. 24 N., R. 29 W. The bulldozing was done in 1956 or 1957.

Ajax Placer

The Ajax gold placer is in NW$\frac{1}{4}$ sec. 9, T. 24 N., R. 30 W. on the Vermilion River in the Thompson Falls quadrangle. The two unpatented claims, Ajax Nos. 1 and 2, were relocated by Albert Thayer in 1948. The ground has recently been leased to Frank Duval of Spokane.

Mr. Thayer reports the ground was originally located and worked by Ed Coleman and Mr. Rowdy of Butte, who produced a total of $90,000 from these and other Vermilion River claims between 1900-06. Between 1930-36 Thayer reports the claims produced $60,000-$70,000. Since 1948 production has amounted to about $3,500.

The largest tailings pile covers an area about 100 by 400 feet. Mr. Thayer is presently working a small strip of ground adjacent to the river; he uses a 6-foot sluice box and reports only the upper 6 feet of gravels are productive with the ground averaging about $1.00 a yard in coarse gold.

According to local residents all placer production of consequence from the Vermilion River placers came from below the Lyons Creek-Vermilion River junction. This suggests the source of the placer gold may have been from the Lyons Creek area. The exception is the unverified occurrence of a placer operation in Sims Gulch described under "Other Placers."

Waylett Placer

Harry K. Waylett of Star Route, Libby, is presently developing a placer in lower Lyons Creek where he owns the mineral rights to 160 acres in sec. 4, T. 24 N., R. 30 W., and sec. 34, T. 25 N., R. 30 W. The ground was homesteaded by Fred Hayles of Kalispell and was acquired by Harry Waylett's father in 1919.

Other Placers

Albert Thayer of Vermilion River stated that about 1890 his father attended an inquest into the deaths of two placer miners, killed in a cavein of a vertical 86-foot shaft in Sims Gulch approximately 2½ miles above the Sims Creek-Vermilion River junction. According to Mr. Thayer, the coroners party removed 2 or 3 pounds of gold from the sluice box and disposed of a quart bottle filled with placer gold. The writer and others have not been able to determine the location of the shaft which may have been filled with gravel and mud from annual spring runoff.

NONMETALLIC DEPOSITS

Clay

Glacial lacustrine laminated clays and silty clays overlie glacial till and glacio-fluvial deposits exposed in roadcuts along U.S. Highway 2 and in Pleasant and Little Bitterroot Valleys. Clay deposits are horizontally bedded.

Clays analyzed in the adjoining Thompson Lakes quadrangle (Appendix, MBMG Bull. 17) contain silica in amounts ranging from 56.40 to 77.00 percent. Alumina oxide content ranged from 8.70 to 22.50 percent, while small amounts of calcium oxides, magnesium oxides, and iron oxides are present in all samples.

Limestone

Middle Piegan carbonate-bearing rocks in the adjoining Thompson Lakes quadrangle contain 34.00 to 51.00 percent silica, 9.80 to 13.20 percent alumina oxide, 13.60 to 27.00 percent calcium oxide, and 1.20 to 3.50 percent magnesium oxide; ferrous iron oxide content amounts to 1.20 to 1.40 percent, whereas ferric iron oxide in the specimens amounted to 1.50 to 3.60 percent. A representative sample of Middle Piegan limestone in the Pleasant Valley northwest quadrangle assayed 53.20 percent silica, 12.80 percent alumina oxide, 12.90 percent calcium oxide, and 6.11 percent magnesium oxide.

Quartzite

The silica content of Ravalli Quartzites that were analyzed ranges from 70 percent to about 86 percent, and, as in other parts of Lincoln County, the silica content does not appear to be high enough for commercial uses. The iron oxide content amounts to only a few percent in the samples selected for analysis.

SUGGESTIONS FOR PROSPECTING

Quartz-bearing copper veins in the Star Meadows district occupy former fault fissures predominantly trending eastward. It is suggested that fault and vein extensions from known deposits be further examined for base-metal mineralization.

Quartz diorite mantle rock was found on a ridge in the N½ sec. 19, T. 31 N., R. 24 W. Sections 19 and 20 should be further examined for eastward and northwestward-striking quartz-bearing copper veins.

It is suggested that the S½ sec. 30 and the N½ sec. 31, T. 29 N., R. 23 W. be examined for lead-silver mineralization, and the area north and south of Haskill Pass for gold-bearing quartz veins.

APPENDIX.--Analyses of limestones, quartzites and argillites in Flathead and Lincoln Counties, Montana.

Sample No.	Location	CaO %	MgO %	K_2O %	Al_2O_3 %	FeO %	Fe_2O_3 %	SiO_2 %	P_2O_5 %
1.	Middle Piegan limestone, sec. 1, T. 31 N., R. 26 W.	12.90	6.11	---	12.80	2.50	0.15	53.20	0.44
2.	Ravalli white quartzite, sec. 7, T. 30 N., R. 25 W.	1.70	1.30	---	---	1.50	0.24	86.00	---
3.	Ravalli quartzite, sec. 3, T. 29 N., R. 25 W.	---	---	---	---	1.50	0.56	76.00	---
4.	Purple Ravalli quartzite, sec. 20, T. 27 N., R. 27 W.	---	---	---	---	1.28	0.90	81.90	---
5.	Middle Ravalli quartzite, sec. 21, T. 27 N., R. 25 W.	---	---	---	---	1.80	1.74	71.60	---
6.	Piegan argillite, NE¼ sec. 6, T. 30 N., R. 25 W.	2.50	6.00	6.75	15.60	3.10	0.32	55.40	---
7.	Upper Prichard calcareous argillite member, sec. 25, T. 28 N., R. 27 W.	6.70	2.70	---	17.20	3.84	0.56	59.20	0.40
8.	Prichard argillite, sec. 31, T. 29 N., R. 26 W.	1.10	2.38	---	23.25	4.04	1.35	60.00	---
9.	Piegan argillite, sec. 8, T. 26 N., R. 27 W.	1.50	3.10	---	18.90	1.28	1.55	66.20	---
10.	Piegan calcareous argillite, sec. 8, T. 26 N., R. 27 W.	4.20	6.50	---	16.65	2.80	0.43	59.30	---
11.	Piegan argillite, sec. 6, T. 30 N., R. 25 W.	9.00	5.56	---	18.15	2.80	0.16	64.40	---
12.	Prichard argillite, SE¼ sec. 11, T. 30 N., R. 26 W.	2.20	2.17	7.80	18.40	3.30	0.26	68.60	---
13.	Ravalli quartzitic argillite, sec. 22, T. 27 N., R. 25 W.	1.00	1.45	---	14.70	1.28	1.40	73.80	---

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