CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

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Tim Babcock, *Governor*

BUREAU OF MINES AND GEOLOGY
E. G. Koch, *Director*

BULLETIN 61

September 1967

GEOCHEMICAL INVESTIGATIONS IN LINCOLN AND FLATHEAD COUNTIES, MONTANA

by

U. M. Sahinen, W. M. Johns, and D. C. Lawson

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

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GEOCHEMICAL INVESTIGATIONS

IN

LINCOLN AND FLATHEAD COUNTIES, MONTANA

by

U. M. Sahinen, W. M. Johns, and D. C. Lawson

ABSTRACT

Soil samples at 1/8-mile intervals and stream-sediment samples at 1/2-mile intervals were collected from four areas in northwestern Montana. Soil sampling in the Swamp Creek area of the Cabinet Mountains, stream-sediment sampling in upper Wolf Creek drainage, soil sampling in the Sheppard Creek area of the Salish Mountains, and stream-sediment sampling along the western front of the Whitefish Mountains involved collecting 3,135 soil samples and 634 stream-sediment samples from areas totaling 429 square miles. All samples were analyzed in the Bureau laboratory individually for copper, lead, and zinc, by the pyrosulfate-fusion method. Total cost per square mile amounted to $26.11; chemical cost was about 9 cents per sample and 2-1/2 cents per determination. Additional investigation is recommended for twelve specific localities in the areas sampled.

INTRODUCTION

A 6-year reconnaissance mapping and mineral-survey program, principally in Lincoln and Flathead Counties, northwest Montana, was completed by the Montana Bureau of Mines and Geology in 1963. This program, the Kootenai-Flathead Project, was made possible through a cooperative agreement between the Bureau, the Pacific Power & Light Company, and the Great Northern Railway Company.

As a follow-up project a geochemical program was started during the 1964 field season under a supplemental agreement between the Bureau and co-sponsors. This project involved reconnaissance stream-sediment sampling for base metals in three areas thought to be promising on the basis of previous mapping. These areas are in the Purcell Mountains north of Troy and in the Salish Mountains northwest and southwest of Kalispell. The total area sampled in this phase of the project amounted to 818 square miles (Sahinen, Johns, and Lawson, 1965).

In 1965, follow-up soil sampling of the Swamp Creek and Sheppard Creek areas was undertaken under a second supplemental agreement, and stream sediments were sampled in upper Wolf Creek and its tributaries and along the west flank of the Whitefish Range from the international boundary south to Upper Stillwater Lake. A total of 15 weeks was spent in the field collecting 3,135 soil samples and 634 stream-sediment samples from an area of 429 square miles.

A four-man field crew was supervised by D. C. Lawson. The crew consisted of R. J. Glovan, R. W. Roberts, R. F. Heaphy, and T. R. Downey, with Heaphy and Downey working only part of the field season. Field work began on June 14 and ended on September 26, 1965. An additional 10-day period in early October was spent by D. C. Lawson and J. M. Chelini in the southwest part of the Whitefish Range completing stream-sediment sampling.

METHOD OF SAMPLING

Boundaries of areas to be soil sampled were predetermined on the basis of previous stream-sediment sampling results, geologic data, and topography. For control, a base line was taped along roads traversing the area to establish the location of section lines; the base line for Swamp Creek followed U.S. Highway 2, and that for Star Meadows followed the Sheppard Creek road.

Soil samples were spaced on 1/8-mile grid lines, 64 samples being collected within each section (square mile). Samples were obtained from the C zone, or mixtures of A and C zones, of the soil profile. Each 3/4-pound sample was placed in a metal-free sample sack and subsequently dried in an aluminum pan and stirred with a wooden stirrer at 450° to 500°F to burn off all organic material to prevent its interference with analytic determinations. When each sample was completely dried and all chunks broken, the material was screened through a nylon cloth, and the minus-80-mesh fraction was placed in sample bags marked by sample number and letter corresponding to the number and letter of the intersecting grid lines within sections; that is, 1 N, 2 E. The section, township, and range were also recorded on the sample tag.

The close and regular spacing of the soil samples permitted the use of a contouring technique for emphasizing metal concentration in these areas. For each area, a separate map was prepared for each metal, and values were plotted and contoured, starting with the maximum. That value at which contouring became more or less random might be regarded as the threshold value, and contouring was discontinued. Areas that appear as peaks or ridges may be regarded as anomalous. In the Swamp Creek area, the lowest values contoured are 100 ppm zinc, 50 ppm lead, and 60 ppm copper. In the Sheppard Creek area, the limiting values are 75 ppm zinc, 35 ppm lead, and 60 ppm copper.

Stream sediments were sampled at 1/2-mile intervals, or at each stream intersection, whichever was reached first. Streams were sampled to a point within 1/2 mile of their heads, or as far upstream as sediment was being deposited. Marshes and swamps were avoided because of possible abnormal concentration of base metals. Sample sacks were filled with stream sediment consisting of black loam intermixed with organic material; composite samples were obtained from several spots in the stream bed. The samples were dried and screened by the procedure described for soil samples.

Selection of threshold values separating anomalous samples from those having normal background values was facilitated by the use of frequency-concentration graphs. A separate histogram was prepared for each of the three metals in each of the two areas where stream sediment was sampled. In the Wolf Creek area, samples containing 100 ppm zinc, 100 ppm lead, or 150 ppm copper were judged to be anomalous. In the Whitefish Mountains area, samples containing 100 ppm of any one metal were regarded as anomalous.

All soil and stream-sediment samples were analyzed* in the Bureau laboratory by D. C. Lawson and F. P. Jones. The pyrosulfate-fusion method was used to determine copper, lead, and zinc individually, and 12,782 determinations including 1,475 checks and reruns were completed during a 9-week period (total of 90 man-days).

LOCATION

Project areas are in the Cabinet, Salish, and Whitefish Mountains of northwestern Montana. Fisher River and Thompson River valleys lie between the Cabinet Mountains to the southwest and the Salish Mountains to the northeast. The Rocky Mountain trench separates the Salish Mountains from the Whitefish Mountains (Fig. 1).

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*Tabulated results of sampling are on open file at the office of the Montana Bureau of Mines and Geology, Butte, where they can be consulted by interested persons.

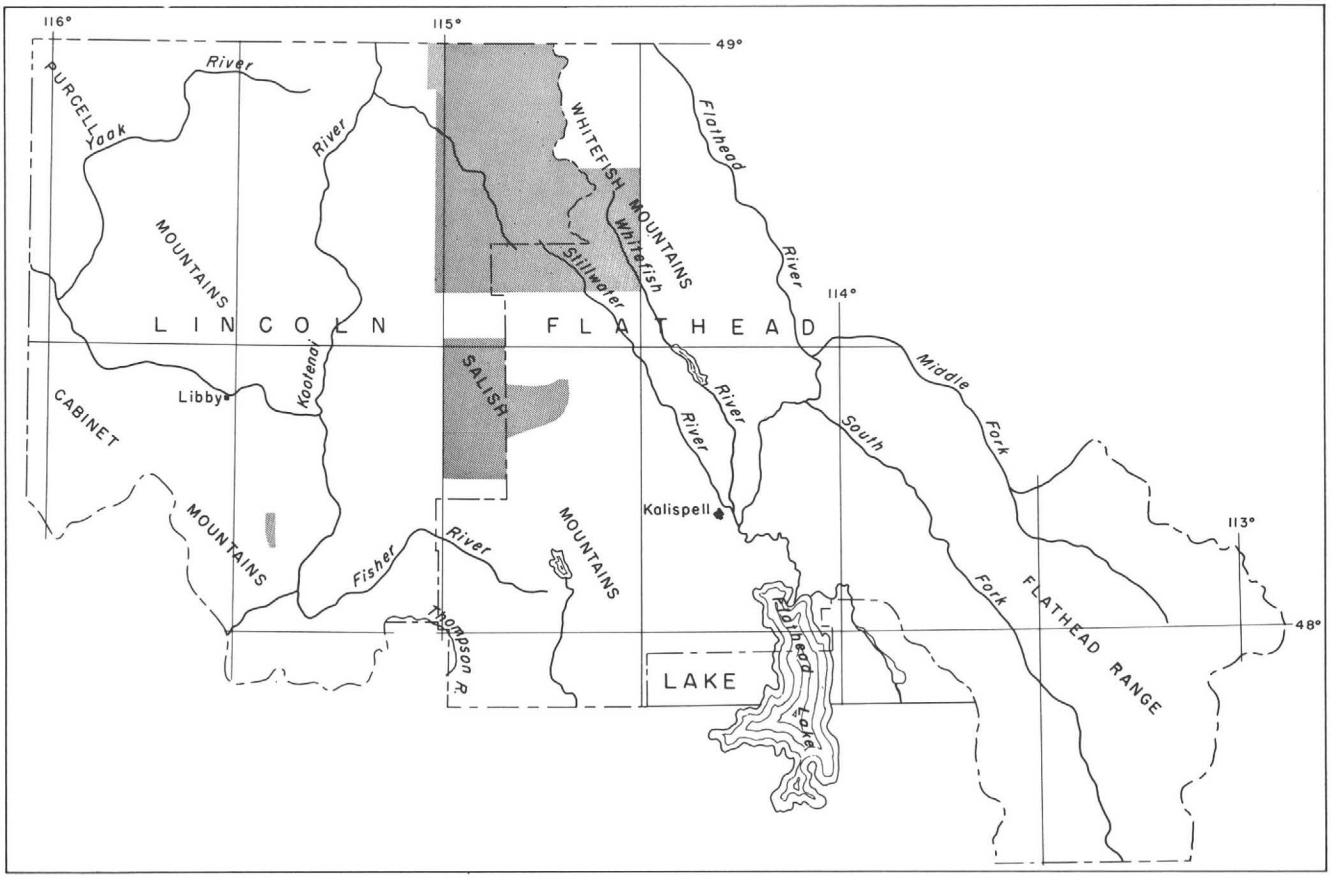

Figure 1. --Index map of Kootenai-Flathead project area showing locations of areas sampled.

SWAMP CREEK AREA

Swamp Creek, a tributary of Libby Creek, flows north through a moderately wide valley, ranging in altitude from about 2,730 feet at Libby Creek to 2,960 feet at its head. To the southwest, Horse Mountain rises to 5,806 feet. Maximum relief is thus about 2,800 feet. The steep slopes descending toward Swamp Creek are forested with second-growth conifers, but talus cover is locally conspicuous on the east flank.

Soil sampling in the foothills of the Cabinet Mountains was confined to the valley of Swamp Creek between Reinhart Gulch and Detgen Creek and along east- and west-facing slopes parallel to Swamp Creek. In nine days spent sampling this area, 336 samples were collected within an area of 6 square miles.

Belt rocks (Precambrian) of the Piegan and Missoula Groups and Cambrian rocks (lower Paleozoic) underlie part of the valley of Swamp Creek and adjacent areas. The Wallace Formation of the Piegan Group, the lowest unit exposed in the sampled area, and the Striped Peak and Libby Formations of the Missoula Group trend slightly west of north parallel to the trend of fold axes. A down-faulted block of Cambrian shale, limestone, and dolomite occupies the northern part of Swamp Creek valley. The sampled area is on the west limb of an asymmetrical syncline, within which overturning of beds and complex faulting occur. Northwest-trending faults are displaced by faults trending slightly north of east.

Wallace strata total 11,000 to 13,000 feet in thickness. Various shades of gray, gray-green, grayish-yellow, greenish-gray, and green argillite, siltstone, and quartzite, predominantly thin bedded or finely laminated, make up the bulk of the lower and upper parts of the Wallace. Gray pyritic limestone, magnesian limestone, and dolomite interbedded with some gray, green, and grayish-yellow argillite form the central part of the formation. Locally, grayish-red argillite, siltstone, and quartzite are present in the upper part of the Wallace. Ripple marks and mud cracks are common in argillite and siltstone.

The Striped Peak Formation is breached by the valley of Swamp Creek between Cowell Creek and Reinhart Creek. The Striped Peak is as much as 3,500 feet thick and consists of grayish-red and purple quartzite containing intercalations of argillite and siltstone. The formation is abundantly ripple marked and mud cracked; occasional casts of salt crystals are found in the argillitic portions. Stromatolitic dolomite and edgewise conglomerate are sparse.

The Libby Formation overlies in fault contact the Cambrian limestone at the northern end of the sample area. To the southeast, Libby strata conformably overlie Striped Peak rocks. In a tilted isoclinal syncline at Kenelty Mountain, the Libby is about 7,600 feet thick. The unit consists mainly of gray, green, and grayish-yellow argillite and sandstone containing some calcareous and ferruginous material. Thin beds of yellow to yellow-brown limestone are sparse.

The Cambrian rocks bordering Swamp Creek valley include red and gray fossiliferous sandy shale intercalated with some fossiliferous limestone, overlain(?) by massive gray dolomite and limestone and gray fetid carbonate rocks. The shale may be equivalent to the Gordon Shale of the Silvertip region, and the overlying limestone and dolomite to the Hasmark Formation of the Philipsburg area.

In the SE$\frac{1}{4}$ sec. 9 and S$\frac{1}{2}$ sec. 10, T. 28 N., R. 30 W., weakly anomalous copper values occur consistently within an east-trending zone (Fig. 2). Anomalous zinc values were recorded for samples 7 N, 6 E;

8 N, 6 E; 8 N, 7 E; and 8 N, 8 E, in sec. 9, and samples 8 N, 5 E and 8 N, 6 E in sec. 15 (Fig. 3); the area from which these samples were taken borders the zone of anomalous copper on the south. This weakly anomalous area should be tested for copper and zinc in bedrock under the soil cover. Sample 2 N, 3 E in sec. 10 gave an anomalous value for lead (Fig. 4), but this sample may be contaminated, as it is close to U.S. Highway 2 and Cliffside.

Weakly anomalous copper values were recorded from west to east through the center of sec. 15 and W$\frac{1}{2}$ sec. 14. In this area individual samples gave above-threshold values for copper, lead, and zinc. This area should be investigated by trenching to determine the source of copper.

Samples 5 N, 1 E and 5 N, 2 E in sec. 26 gave weakly anomalous values for copper and zinc, and samples 8 N, 1 E and 8 N, 2 E, sec. 35, gave above-threshold values for copper, lead, and zinc. These two sample sites should be investigated further. Sample 2 N, 5 E in sec. 22 gave anomalous values for copper and zinc, but the sample may be contaminated by material from adjacent farm buildings.

The Swamp Creek area lies within a structurally complex zone broken by east-trending and northwest-trending faults. Some of the anomalous samples are believed to be related to this faulting, but the apparent widespread though somewhat weak anomalous area of sec. 9, 10, 14, and 15 in the north end of the area sampled seems to indicate uniform dissemination of mineralization in the bedrock. The area should be further investigated by core drilling.

SHEPPARD CREEK AND WOLF CREEK AREAS

The Star Meadows district is in the northern part of the Salish Mountains, about 35 miles northwest of Kalispell. The sampled area is bounded on the north by the Mt. Swaney-Dunsire Point divide, on the east by Sinclair Creek, on the south by the Ingalls Mountain-Mt. Conner divide, and on the west by the Tepee Hill-Sheppard Peak divide and upper Brush Creek. Within the upper drainage basins of Sheppard Creek and Brush Creek and their tributaries, an area of 45 square miles, 2,799 soil samples were obtained; 11 soil sample sites in the Sheppard Creek area were excluded because of swamps. Sampling the area required about 55 days.

The upper part of the Wolf Creek drainage is about 30 miles west-northwest of Kalispell. Stream-sediment sampling, at stream intersections or 1/2-mile intervals, was confined within an area bounded on the north by lat 48° 30', on the east by the Sanders Mountain-Elk Mountain divide, on the south by Grubb Mountain and Island Lake, and on the west by long 115°.

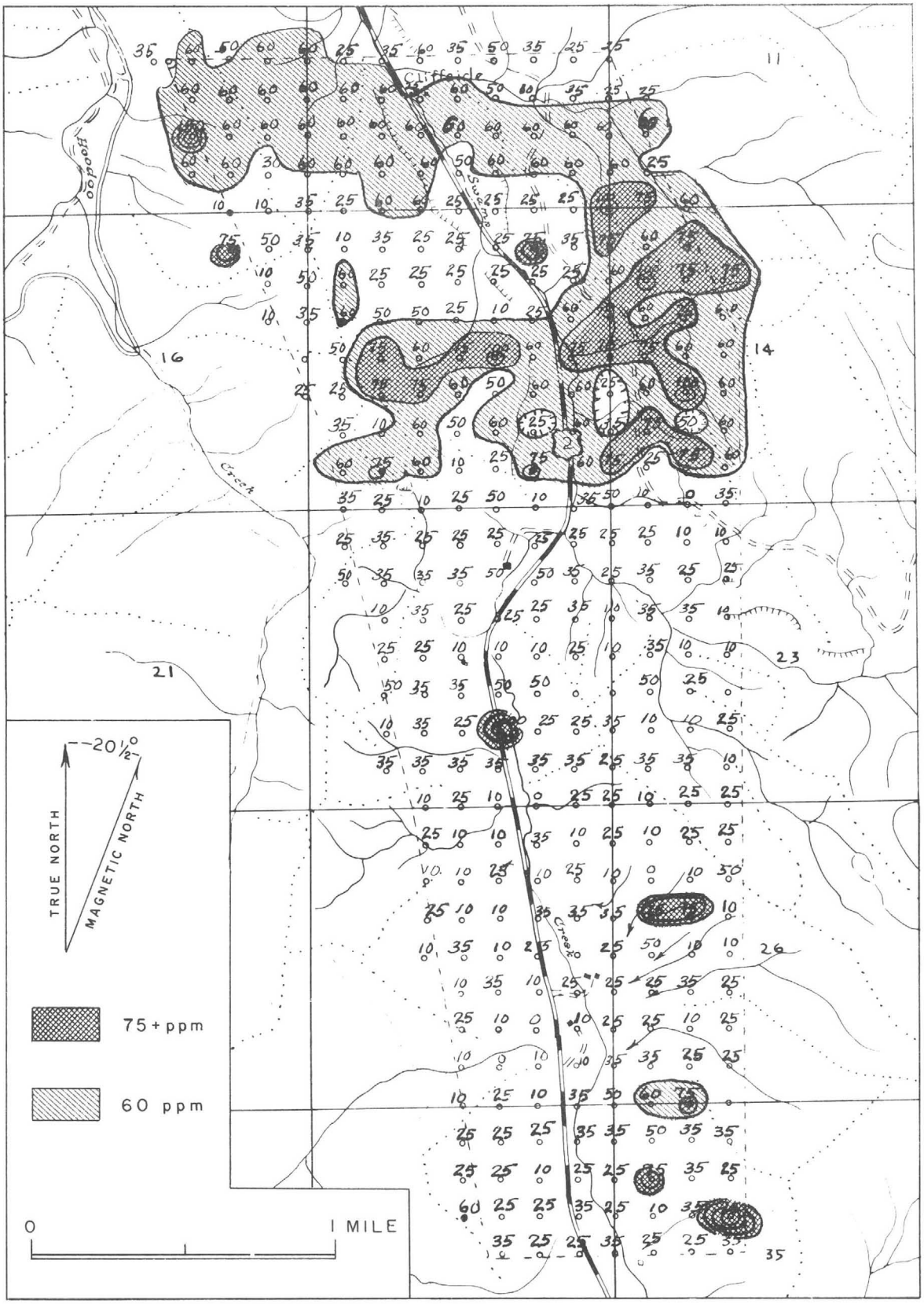

Figure 2. --Map of Swamp Creek area, T. 28 N., R. 30 W., showing soil sampling sites and copper values.

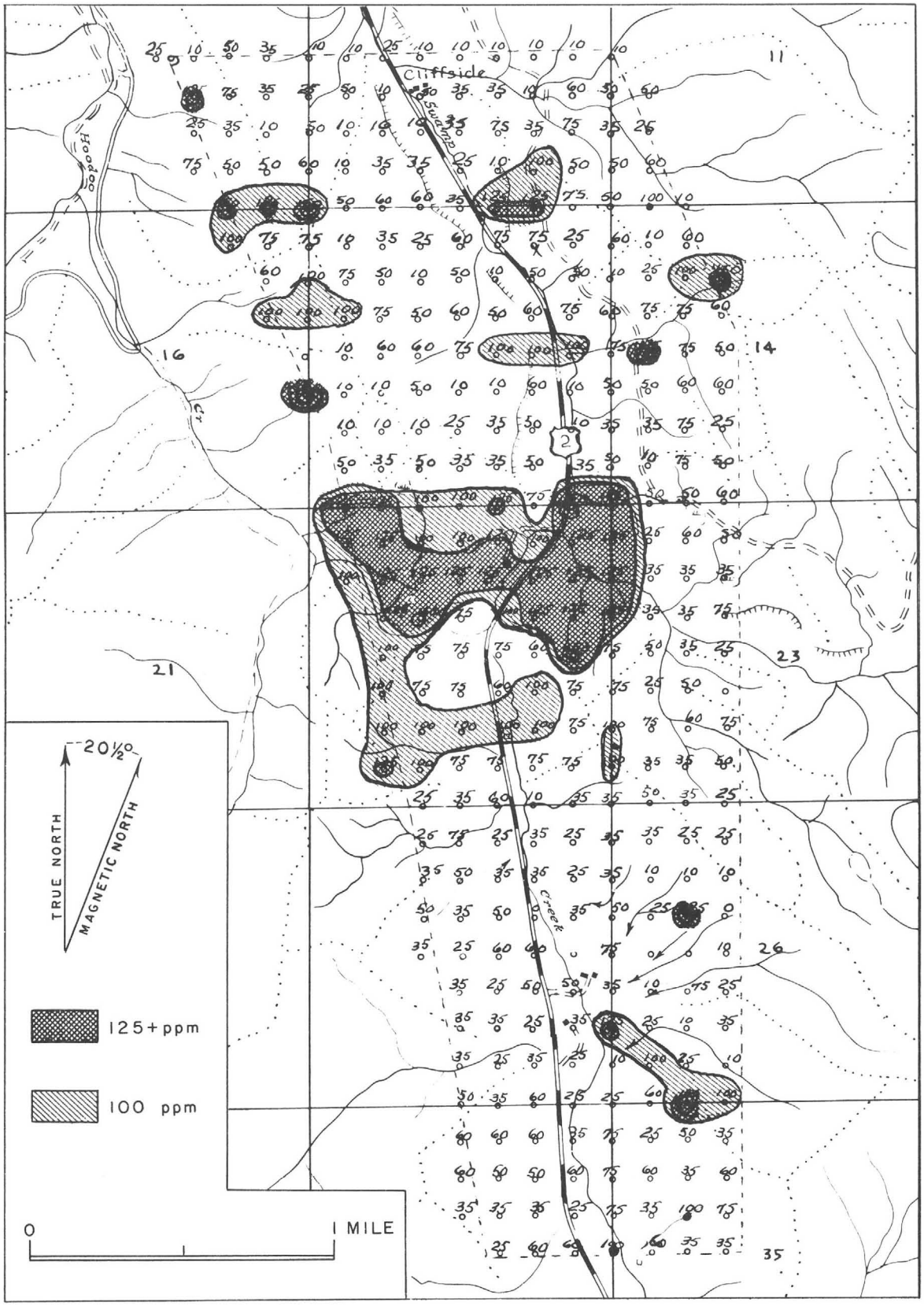

Figure 3. --Map of Swamp Creek area, T. 28 N., R. 30 W., showing soil sampling sites and zinc values.

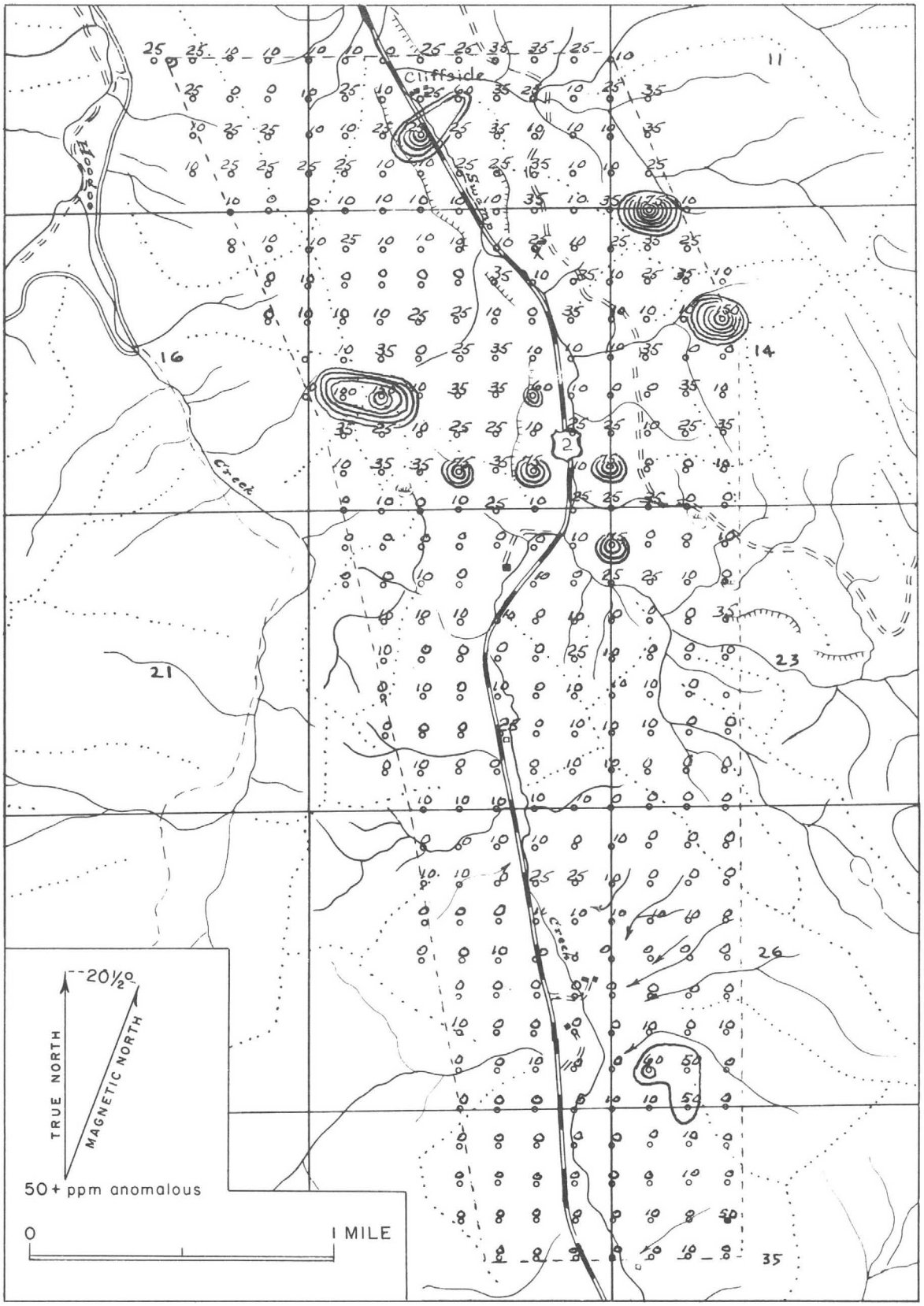

Figure 4.--Map of Swamp Creek area, T. 28 N., R. 30 W., showing soil sampling sites and lead values.

Six streams and 15 tributaries were sampled within this 110 square miles; 170 samples were collected in seven days.

Topography in the upper Wolf Creek drainage and the Star Meadows region is mountainous, although somewhat more subdued west of Wolf Creek. Maximum relief amounts to about 2,500 feet, but average relief is about 2,000 feet. Both areas are heavily forested. Elk Mountain, the highest peak in the region, stands at the head of Good Creek and attains an altitude of 6,581 feet. Most valleys are at 4,000 feet or higher. In the Star Meadows region, drainage is eastward to the Stillwater River. Wolf Creek flows south and west to the Fisher River, a tributary of the Kootenai River.

The Sheppard Creek and Wolf Creek areas are underlain by lower and middle Belt rocks; in ascending order they are the pre-Ravalli Prichard Formation, Ravalli (undifferentiated), and Piegan (Johns, 1962). The Piegan Group here is represented by the lower unit (P_1) and the Siyeh Formation.

Prichard rocks, consisting of a homogeneous sequence of laminated dark-gray, medium-gray, and light-gray sericitic argillite, are exposed along a northwest-trending thrust fault, passing west of Elk Mountain, that brings several hundred feet of upper beds of this formation to the surface. Two exposures in the sample area are east of Sheppard Peak and east of Tepee Hill.

The Ravalli Group, ranging in thickness from 7,000 to 10,000 feet and covering a fairly extensive area, is thin- and medium-bedded, white, light-gray, and purple-toned quartzite, argillaceous quartzite, and argillite, containing magnetite, biotite, and sericite. These beds form cliffs and resistant ridges.

Lower Piegan strata are exposed at Dunsire Creek, and beds of the middle unit are well exposed on Ingalls Mountain and Mt. Swaney. The lower (P_1) unit is laminated to medium-bedded gray-green calcareous argillite and noncalcareous argillite. It is conformably overlain by the Siyeh Formation (P_2) of dark-gray, purple-gray, and light-gray molar-tooth limestone and interbedded calcareous argillite. Combined thickness of these two units of the Piegan Group is about 6,000 feet.

Sparse metadiorite dikes trend east and sills trend northwest, respectively, almost perpendicular and almost parallel to the regional strike of the Belt rocks. Valleys are floored with Quaternary glacio-fluvial and fluvial gravel. Recent alluvium borders streams.

Symmetrical and asymmetrical broad to tight folds plunge north-west and southeast; northwest-trending normal faults, high-angle thrusts, and east-trending transverse faults displace the folds.

SHEPPARD CREEK SOIL SAMPLING

Three strongly anomalous copper samples were recorded (Pl. 1) in the NW$\frac{1}{4}$ sec. 8, T. 30 N., R. 25 W. (5 N, 1 E), and in the NE$\frac{1}{4}$ sec. 13, T. 30 N., R. 26 W. (7 N, 5 E and 7 N, 6 E). Copper values of 2,000, 800, and 250 ppm were determined, and values for lead and zinc were anomalous. Between Sheppard Peak and the center of sec. 18, T. 30 N., R. 25 W., anomalous copper, lead, and zinc values range from threshold to 200 ppm. In the NE$\frac{1}{4}$ sec. 12, T. 30 N., R. 26 W., on the divide separating Brush Creek from Sheppard Creek, a copper-lead anomaly was recorded. These four areas require additional investigation by means of trenching or core drilling.

Weakly anomalous copper values were recorded for samples from Brush, Dunsire, and Swanson Creeks and the area south of Star Meadows Guard Station. Those anomalous samples in the N$\frac{1}{2}$ sec. 7, T. 30 N., R. 24 W., are possibly salted by buildup of copper in swampy ground.

Lead anomalies were recorded southeast of Sheppard Peak and adjacent to Dunsire and Sinclair Creeks. Samples 8 N, 2 E, sec. 18, T. 30 N., R. 25 W., and 3 N, 7 E and 4 N, 7 E, sec. 12, T. 30 N., R. 24 W., may be unreliable because of proximity to culverts and swampy ground.

Intermittent zinc anomalies occur along an east line from the SW$\frac{1}{4}$ sec. 2, T. 30 N., R. 26 W., to Star Meadows Guard Station, a distance of 6 miles. Anomalous zinc values are fairly widespread in the S$\frac{1}{2}$ sec. 2 and 23, T. 30 N., R. 26 W.; in the N$\frac{1}{2}$ sec. 1 and 9, the S$\frac{1}{2}$ sec. 14, and sec. 18, T. 30 N., R. 25 W.; and in the NE$\frac{1}{4}$ sec. 7, T. 30 N., R. 24 W. In sec. 18, T. 30 N., R. 25 W., samples 4 N, 1 E through 4 N, 8 E gave anomalous values for zinc, and several gave weak to moderate copper values.

The upper (headwater) reaches of Sheppard Creek, including sec. 12, 13, 14, and 15, T. 30 N., R. 26 W., and sec. 7 and 8, T. 30 N., R. 25 W., show a fairly good correlation between copper and lead anomalies, and some support from zinc. This area seems to deserve more careful examination.

WOLF CREEK STREAM-SEDIMENT SAMPLING

Weakly anomalous values (Fig. 5) for copper and lead (150 ppm) were recorded in sec. 11, T. 29 N., R. 26 W., along a short tributary of Little Wolf Creek. Along upper Little Wolf Creek, weakly anomalous lead values (100 ppm) were recorded for samples in the SE$\frac{1}{4}$ sec. 10 and N$\frac{1}{2}$ sec. 24, and an anomalous copper value (150 ppm) was recorded in the NW$\frac{1}{4}$ sec. 14, T. 29 N., R. 26 W. Upper strata of the Prichard Formation underlie the sample sites; beds strike northwest and dip at low angles southwest.

The area should be investigated for copper- and lead-bearing minerals in quartz veins or disseminated in Prichard (or Ravalli) rocks.

A weakly anomalous value of 150 ppm copper for a sample in the SE$\frac{1}{4}$ sec. 31, T. 30 N., R. 26 W., and values in copper and lead of 150 ppm for a sample in the NE$\frac{1}{4}$ sec. 33 were recorded. The sample site in sec. 33 should be investigated to determine the source of the copper and lead. These sample sites are adjacent to northwest-trending anticlinal fold axes, and copper and lead might have been derived from parallel-trending quartz veins. A stream-sediment sample containing 200 ppm copper was obtained from a short tributary drainage in the NE$\frac{1}{4}$ sec. 24, T. 30 N., R. 27 W. Anomalous copper values were recorded also for two samples in upper Kelsey Creek in the W$\frac{1}{2}$ sec. 36, T. 31 N., R. 27 W. A synclinal fold axis is a short distance east of the sample site.

Anomalous copper values were recorded for several stream-sediment samples from the south and west forks of Brush Creek, a tributary of Wolf Creek. The anomalous areas were subsequently covered by soil sampling on 1/8-mile grid lines. The results are recorded on Plate 1 covering soil sampling in the Sheppard Creek area.

Weakly anomalous zinc values were obtained from two samples on a short tributary of Wolf Creek in the W$\frac{1}{2}$ sec. 27 and E$\frac{1}{2}$ sec. 28, T. 31 N., R. 26 W. A large high-angle northwest-trending reverse fault parallels an anticlinal axis in the vicinity of the sample site. Zinc minerals in sparse amounts may be related to these structures.

Anomalous copper values were recorded along Wolf Creek in the N$\frac{1}{2}$ sec. 31, T. 32 N., R. 26 W., and the SE$\frac{1}{4}$ sec. 7, T. 31 N., R. 26 W. A weakly anomalous lead value was recorded at the mouth of Weigel Creek, in the E$\frac{1}{2}$ sec. 1, T. 31 N., R. 27 W. As all sample sites are adjacent to swampy areas, copper and lead may have been concentrated by precipitation.

Correlation between copper, lead, and zinc values of samples from the Wolf Creek area is poor. Anomalous zinc was recorded in only two samples within the area and both were weak. Although only weak anomalies in copper and lead were recorded along Little Wolf Creek and its tributaries, the possibility of native gold in association with these base metals should not be overlooked.

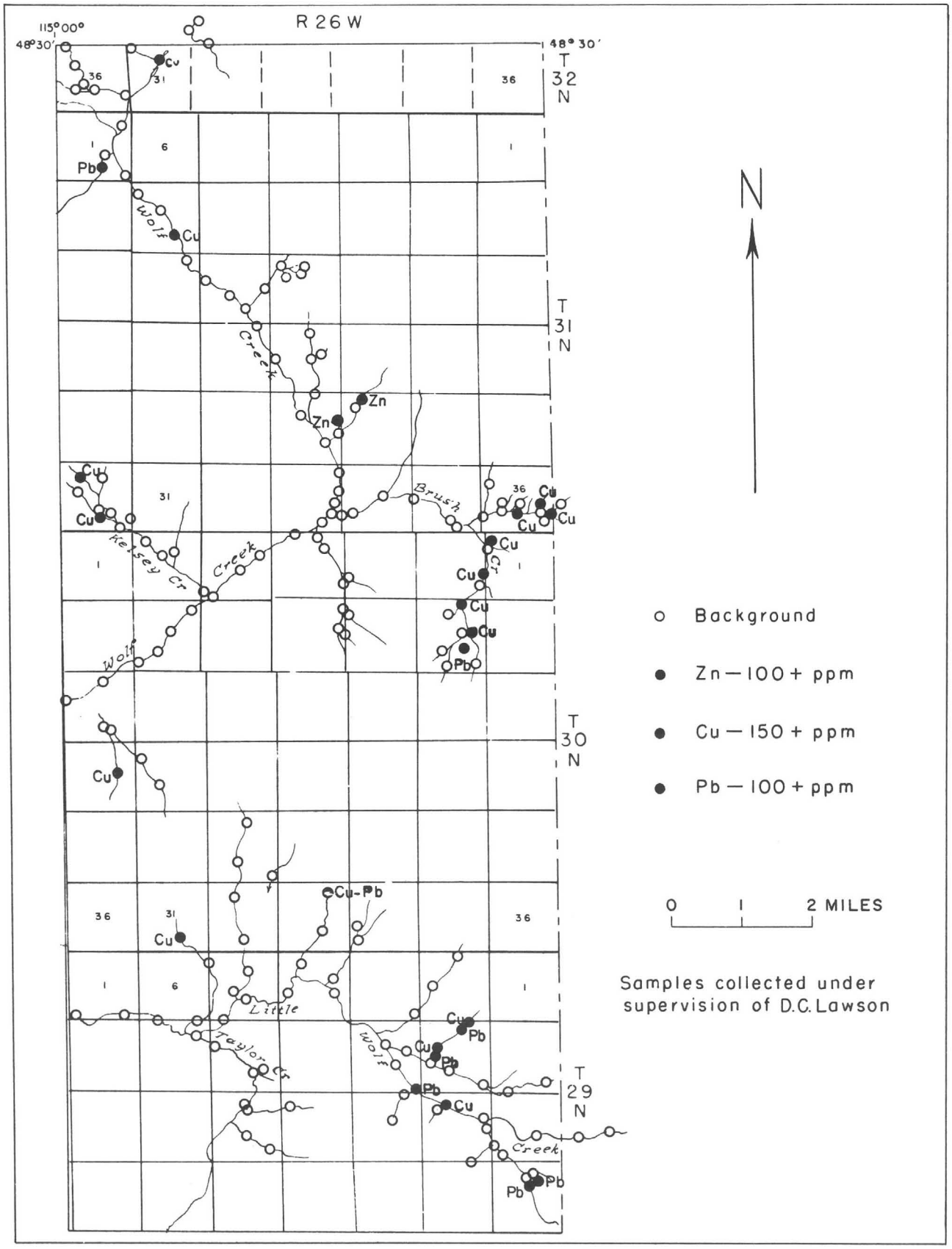

Figure 5.--Map of Wolf Creek area showing stream-sediment sampling sites.

WHITEFISH MOUNTAIN FRONT AREA

The fourth area, totaling 268 square miles, extends from the international boundary south to Upper Stillwater Lake, along the west front of the Whitefish Mountains. It is bounded on the east by the divide through Independence and St. Clair Peaks, Mt. Wam, Bald and Whitefish Mountains, and Diamond Peak. The west boundary is the east side of the Stillwater and Tobacco River valleys. During a 29-day period, 464 stream-sediment samples were collected.

The Whitefish Mountains are the southward extension of the MacDonald and Galton Ranges of southeastern British Columbia. South of the international boundary they are bounded on the west by the Stillwater-Tobacco River valleys (part of the southern Rocky Mountain trench) and on the east by the valley of the North Fork Flathead River. The south end is the northern Flathead Valley at Whitefish and Columbia Falls. Along the bold, precipitous western slope of the Whitefish Mountains, peaks attain altitudes exceeding 7,200 feet; Moose Peak rises to a height of 7,521 feet. Altitude of the Stillwater Valley ranges from 3,100 to 3,300 feet. From its head to its confluence with the Kootenai River, the valley of the north-flowing Tobacco River drops from about 3,300 feet to about 2,300 feet. Maximum relief amounts to 5,200 feet. The streams sampled drain westward to the Tobacco and Stillwater Rivers.

Along the western front of the Whitefish Mountains, rocks of the Ravalli, Piegan, and Missoula Groups crop out in northwest-trending belts parallel to the range trend. These rocks, in ascending order, are the Appekunny and Grinnell Formations of the Ravalli Group, the Piegan Group, represented by the P_1 unit and the Siyeh Formations, and the Snowslip, Shepard, and Kintla Formations higher in the Belt sequence.

The Phillips and Roosville Formations are exposed only in the central and eastern parts of the Whitefish Mountains. Purcell Lava separates the Snowslip and Shepard Formations. It is estimated to be 450 feet thick in the Mount Ksanka-Green Mountain area, but it thins uniformly southeastward and wedges out in the southeastern part of the Whitefish Mountains (Smith, 1963).

Appekunny rocks are light-gray siliceous argillite that weathers medium orange brown to brownish gray. Some beds exhibit thin laminae of alternating light- and dark-gray argillite, and the upper part of the formation is light-gray or light-greenish-gray fine-grained quartzite that weathers pale yellowish gray. Limonite specks derived from magnetite and rhombic specks of limonite possibly derived from ferroan dolomite speckle the siliceous argillite and quartzite. The formation is estimated to be at least 5,000 feet thick. It grades into the overlying Grinnell Formation.

Grinnell rocks are chiefly purplish-gray silty argillite, grayish red-purple fine-grained mud-cracked argillite, and interlaminated greenish-gray or pale-blue-green and grayish-red-purple argillite. Some light-gray or white medium-grained cross-bedded quartzite and sandstone containing purple-gray mud chips occur in the formation. Mud cracks and a few ripple marks are present. On Diamond Peak the formation attains a thickness of 2,500 feet. Total thickness for the Ravalli Group exceeds 7,500 feet.

The lower (P_1) unit of the Piegan Group is greenish-gray fine-grained argillite interlaminated with smaller amounts of light-gray silty argillite, producing a banded appearance. Some greenish-white and grayish-yellow silty argillite occurs with the green-gray rocks but makes up only a minor part of the unit. The formation is calcareous and dolomitic, the carbonate content increasing stratigraphically upward. The formation is about 1,400 feet thick in the sampled area.

A middle unit, the Siyeh Formation, is an interlaminated light- and dark-gray argillite, which is calcareous and dolomitic and cross laminated, as shown on weathered surfaces. Molar-tooth structures are common throughout the formation. Two stromatolitic limestone units in the upper part of the Siyeh are about 50 feet and 40 feet thick. The lower thicker one is a mappable unit on the western slope of the Mount Ksanka (Smith, 1963). The thickness of the Siyeh in the northwest part of the Whitefish Range is reported to be about 2,900 feet.

The Snowslip Formation is yellowish-green, yellowish-greenish-gray, and pale-green argillite interlaminated with grayish-green, greenish-gray, yellowish-green, and light-gray silty argillite, mostly calcareous. Minor amounts of grayish-red argillite are interbedded with the silty argillite, the amount increasing in abundance southeastward. The thickness of the formation ranges from 1,200 to 1,800 feet.

Purcell Lava, named the Purcell Basalt (Wilmarth, 1938), includes a basal flow and overlying flows exhibiting ropy upper surfaces and pillows and containing amygdules filled with quartz and calcite. The lava is bluish gray or grayish purple on fresh surfaces but weathers brown olive gray. About 450 feet of Purcell Lava is exposed on Mount Ksanka.

The Shepard Formation consists of light-gray cross-bedded carbonate-bearing quartzite, oolitic limestone, and some pale orange stromatolitic dolomite, all interbedded with grayish-green and gray dolomitic argillite and argillite. Quartzite and limestone strata weather grayish orange and yellowish orange. In the northern part of the sampled area the Shepard is about 180 feet thick.

The uppermost unit exposed along the west front of the Whitefish Mountains is the Kintla Formation, which consists of greenish-gray silty to sandy argillite or fine-grained quartzite and sandstone interlaminated with grayish-red-purple argillite or siltstone. Thin beds of medium-gray silty dolomite occur in the upper part of the unit. Mud chips, current ripple marks, and casts and moulds of salt crystals are present. Thickness of the formation ranges from 2,900 to 3,300 feet and averages 3,000 feet.

Tectonic activity in the western part of the Whitefish Mountains first produced large open symmetrical folds, then thrust faults contemporaneous with smaller asymmetrical west-plunging anticlines and synclines. Later deformation produced west-dipping high-angle normal faults having stratigraphic displacement amounting to as much as 10,000 feet.

Copper and zinc values slightly above threshold were recorded for only a few stream-sediment samples in the Whitefish Mountain Front area (Pl. 2). As a whole the stream-sediment sampling results within the Whitefish Mountain Front were disappointing.

On a tributary of the East Fork Swift Creek in the SE$\frac{1}{4}$ sec. 27, T. 34 N., R. 23 W., and about three-fifths of a mile southwest of Diamond Peak, weakly anomalous values for copper, lead, and zinc were recorded for one sample. Three other weakly anomalous individual copper values were recorded in the S$\frac{1}{2}$ sec. 22, T. 37 N., R. 26 W. (headwaters of Indian Creek), in the SW$\frac{1}{4}$ sec. 17, T. 35 N., R. 24 W. (headwaters of Deep Creek), and in the NE$\frac{1}{4}$ sec. 6, T. 34 N., R. 23 W. (south of Whitefish Mountain). Weakly anomalous zinc values were determined for individual samples in the NW$\frac{1}{4}$ sec. 19, T. 35 N., R. 24 W. (Deep Creek), and the S$\frac{1}{2}$ sec. 8, T. 34 N., R. 23 W. (upper East Fork Swift Creek).

APPENDIX--ANALYTICAL PROCEDURE

All soil and stream-sediment samples were analyzed in the Bureau laboratory by the pyrosulfate-fusion method for individual determinations of copper, lead, and zinc. This technique gives near-total solution of the copper, lead, and zinc in most samples of soil and rock. Dithizone is used for determining zinc by the mixed-color method. It is also used in the presence of cyanide to determine lead by means of the monocolor method. The copper, however, is determined by using 2,2'-biquinoline to form a monocolored copper complex.

The procedure for the fusion method is as follows:

> Measure 0.1 g of the sample into a 15 by 150-mm culture tube. Scoop 0.5 g of potassium pyrosulfate flux into the tube and shake the tube to mix the sample and flux. Fuse the mixture for about 2 minutes after the flux melts. Remove the tube from the flame and rotate the tube so that the melt cools in an easily digestible thin film on the sides of the tube. When the tube is cool, add 3 ml of 1:1 hydrochloric acid to the tube, and place in a hot-water bath until the melt has disintegrated. Remove the tube from the water bath and dilute the sample to 10 ml with metal-free water and shake vigorously to mix the solution. Suitable aliquots are taken from this solution for the copper, lead, and zinc determinations,* and compared colorimetrically with standards from which ion concentration is determined.

Soil and stream-sediment samples obtained from the sampled areas totaled 3,769, and 12,782 fusion analyses including 1,475 reruns were determined.

Fusion determinations for all zinc and lead analyses exceeding 70 ppm and all copper analyses exceeding 50 ppm were rerun. Samples showing only traces but which were bracketed by samples showing numerical values were reanalyzed, and any series of low samples was spot checked.

Reagent consumption for potassium-pyrosulfate fusions of 3,769 samples and 12,782 determinations amounted to $313, or about 9 cents per sample and $2\frac{1}{2}$ cents per determination.

Costs for the project were:

Total cost per square mile	$ 26.11
Total cost per sample	2.97
Total cost per sample determination. .	0.876
Total chemical cost	313.00
Chemical cost per sample	0.083
Chemical cost per determination . . .	0.025

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*The procedure used for the pyrosulfate fusions was obtained from the field-method text for the summer geochemical prospecting course taught by Prof. Harold Bloom at Colorado School of Mines.

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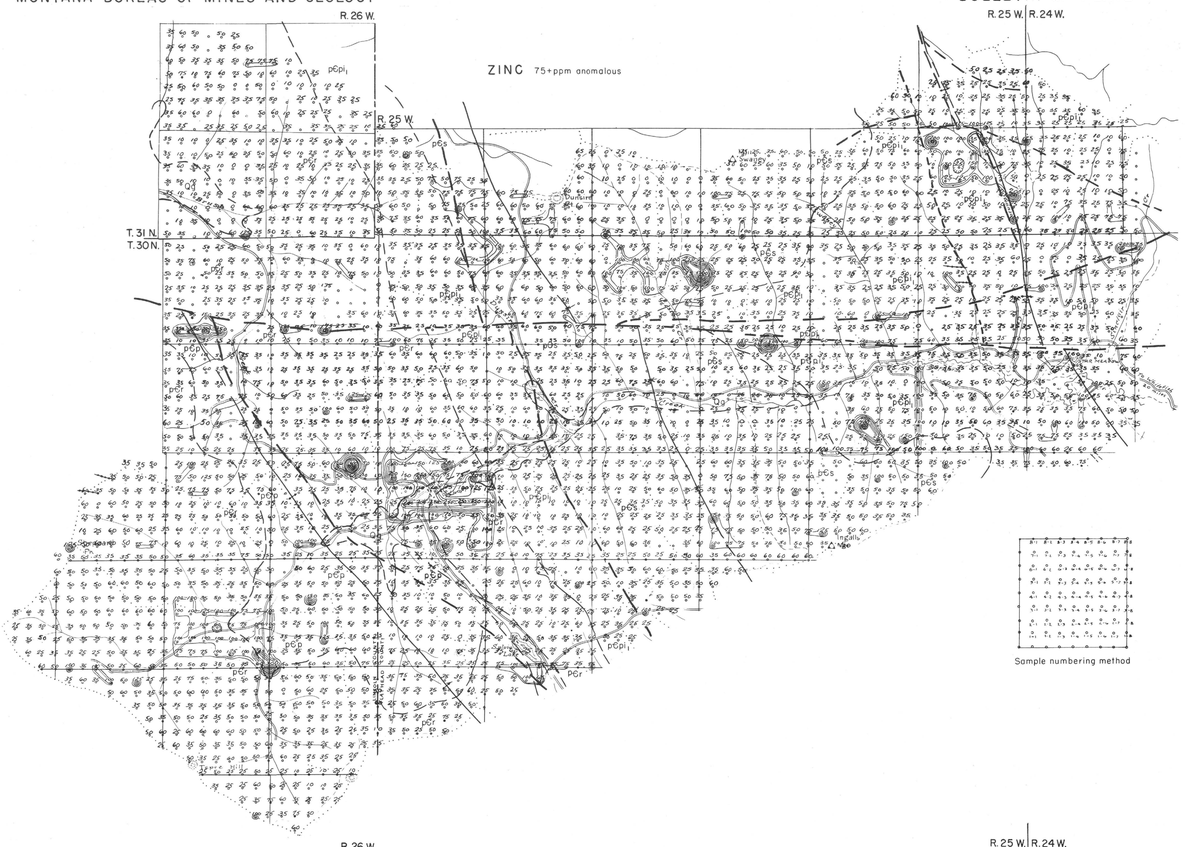
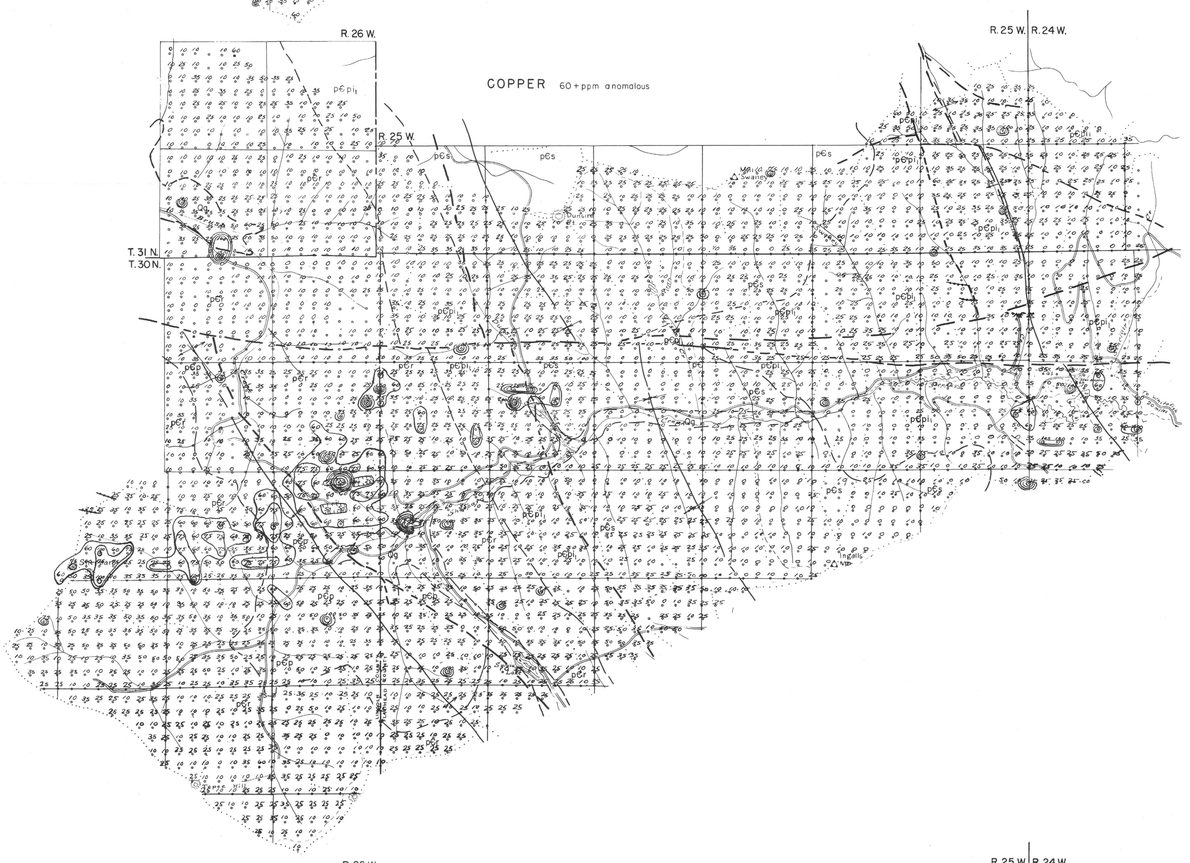
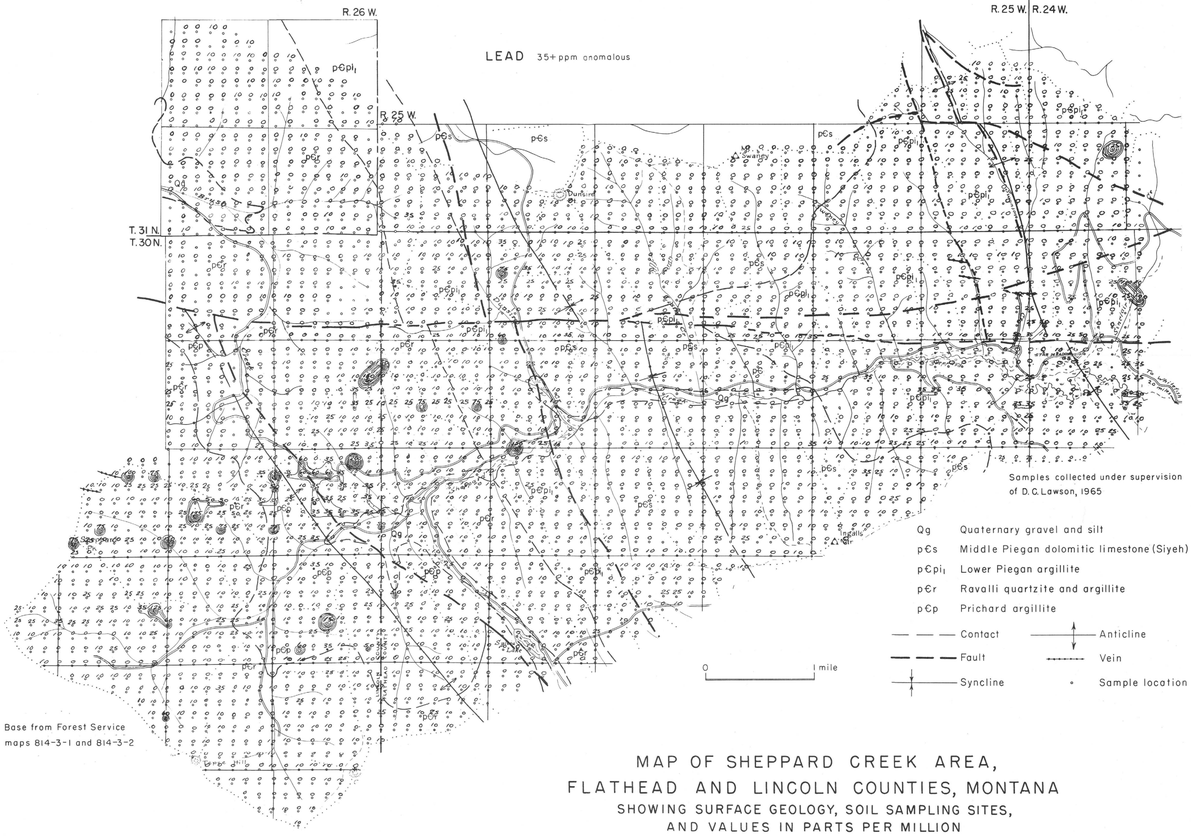


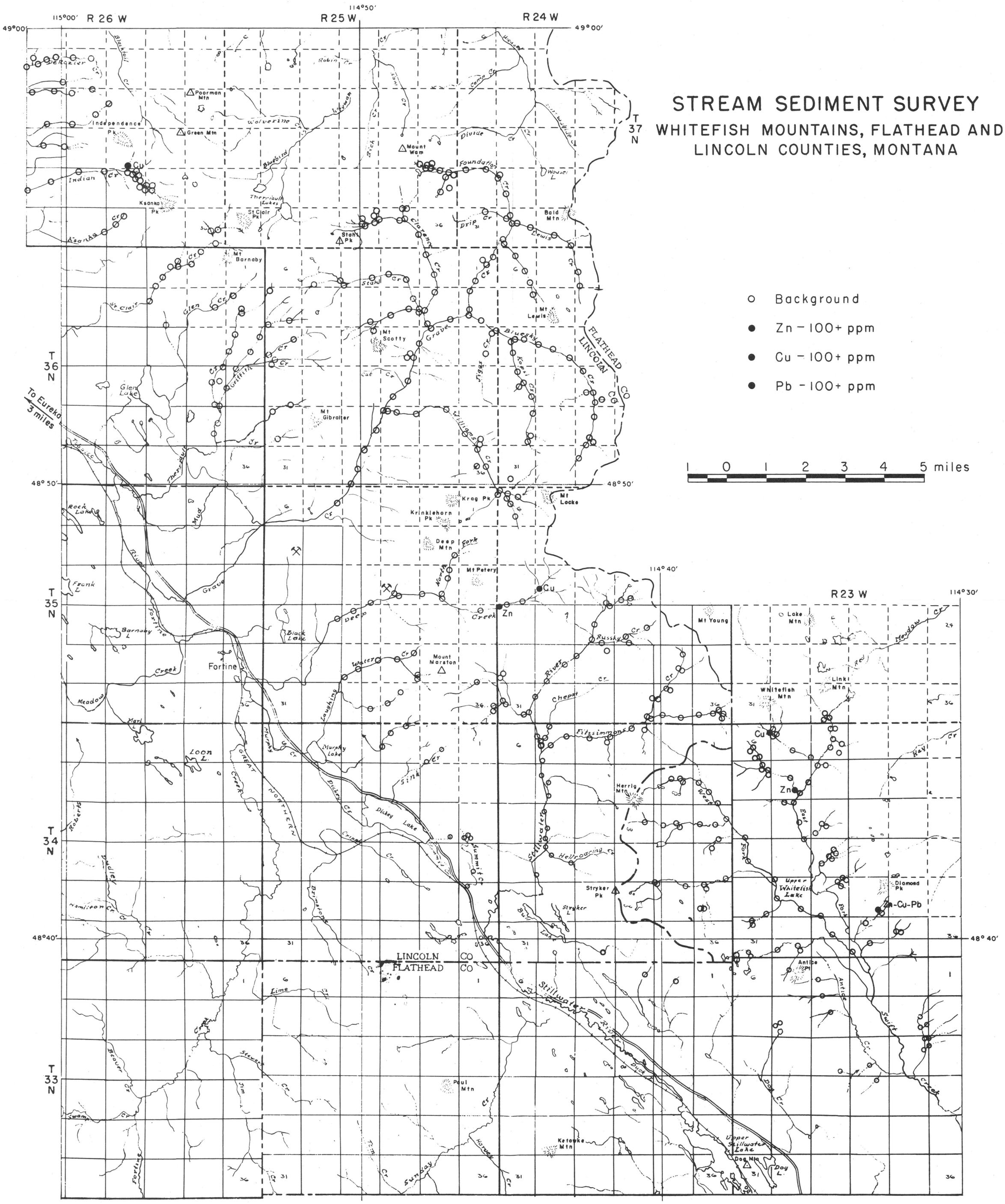




MAP OF SHEPPARD CREEK AREA,
FLATHEAD AND LINCOLN COUNTIES, MONTANA
SHOWING SURFACE GEOLOGY, SOIL SAMPLING SITES,
AND VALUES IN PARTS PER MILLION

STREAM SEDIMENT SURVEY

WHITEFISH MOUNTAINS, FLATHEAD AND LINCOLN COUNTIES, MONTANA



Background

Zn – 100+ ppm

Cu – 100+ ppm

Pb – 100+ ppm

Base from Flathead National Forest map -1965-

Samples collected under supervision of D.C. Lawson-1965-