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Geochemical Anomalies and Metalliferous Deposits Between Windy Fork and Post River Southern Alaska Range

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Abstract

Geochemical sampling between Windy Fork and Post River, southern Alaska Range, defines seven areas with anomalous concentrations of lead, zinc, silver, copper, or molybdenum in stream-sediment samples. Five of these areas contain metalliferous deposits that are spatially related to centers of hypabyssal igneous bodies. The deposits occur as replacement bodies in limestone and as replacement bodies and fracture fillings in intrusive rocks. Most of the deposits that crop out are small and discontinuous, but the number of occurrences with locally high silver content, their possible continuity beneath surficial deposits, and a favorable geologic environment suggest that this region has an economic potential for base and precious metals.

INTRODUCTION

A new region of lead, zinc, and silver mineralization was identified in the summer of 1967 during field geologic evaluation of the southern Alaska Range as part of the U.S. Geological Survey's Heavy Metals Program. One lead-zinc-silver deposit in this region has already been described (Reed and Elliott, 1968). The seven geochemical maps accompanying this report delineate other areas of anomalous concentrations of lead, zinc, silver, copper, molybdenum, and nickel in stream-sediment samples. Known mineral occurrences in these areas are briefly described.

The region described in this report is about 150 miles northwest of Anchorage, on the west side of the upper reaches of the South Fork of the Kuskokwim River. The region covers about 560 square miles and includes parts of the McGrath A-2, A-3, B-2, and B-3 quadrangles (fig. 1). It lies south of Farewell, a Federal Aviation Agency Station that maintains a 5,000-foot gravel runway. McGrath, about 62 air miles northwest of Farewell, is the nearest source of gasoline and supplies.

The region described herein is best reached by helicopter. The only road in the region is a jeep trail which extends south from the Farewell airfield along Sheep Creek for about 5 miles. From this point a four-wheel-drive vehicle with large tires can continue south along the creek for an additional 6 miles. This, however, necessitates crossing the creek several times, and crossings can be accomplished only during periods of low water. Travel by tracked vehicle is possible in the major north-south valleys (Kuskokwim River, Post River, Sheep Creek, and Windy Fork) in the winter and early spring. Small, properly equipped aircraft can land on gravel bars along the Post and Kuskokwim Rivers and Windy Fork, and on Smith, Post, and Valeska Lakes.

The region is in rugged terrain. Relief increases from north to south and averages between 2,000 and 3,000 feet; peaks in the southern part of the region crest between 6,000 and 7,700 feet in height. Timber is sparse and consists chiefly of spruce and scattered cottonwood that are restricted to the lower altitudes along the major north-south valleys.

The only previous geological investigation in this region is that made by Brooks (1911) who traversed the Alaska Range via the South Fork of the Kuskokwim River in 1902. The present report describes the mineral occurrences and results of stream-sediment sampling in part of the region that was covered during the 1967 field season. Between 15 minutes and an hour were spent examining each of the metalliferous deposits described in this report; additional mapping and physical exploration are necessary to evaluate these occurrences.

GEOLOGIC ENVIRONMENT

The part of the Alaska Range considered here is made up of Paleozoic sedimentary rocks intruded by granitic stocks, hypabyssal breccia bodies, and many felsic and mafic dikes. Tertiary extrusive rocks, including mafic flows and pyroclastic deposits with interbedded sedimentary units, locally overlie the Paleozoic rocks. Mineral deposits are spatially related to the intrusive bodies and occur as replacement deposits in limestone or in the intrusive rocks.

Sedimentary Rocks

The Paleozoic rocks consist predominantly of interbedded shale, siltstone, and argillite, but they include prominent units of thin to massively bedded gray limestone. These rocks show little or no effect of regional metamorphism. Because of the stratigraphic and structural complexity of the region, the sedimentary rocks are shown in figure 2 as one unit, with the exception of prominent limestone units. The limestone units shown locally in the southeast part of figure 2 may be Ordovician in age, whereas the limestone north of the Farewell fault is believed to be of Devonian age. Graptolites, including species of Glyptograptus and Climacograptus of Middle or Late Ordovician age (Michael Churkin, oral commun., 1968), were found in carbonaceous shale at localities F-1 and F-2 in figure 2. At Saint Johns Hill, north of the Farewell fault (locality F-3, fig. 2) several rugose corals, including Cylindrophyllum and Disphyllum of probable Middle Devonian age (Charles Merriam, oral commun., 1968), occur in thick to massive gray limestone.

Igneous Rocks

The intrusive rocks are typically porphyritic and include quartz monzonite, granodiorite, and minor amounts of quartz diorite. Most of the intrusive bodies shown in figure 2 have nearly vertical contacts and include varying amounts of igneous breccia. Many of the breccia bodies are roughly circular in plan and probably are volcanic breccia pipes that were feeders for explosive eruptions. Parts of the igneous bodies are hydrothermally altered. Narrow contact aureoles are locally developed, and in places the bordering limestone is bleached and recrystallized to hard, fine-grained, silicated marble or calc-silicate hornfels. The pelitic rocks are baked and converted to hornfels. All the known mineral deposits are spatially related to intrusive rocks.

The dike swarm shown diagrammatically in the southwest part of figure 2 appears to be related to a large intrusive body west of Windy Fork. Other dikes, too small to be shown at the scale of figure 2, are also spatially related to the intrusive bodies shown in figure 2. They are intermediate to felsic in composition, and, where they intrude limestone, skarn zones of potential economic significance may be developed. Ore minerals in the skarn are chiefly pyrrhotite and sphalerite (marmatite) with associated calc-silicate minerals, chiefly epidote and clinopyroxene.

Extrusive volcanic rock consists of flows of intermediate composition and pyroclastic deposits that are interbedded with local units of tuffaceous sandstone, siltstone, and shale. These rocks are spatially related to intrusive centers and probably belong to the same period of igneous activity. Fossil plants from sediments interbedded with the volcanics (F-4, fig. 2, USGS Paleobotany locality 11126) include Metasequoia cf. occidentalis (Newb.) Chan. and Cocculus cf. flabella (Newb.) Wolfe, of early Tertiary, probably Paleocene, age (J. A. Wolfe, oral commun., 1968).

Structure

The dominant structural grain of the Alaska Range within the region described in this report is approximately north to northeast. The region is characterized by tightly compressed north-trending folds that are locally overturned to the west. Near the mountain front, west of the area shown in figure 2, broad open folds that trend east-northeast are superimposed on the north-trending folds.

The north- to northeast-trending structural features are truncated to the north by the Farewell fault zone, a major right-lateral strike-slip crustal feature that is part of the Denali fault system (Grantz, 1966). Immediately south of the fault zone, folds are dragged to the east-northeast, and the fault zone is broken into numerous small segments. Small, hydrothermally altered, slightly serpentinized bodies of ultramafic rock (picrite?) occur locally along segments of the Farewell fault zone in this part of the Alaska Range.

The faults that trend north-northeast as shown in the southern part of figure 2 may have formed during the same period of deformation as the north- to northeast-trending folds. Parts of the broad northeast-trending valleys in the southern part of the map area probably follow large fault zones. Many small cross faults, too small to show at the scale of figure 2, border the intrusive bodies. These cross faults and related shear zones locally contain sulfide mineral deposits.

Emplacement of the igneous bodies may have been controlled by the preexisting north- to northeast-trending structural grain. In particular, a fault west of Post River that has been traced for more than 20 miles seems to have guided the intrusion of several igneous masses. From south to north these masses include a small stock with associated pyrrhotite and chalcopyrite on the West Fork of Post River (fig. 10, samples 24, 25); intrusive breccias, with associated deposits of lead, zinc, and silver, at Bowser Creek (fig. 10, area 1); and the large elongate north-trending igneous body between Sheep Creek and Post River, where tributary streams contain sediments with anomalous amounts of lead and zinc (fig. 10, area 5). This fault also appears to have been a locus of mineralization as suggested by high molybdenum values along the southern 10 miles of its length (figs. 2 and 6), by a small shear zone that contains pyrite and argentiferous galena (fig. 10, sample 22) on the south tributary of Hippie Creek, and by the vein of calcite, argentiferous galena, and pyrite on Hippie Creek (fig. 10, south part of area 5).

GEOCHEMICAL DATA

The locations of the stream-sediment samples are shown in figure 3. Analytical data for the 34 elements determined in these 556 samples have been released in an open-file report (Elliott and Reed, 1968).

Standard procedures were followed in the collection and preparation of the stream-sediment samples. Where possible, the sample was collected from the active stream channel; where this was not possible, the sample was collected from higher level stream deposits adjacent to the active channel. The samples were dried, sieved, and the minus 80 mesh fractions were analyzed for 34 elements by the six-step semiquantitative spectrographic method. The spectrographic analyses were reported in percentage or parts per million (ppm) to the nearest number in the series 0.5, 0.7, 1.0, 1.5, 3, 5, 7, 10, 15, and so on. The precision of a reported value is approximately plus 100 percent or minus 50 percent. The analysts were W. L. Campbell, N. M. Conklin, Arnold Farley, Jr., J. L. Finley, D. J. Grimes, J. C. Hamilton, A. L. Meier, R. L. Miller, H. G. Neiman, and T. A. Roemer.

Limits of detection for the six elements discussed in this report are: 1 ppm for silver, 2 ppm for copper, 5 ppm for molybdenum, 2 ppm for nickel, 10 ppm for lead, and 200 ppm for zinc. Three of the six elements considered (Ag, Mo, and Zn) either were not detected or were detected but below the limit of determination in the majority of samples. Lead was not detected in 3 percent of the samples submitted for analysis.

Six monoelemental geochemical maps (figs. 4–9) show the distribution of possibly anomalous concentrations of each of the metals. Histograms are given for each of the geochemical maps. The histograms represent the distribution of analyses of the element for the 556 stream-sediment samples shown in figure 3. The cutoff point for concentrations represented on each map was selected largely on the basis of these histograms; the selection of anomalous levels is subjective and interpretive on the part of the writers. The assignment of symbols to represent certain concentrations or ranges of concentrations is arbitrary; the same symbols on different maps do not imply an equal degree of anomaly.

Analytical results are summarized below and anomalous values are suggested for each element.

Copper.—Concentrations of copper range from 10 to 500 ppm in the stream-sediment samples. The median copper content is 50 ppm. Samples which contain 100 ppm or greater, about 14 percent of the total number of samples, are shown in figure 4. Values of 150 ppm or greater, 7 percent of the total, are considered anomalous.

Lead.—In 97 percent of the samples, lead was reported in concentrations ranging from 10 to 700 ppm. The median value is 20 ppm. Samples with a lead content of 50 ppm or greater, about 24 percent of the total number, are shown in figure 5. Lead contents of 100 ppm or greater, about 10 percent of the total, are considered anomalous.

Molybdenum.—In the majority of analyses, molybdenum was not detected. The median value is less than 5 ppm—the limit of detectability for the spectrographic method. About 18 percent of the samples contain 5 ppm or more of molybdenum; these are shown in figure 6. Molybdenum concentrations of 10 ppm or greater, about 7 percent of the total, are considered anomalous.

Nickel.—The content of nickel in the samples ranges from 2 to 300 ppm, and the median value is 50 ppm. About 6 percent of the samples had contents of 100 ppm or greater; all are shown in figure 7. It is questionable whether any of these amounts should be considered truly anomalous; rather, they may represent an area of locally higher background concentrations related to small mafic or ultramafic bodies.

Silver.—In the majority of samples, silver was not detected. The median value falls below the 1-ppm limit of detectability for the analytical method. Samples with a silver content of 1 ppm or greater, or about 8 percent of the total number, are considered anomalous and are shown in figure 8.

Zinc.—In the majority of stream-sediment samples, zinc was not reported. The median value is probably well below the 200-ppm minimum detectability of the analytical method. Samples which contain 200 ppm or greater, about 15 percent of the total, are shown in figure 9. Amounts of 300 ppm and above, 10 percent of the total, are considered anomalous.

AREAS OF ANOMALOUS METAL CONCENTRATIONS

The six monoelemental geochemical drainage maps show seven areas with anomalous concentrations of two or more metals. These areas, shown in figure 10, are:

Area and location	Anomalous metals
1. Bowser Creek	Pb, Zn, Ag, Cu
2. Between Rat Fork and Ozzna Creek	Pb, Zn, Ag, Cu
3. South of Ozzna Creek	Pb, Zn, Ag
4. Southwest of Smith Lake	Pb, Zn, Cu
5. Between Sheep Creek and and Post River	Pb, Zn
6. Southwest of Saint Johns Hill	Zn, Cu, Mo, Ni
7. Jay Creek area	Mo, Pb

Areas 1–5 contain deposits of sulfide minerals, and a brief description of these deposits is given below. As yet, no metal deposits have been found in areas 6 and 7; therefore, the reason for the anomalous metal concentrations in these areas is uncertain. The location of bedrock samples described below is also shown in figure 10.

Area 1

Bowser Creek drains an area of known lead, zinc, and silver deposits previously described (Reed and Elliott, 1968). The deposits in this area are (1) argentiferous galena-sphalerite or sphalerite-pyrrhotite deposits in limestone, and (2) pyrrhotite-sphalerite fracture fillings in igneous breccia. The deposits in limestone are replacement bodies and fissure veins; some chip samples show as much as 14.7 percent zinc and 52 ounces of silver per ton. Stream-sediment samples from this creek serve as a basis of reference in interpreting lead-zinc-silver values of other areas sampled.

The location of stream-sediment samples, areas of sulfide mineralization, and sampling profiles along Bowser Creek are shown in figure 11. The sampling profiles show, in general, an increase in Pb, Zn, Ag, and Cu as the mineralized areas are approached. The sampling profiles also show that metal concentrations diminish rapidly downstream from the known sulfide deposits. Within 1½ miles from the deposits all metal concentrations fall below levels considered anomalous for the region in general. One possible explanation for this short metal train is that Bowser Creek is in an area of high relief, and colluvium from valley slopes is constantly being supplied to the creek. In many places, steep talus slopes feed directly into the creek. Thus, a rapid dilution of the sediment anomaly begins as soon as the stream leaves the source area. Other factors such as the pH of the stream (limestone forms a large percentage of rocks in the drainage area) may also influence the extent of the anomaly.

Most of the high metal values in Bowser Creek are related to areas of known sulfide deposits (fig. 11; and Reed and Elliott, 1968). However, the highest metal contents (Cu, 500 ppm; Pb, 700 ppm; Ag, 7 ppm; and Zn, 2000 ppm) are from the northeasternmost tributary to Bowser Creek, an area not examined. This drainage area should be investigated.

Area 2

Stream-sediment samples from the headwaters of Rat Fork and Ozzna Creek show anomalous contents of copper, lead, zinc, and silver. The headwaters of these two creeks are separated by the southern part of a dumbbell-shaped intrusive (fig. 2) that forms a prominent peak at an altitude of 6,657 feet. Because of the extremely rugged terrain, this intrusive was not examined, but it is probably quartz diorite inasmuch as quartz diorite porphyry dikes cut limestone and argillite in the nearly vertical 1,500-foot-high cirque walls at the headwaters of Rat Fork. Skarn zones 2 to 10 feet wide that contain pyrrhotite, sphalerite, and chalcopyrite are associated with some of the quartz diorite porphyry dikes (samples 1 and 2, fig. 10, table 1). The intrusive cuts limestone, siltstone, and argillite. Rocks near the north and west contacts of the southern part of the intrusive are intensely altered and dark reddish and yellowish brown. Boulders of pyrrhotite and sphalerite, pyrite-phrrhotite-galena-sphalerite-arsenopyrite, or pyrite and bluish-gray magnetite are abundant near the headwaters of Ozzna Creek and Rat Fork and in the talus slopes adjacent to the intrusive (samples 3–5, fig. 10, table 1).

One of the boulders (sample 3, table 1), about 14 inches in diameter, assayed 9.6 ounces of silver per ton (300 ppm), more than 10 percent of lead, and 7 percent of zinc.

The anomalously high metal content of the stream-sediment samples, the intense alteration along the intrusive contacts, and the locally derived sulfide boulders with high metal content indicate that this area merits further investigation.

Area 3

Sediment samples from the main northwest-flowing tributary to Ozzna Creek show high values for lead, zinc, and silver. This stream drains the northern part of a roughly circular igneous body about 2 miles in diameter (fig. 2). The body forms a prominent 7,205-foot peak which is surrounded by complexly folded argillite, limestone, and siltstone. Talus from adjacent slopes is chiefly coarse igneous breccia with clasts ranging from less than 1 mm (millimeter) to more than 18 inches in diameter. The clasts are angular to subangular and consist of fine-grained dioritic rock, argillite, silicated limestone, and quartz-feldspar fragments. The clasts are embedded in an aphanitic greenish-gray matrix. Other lithologies in the talus are greenish-gray lithic tuff and yellowish-gray felsic tuff. The composition and texture of the talus material adjacent to the body, the shape of the body, and its nearly vertical contacts suggest that it may be a breccia pipe. The nearly flat-lying horseshoe-shaped outcrop of flows and lithic tuffs 2 miles southwest of the peak (fig. 2) is probably related to this igneous center. The center also may contain pyroclastic material. Felsic dikes, chiefly quartz monzonite porphyry, and mafic dikes cut the sedimentary rocks. Relations between the dikes and the main igneous body are not known.

Sulfide mineral deposits are exposed at an altitude of about 4,750 feet on the valley wall south of the northwest-flowing tributary. The area is intensely stained by iron oxide. The deposits are small pods and narrow lenses of pyrrhotite (which contains euhedral pyrite crystals), sphalerite, and argentiferous galena. Galena appears to replace pyrrhotite and sphalerite. Veinlets of calcite cut all the sulfide minerals. The deposits are along shear zones in a felsic dike. The shear zones are subvertical and strike N. 55° E. Sporadically distributed sulfide minerals extend updip along the shears for about 150 feet; their downdip distribution is obscured by talus. The pods, although locally quite rich (samples 7 and 8, table 2), are small, ranging from 0.5 foot to 2 feet in width and from 1 foot to 3 feet in length. Some pods are connected by sulfide veins 1 to 3 inches thick. A selected sample of galena contained 52.2 ounces of silver per ton (sample 8, table 2), but a 10-foot chip sample across two pods in the dike yielded less than half an ounce of silver per ton, 1.5 percent of lead, and 1 percent of zinc (sample 6, table 1).

Another lens of sulfide minerals, about 200 feet west of where samples 6–8 were collected, is along an east-striking fault zone that cuts igneous breccia and a series of felsic and mafic dikes (samples 9 and 10, fig. 10, table 2). The fault zone is 3 to 15 feet wide, dips vertically, and shows intensive hydrothermal alteration. The sulfide lens has a maximum exposed width of 4½ feet. It pinches out within 20 feet upward and to the west. Possible extensions below and east of the outcrop are covered by talus. Ore minerals in the lens are pyrrhotite, argentiferous galena, pyrite, and sphalerite. The galena appears to be late and cuts the pyrrhotite. A selected sample of galena, sphalerite, and pyrrhotite from this lens (sample 10, table 2) contains 70.4 ounces of silver per ton, 11.3 percent of lead, and 7 percent of zinc. The chip sample across the lens (sample 9, table 2) shows moderate amounts of lead, zinc, and silver.

The exposed deposits in this area are small but locally rich. Additional prospecting, mapping, and physical exploration is necessary to further define their extent and tenor.

Area 4

Stream-sediment samples in the northern half of area 4 are characterized by moderately high concentrations of copper, lead, and zinc, and sediment from a stream in the southern part of the area contains 10 and 15 ppm of molybdenum. A small stock of quartz monzonite or granodiorite porphyry cuts limestone, siltstone, and argillite in the southern part of this area (fig. 2). Shear zones in dikes near the north side of the stock contain sphalerite and pyrrhotite in small lenses (tables 1 and 2, samples 11-13). Contacts of the stock were not investigated, and only scattered stream-sediment samples were obtained from the south and west drainages of the stock.

Area 5

Streams that drain the eastern margin of the elongate north-trending igneous complex in area 5 are characterized by anomalous lead and zinc values. Other scattered anomalous lead and zinc values occur north and south of the igneous body.

This large igneous complex consists of porphyritic felsic intrusives in the form of dike swarms and small stocklike bodies, with local capping flows and pyroclastic units. The bordering rock is chiefly limestone with subordinate amounts of argillite and siltstone.

Sulfide minerals occur in small veinlets and along shear zones in this area (table 1, samples 14-17). The largest deposit seen is a calcite vein in limestone on Hippie Creek (samples 18-21, fig. 10, tables 1 and 2). The vein contains pyrite and argentiferous galena in scattered grains and as discontinuous bands 1 to 10 inches wide. It also contains minor amounts of arsenopyrite. The vein strikes east-northeast, dips vertically, and is exposed discontinuously for about 100 feet along the creek where it appears to be along a fault. The vein has a maximum width of 6 feet and narrows eastward to about 6 inches. To the west the vein is covered by surficial deposits. Lead values downstream from the vein are low, but slightly anomalous lead values upstream, and a similar occurrence of calcite, pyrite, and galena in a narrow shear (sample 22, fig. 10, table 1), suggest that other lead-silver occurrences may be present.

Viewed individually, these small deposits have no apparent economic significance, but they might justify some prospecting for larger concealed deposits.

Many anomalous metal concentrations are from stream-sediment samples taken from large streams where dilution would be at a maximum. Small cobbles containing lead and zinc sulfides were found in most streams draining the igneous mass. Stream-sediment sampling should be undertaken in all the small streams to delineate the areas of anomalous metal concentrations.

Area 6

Stream-sediment samples from the creek draining the mountain front southwest of Saint Johns Hill show anomalous concentrations of copper, molybdenum, zinc, and nickel. Only a geochemical reconnaissance was made in this area, and bedrock data are not available.

Aerial reconnaissance and photointerpretation suggest that the area consists of limestone, overlain locally by Tertiary lava flows and interbedded sediments. Area 6 is structurally complex and is cut by segments of the Farewell fault zone. The anomalous nickel values may be related to mafic or ultramafic bodies that are emplaced locally along segments of the Farewell fault in this part of the Alaska Range. The source of the copper, molybdenum, and zinc in the sediments is not known.

Area 7

Several stream-sediment samples from Jay Creek show anomalous values for molybdenum and one high value for lead. Sulfide deposits are not known to occur in this drainage--an area underlain chiefly by siltstone, shale, and limestone.

The lead anomaly, which is in a creek that drains the west side of the intrusive breccia at Bowser Creek, probably reflects lead deposits farther upstream near the intrusive contact.

The anomalous molybdenum values at Jay Creek and in the southern part of the map area (fig. 6) cannot be readily explained. Their distribution does not correspond to exposed igneous rocks, but the highest values (10-30 ppm) trend in a northeast direction and show a strong correlation with the faults shown in figure 2. South of the map area stocks and batholiths are present; it is possible that the molybdenum values represent "leakage" of metal-bearing fluids that have migrated upward along the faults from buried intrusive rocks. Metal values in stream-sediment samples downstream from the trace of the faults would be expected to show the effects of sediment dilution; such is the case at Jay Creek.

AGE OF MINERALIZATION

Most of the geochemical metal anomalies and all the known mineral deposits in the region are spatially related to the igneous centers. Many of the deposits are skarn deposits in limestone near granitic bodies or felsic dikes, and others occur within the dikes or granitic bodies themselves. The ore-mineral assemblages include two or more of the following: Pyrrhotite,

Table 1.--Semiquantitative spectrographic analyses and gold

[Analysts: Arnold Farley, Jr., J. Finley, D. J. Grimes, J. C. Hamilton, H. G. ported in the series 0.1, 0.15, 0.2, 0.3, 0.5, 0.7, 1.0, 1.5, and so on, shown; >, greater than value shown; M, greater than 10 percent; ND, not Limit of detectability given by symbol defined at bottom of table. Results percent. Locations and sample numbers are shown in figure 10]

Location	Limit of dectability	Sample No.	Lab. No.	Field No.	Ag	As	Au	Ba	Bi	Cd	Co	Cr
Area 2	**	1	ACJ523	67AMa413	50	N	0.03	7	15	N	150	<5
	**	2	ACJ517	Ma407	3	N	.04	5	N	300	20	30
	†	3	ACG886	Ma272B	300	100,000	.04	7	N	500	N	2
	**	4	ACJ527	Ma415	1.5	N	.06	N	N	N	50	15
	**	5	ACJ136	Er317	30	500	ND	30	N	50	70	<5
3	**	6	ACJ433	67ARa468A	15	N	.08	50	10	200	10	15
4	†	11	ACG021	67AEr359A	2	N	.05	1,000	N	N	15	50
	†	13	ACJ028	R392	7	N	.04	30	N	N	150	2
5	†	14	ACG659	67AR291A	70	N	.04	15	70	200	30	30
	†	15	ACG665	R294B	1.5	N	.05	15	N	N	20	7
	**	16	ACJ448	R480	30	N	.06	1,500	N	100	30	7
	*	17	ACG549	Er187	7	<200	.03	<100	<10	<20	70	N
	†	18	ACG638	R266A	200	3,000	.05	20	N	500	15	3
	†	19	ACG640	R266C	700	5,000	.04	15	N	300	N	1.5
	**	20	ACG758	Ma159B	150	1,500	<.02	10	N	500	N	7
South tributary to Hippie Creek	*	22	ACG831	67AMa235	>1,000	1,000	.06	<100	<10	<20	<10	10
Northeast of area 2	†	23	ACJ106	67AEr260	1	N	<.02	20	100	700	7	20
West Fork-Post River	†	24	ACJ574	67AEr220A	50	30,000	.1	20	150	N	100	5
	†	25	ACJ575	Er270B	10	N	.1	7	N	N	150	10
	†	Limit of detectability			1	2,000	.02	2	10	50	3	1
	*	---------do----------			.5	200	.02	100	10	20	10	10
	**	---------do----------			.5	200	.02	5	10	20	5	5

Sample	Description
1	Chalcopyrite-pyrrhotite and sphalerite in 4-foot-wide skarn adjacent to quartz diorite dike.
2	Pyrrhotite-sphalerite-chalcopyrite skarn, 2 feet wide.
3	Pyrrhotite-pyrite-sphalerite-galena-arsenopyrite boulder, 14 inches in diameter.
4	Magnetite-pyrite boulder.
5	Pyrite-sphalerite-galena in silicated limestone.
6	Sample across altered felsite dike containing two pyrrhotite-sphalerite-galena pods, 1 to 2 feet wide and localized along shear zones.
11	Several light-gray sheared, fractured, and altered felsite porphyry dikes that cut argillite and limestone. Sulfides, chiefly pyrrhotite and sphalerite, occur sporadically as small pods and lenses along shear zones in dikes. Sample 11, across a 2-foot-wide pod that pinches out upward in 3 feet; lower extension covered, includes 3 feet of dike.
13	Discontinuous veins and pods of pyrrhotite in argillite and limestone. Size of bodies variable: 1 to 4 feet wide, as much as 20 feet long; locally adjacent to quartz-feldspar porphyry dikes. Intrusive to south is granodiorite or quartz monzonite porphyry; several oxidized pods seen from a distance in north-facing cirque walls.

analyses of bedrock samples from the Windy Fork - Post River area

Neiman. Analyses unless noted, are semiquantitative spectographic and are re-
or by the following symbols: N, not detected; <, detected but below value
determined; I, interference. Analyses for gold are by atomic absorption.
are given in parts per million except for Fe, Mg, Ca, Ti, which are given in

Cu	Mo	Mn	Ni	Pb	Sb	Sn	Zn	Fe	Mg	Ca	Ti	Sample type
>20,000	N	700	30	50	N	70	1,500	20	3	3	0.01	Selected.
1,000	N	700	30	50	N	10	>10,000	15	1	1	.1	Do.
3,000	N	1,500	N	M	700	15	70,000	M	.05	3	.003	Stream boulder.
1,500	N	300	70	N	N	100	200	20	2	2	.05	Float in talus.
1,000	N	70	30	20,000	<100	N	10,000	15	.07	<.05	.0015	Stream cobble.
150	N	500	10	15,000	N	N	10,000	7	.7	1	.1	Chip;[1] 10—1.
1,000	N	200	20	100	N	N	50,000	10	2	.5	.3	Chip;[1] 5—1.
3,000	N	70	150	70	N	N	3,000	M	.07	.07	.007	Grab.
7,000	N	1,500	N	5,000	N	30	10,000	M	.7	M	.015	Stream cobble.
7,000	N	3,000	15	200	N	15	1,500	7	3	M	.15	Selected.
1,500	N	700	2	20,000	N	N	>10,000	10	.7	.15	.2	Do.
2,000	I	1,500	15	70	N	I	3,000	>20	.7	2	.03	Stream cobble.
700	N	300	3	20,000	<200	30	100,000	M	.03	3	.015	Selected.
3,000	N	300	3	70,000	300	150	70,000	M	<.005	.3	.0015	Do.
1,500	N	5,000	N	>20,000	200	200	>10,000	15	.5	5	.015	Selected.
300	I	1,500	<2	>5,000	3,000	I	>10,000	10	.3	2	.03	Selected.
10,000	5	1,500	5	10,000	N	N	70,000	10	3	7	.1	Selected.
5,000	N	30	7	20	N	N	700	M	.7	.02	.02	Selected
15,000	N	100	50	10	N	N	700	M	1.5	2	.03	Selected.
1	3	1	3	10	200	10	200	.001	.005	.005	.0002	
2	5	20	2	10	100	10	200	.05	.02	.05	.002	
2	5	20	2	10	100	10	200	.05	.02	.05	.002	

[1]/For chip samples: First number is length of chip in feet, second number is interval between chips; that is, 5—1 is a 5-foot-chip sample with chips collected every foot.

Sample	Description
14	Pyrrhotite with minor sphalerite and chalcopyrite.
15	Narrow malachite-stained shear (strike north, dip 80° E.) in limestone. Limestone is altered yellowish gray within 2 to 5 feet of shear. Sparse sulfides (chiefly chalcopyrite) localized within 1 foot of shear for about 20 feet along dip.
16	1-inch-wide seam of pyrite and galena in altered light-gray porphyritic dike.
17	Pyrrhotite with a trace of chalcopyrite and sphalerite.
18	Pyrite with some galena.
19	Pyrite, galena, and arsenopyrite from 10-inch-wide sulfide band in calcite vein.
20	Calcite with pyrite and galena.
22	Narrow 1- to 3-inch shear containing sulfides in massive gray limestone. Shear is 2 feet from contact and parallel to a 20-foot-thick brownish-gray pyrite-bearing felsite porphyry sill (strike N. 35° W., dip 75° SW.). Shear discontinuously mineralized; chiefly calcite, pyrite, and galena.
23	Highly oxidized northeast-striking fault(?) zone about 8 to 10 feet wide between argillite and limestone. Selected sample of oxidized material from zone includes pyrrhotite with subordinate sphalerite, galena, and chalcopyrite that replace silicated limestone.
24 and 25	Scattered small lenses 6 to 8 inches wide and disseminations of pyrrhotite in mafic dikes that cut argillite adjacent to a small stock. Samples include minor chalcopyrite and sphalerite.

Table 2.--Partial analyses of bedrock samples from areas 3, 4, and 5

[Analysts: W. D. Goss, Claude Huffman, Jr., L. B. Riley, V. E. Shaw, and E. J. Fennelly. Copper, lead, and zinc determined by atomic absorption, gold, by fire assay, and silver by gravimetric fire assay]

Area (shown in fig. 10)	Sample No.	Lab. No.	Field No.	Au (ppm)	Ag (oz/ton)	Cu (percent)	Pb (percent)	Zn (percent)	Sample type
3	7	ACJ434	67AR468B	0.03	17.3	0.05	24.4	11.2	Selected.
	8	ACJ436	AR469B	.1	52.2	.01	60.0	1.9	Do.
	9	ACJ437	AR470A	<.02	17.9	.08	5.5	5.0	Chip;1/ 7—1
	10	ACJ438	AR470B	<.02	70.4	.1	11.3	7.2	Selected.
4	12	ACJ023	AR3590	<.02	2/.4	.15	.04	7.6	Do.
5	21	ACG849	67AMa247A	<.02	2/2.2	.03	4.8	.63	Chip;1/ 7—0.5

1/For chip samples: First number is length of chip in feet, second number is interval between samples; that is, 7—0.5 is a 7-foot chip sample with chips collected every 0.5 foot.
2/Analyses by atomic absorption.

Sample No. and description of sample (minerals listed in order of abundance)

7 --------- Pyrrhotite-sphalerite-galena-pyrite from sulfide lens in dike.
8 --------- Galena-pyrrhotite-sphalerite and pyrite from sulfide lens in dike.
9 --------- Across 4 1/2-foot-thick lens of sulfides, and 2 1/2 feet of altered, brecciated felsite dike.

Sample No. and description of sample (minerals listed in order of abundance)--Continued

10 ----- Pyrrhotite-galena-sphalerite-pyrite from same lens as chip sample 9 above.
12 ----- From pod of pyrrhotite and sphalerite; description of occurrence in table 1, sample 11.
21 ----- Across calcite dike containing 2- to 6-inch-thick bands of pyrite and galena.

pyrite, sphalerite (marmatite), and argentiferous galena-which indicates, perhaps, a general contomppoporaneity of the metallization. If the extrusive volcanics and interbedded sedimentary rocks of early Tertiary age are indeed coeval with the period of hypabyssal igneous activity, as suggested by their proximity to the intrusive bodies, then a Tertiary age is indicated for the metallization as well. In other parts of the southern Alaska Range, including the Iliamna area, sulfide mineral deposits are associated with the granitic plutons of Late Cretaceous and Tertiary age (Reed, 1967; B. L. Reed and M. A. Lanphere, written commun., 1968).

SUMMARY AND CONCLUSIONS

Studies of stream-sediment samples have defined seven areas of anomalous metal concentrations in a part of the southern Alaska Range. In these areas, concentrations of copper, lead, and zinc in stream-sediment samples fall off rapidly within a mile of sulfide occurrences, and values considered to be anomalous for these elements are not present more than 1½ miles from the deposits. Sediment dilution due to the addition of large amounts of colluvium from steep valley slopes is probably an important factor controlling the length of observed metal trains.

Five of the geochemically anomalous areas contain metalliferous deposits that are related spatially and perhaps genetically to Tertiary(?) igneous centers. The deposits occur as replacement bodies and fracture fillings in intrusive rocks. Many of the deposits in limestone are narrow skarn zones associated with felsite dikes. The skarn typically contains the ore minerals pyrrhotite and sphalerite (marmatite). Deposits in intrusive rocks occur as fracture fillings in igneous breccia, as at Bowser Creek (Reed and Elliott, 1968) and, more commonly, as narrow discontinuous sulfide bodies along shear zones in felsite dikes.

Further examination of the region should include study of the contacts of the igneous bodies shown in figure 2, with special emphasis on associated dikes. Limestone, where it is in contact with the hypabyssal bodies and associated dikes, is a favorable host for lead, zinc, and silver deposits in skarn. In addition, sampling of sediments in all the smaller streams draining intrusive contacts should be done.

Aerial reconnaissance south of the region described in this report indicates the presence of sedimentary rocks, including limestone, that are intruded by stocks and batholiths. The local development of contact aureoles and zones of alteration suggests that this region also merits consideration by the prospector.

Although the exposed mineral deposits described in this report are small and sporadic, they are locally rich in lead, zinc, or silver, and they occur in a geologic environment that offers some promise for the occurrence of larger deposits. Additional geologic mapping, geochemical studies, and prospecting or exploration will be required to fully evaluate the mineral potential of this region.

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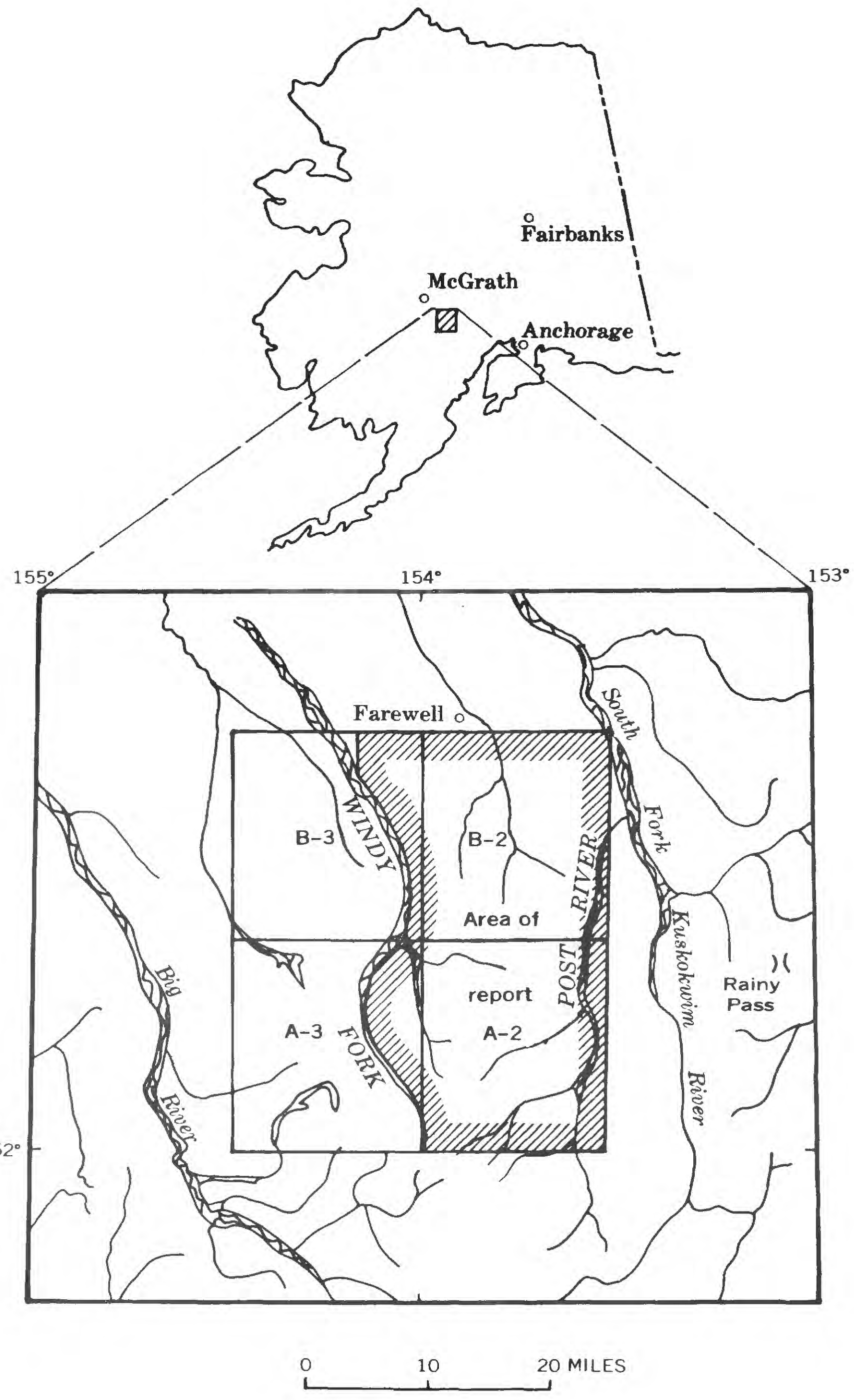

Figure 1.—Index map showing report area and location of McGrath A-2, A-3, B-2, and B-3 quadrangles.

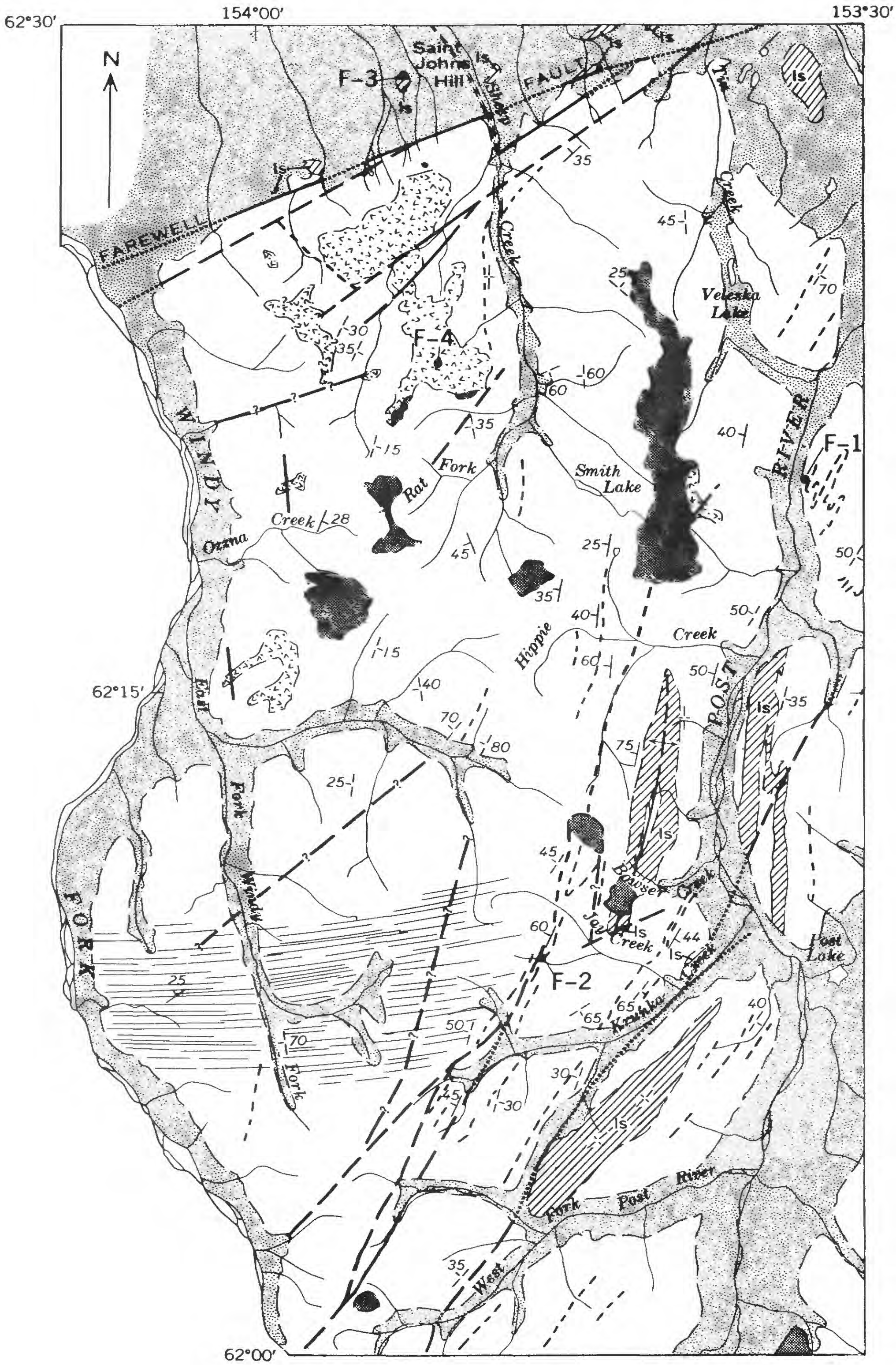

Figure 2.—Reconnaissance map showing generalized geology between Windy Fork and Post River, southern Alaska Range.

EXPLANATION

Surficial deposits
Includes alluvium, talus, rock glaciers, and various mineral deposits

QUATERNARY

IGNEOUS ROCKS

Intrusive rocks
Quartz monzonite, granodiorite, and quartz diorite; includes intrusive breccia and, locally, extrusive equivalents. May include some Mesozoic intrusive rocks

Extrusive volcanic rocks and interbedded sedimentary rocks
Flows, tuffs, and interbedded tuffaceous sandstone, siltstone and shale

Dikes
Intermediate to felsic. Major dike swarm diagramatically shown

TERTIARY

SEDIMENTARY ROCKS

ls

Shale, siltstone, argillite, and limestone
May include some Mesozoic sedimentary rocks. Short dashed lines represent trace of beds
ls, *prominent thin- to massively-bedded gray limestone units, shown locally*

PALEOZOIC

?

Contact
Dashed where approximately located; queried where doubtful

? ?

Fault
Long dashed where approximately located; queried where doubtful; dotted where concealed

Anticline
Showing trace of axial plane; dashed where approximately located

70 40

Inclined **Vertical**

Strike and dip of beds
Dashed symbol indicates altitude estimated from distant field observations

Jeep road

F-1

Fossil locality

Figure 2.—Continued

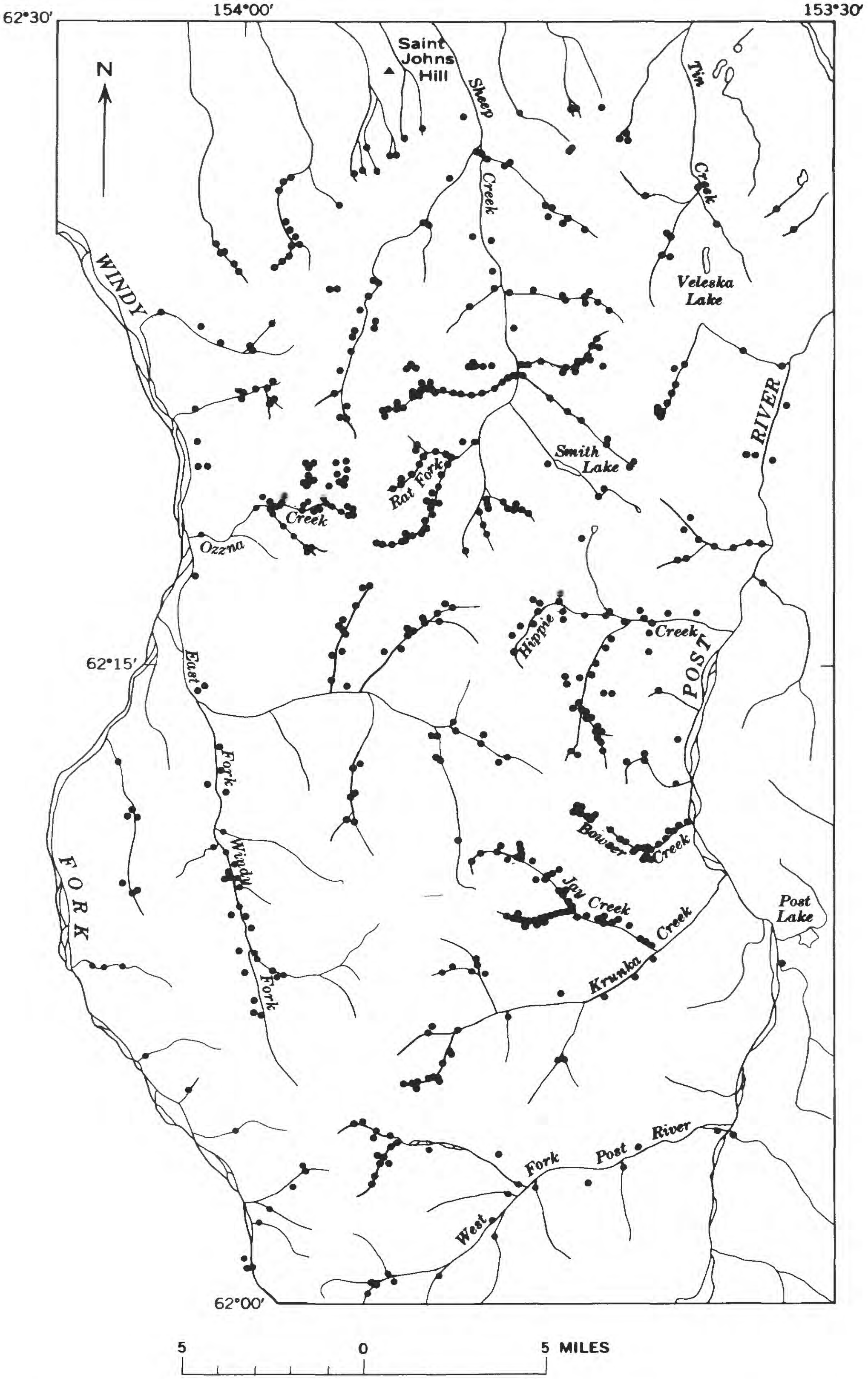

Figure 3.—Map showing location of stream-sediment samples (dots) between Windy Fork and Post River, southern Alaska Range.

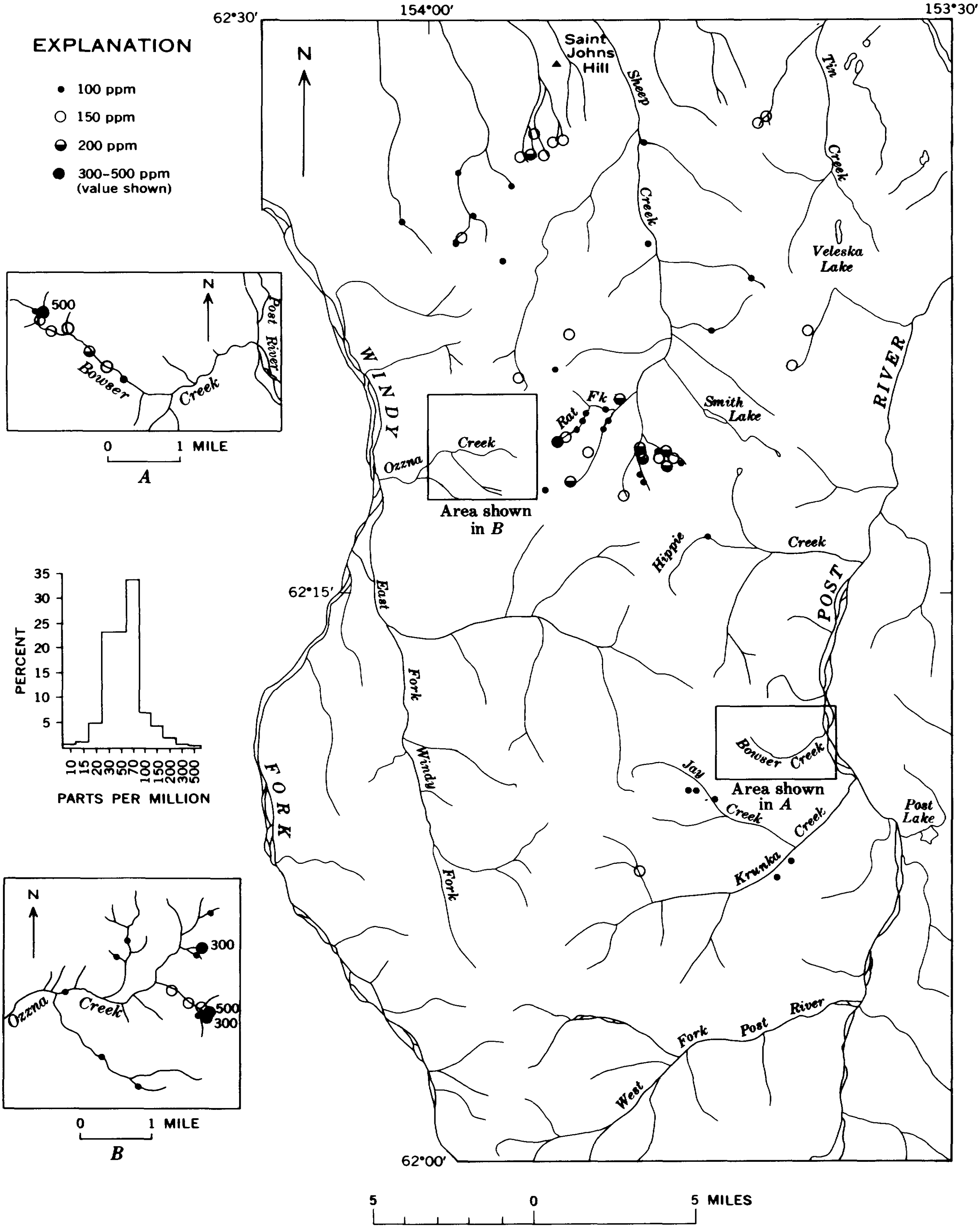

Figure 4.—Copper distribution showing location of samples with 100 ppm or greater. Histogram shows percentage frequency distribution of copper in 556 stream-sediment samples collected in map area.

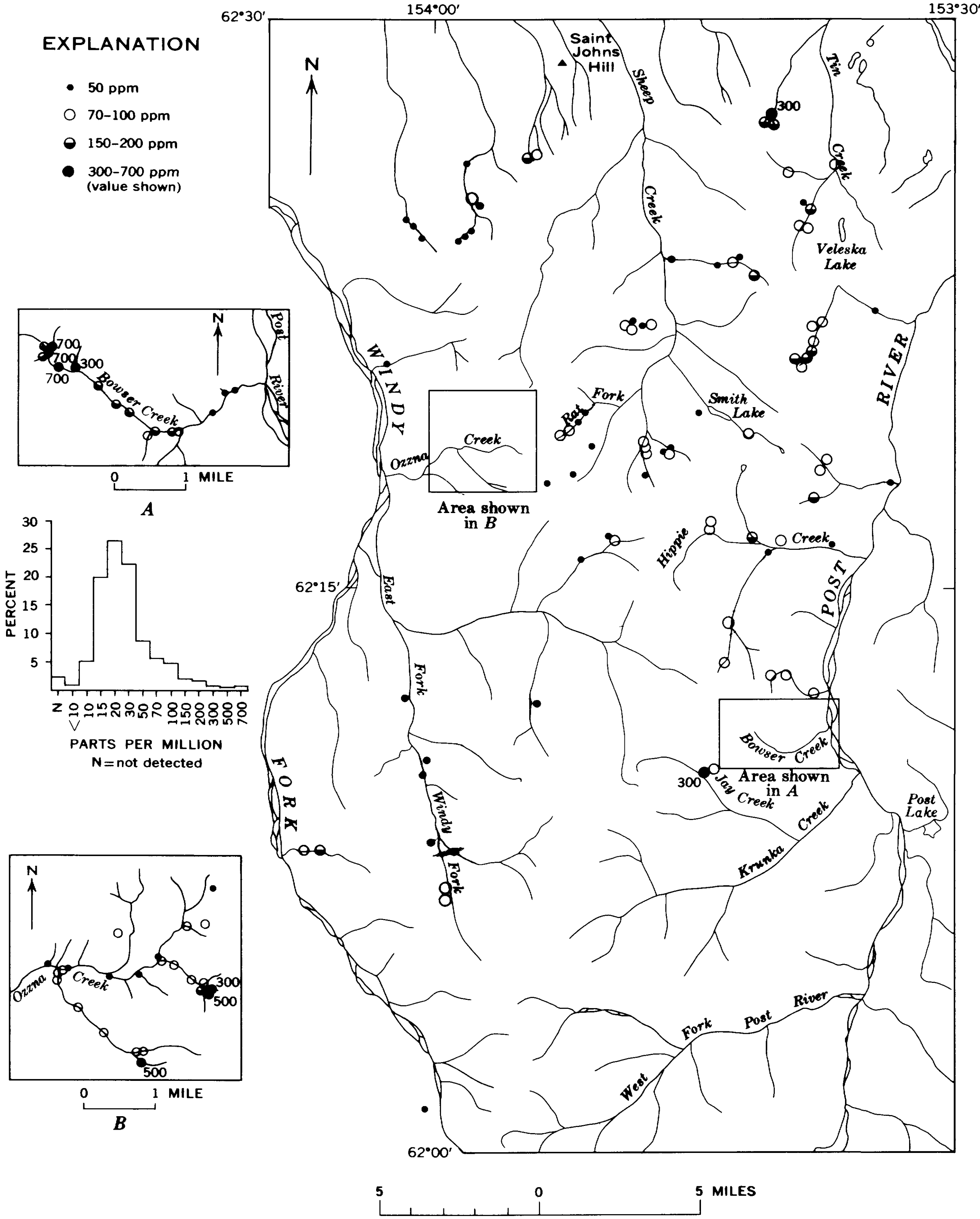

Figure 5.—Lead distribution showing location of samples with 50 ppm or greater. Histogram shows percentage frequency distribution of lead in 556 stream-sediment samples collected in map area.

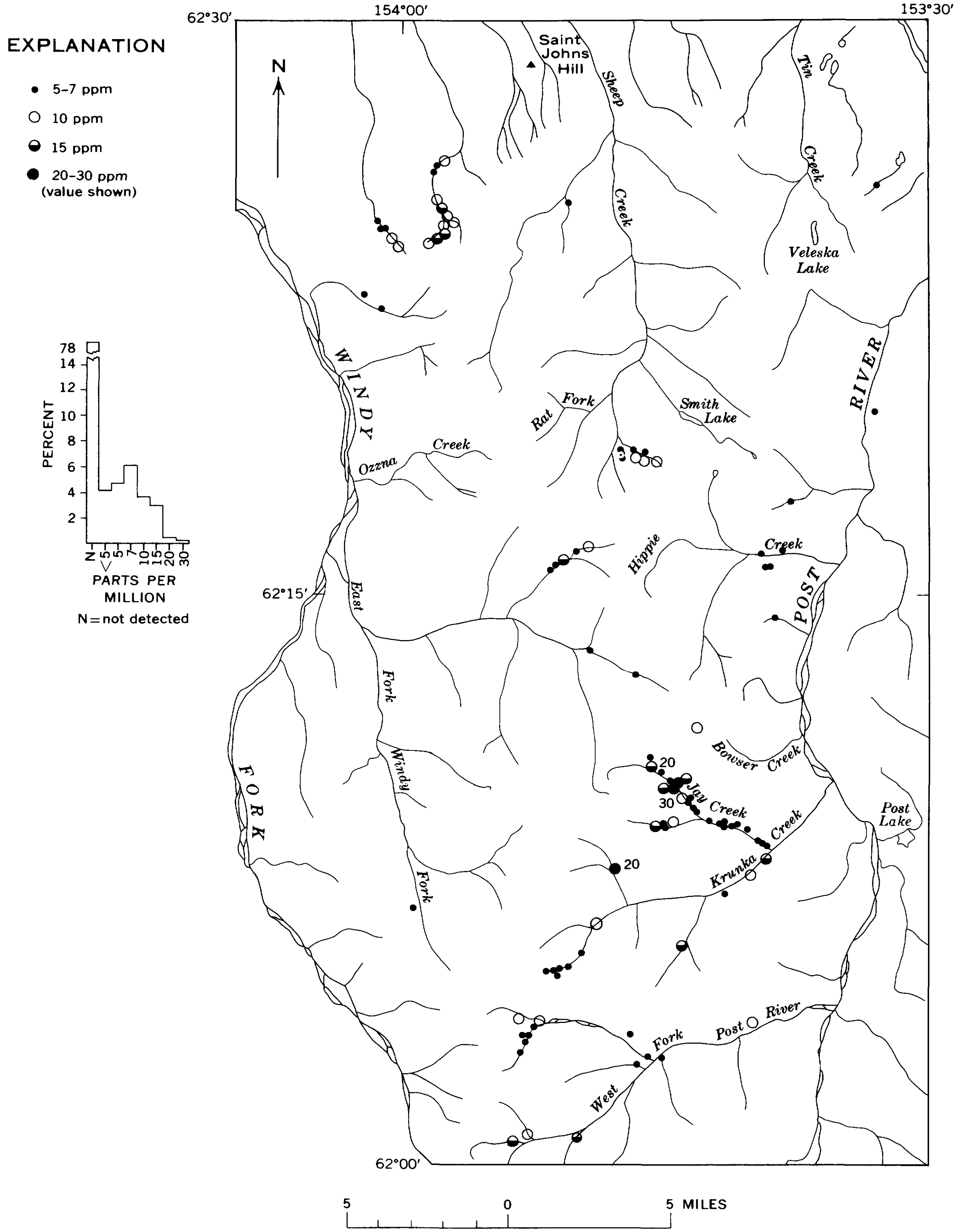

Figure 6.—Molybdenum distribution showing location of samples with 5 ppm or greater. Histogram shows percentage frequency distribution of molybdenum in 556 stream-sediment samples collected in map area.

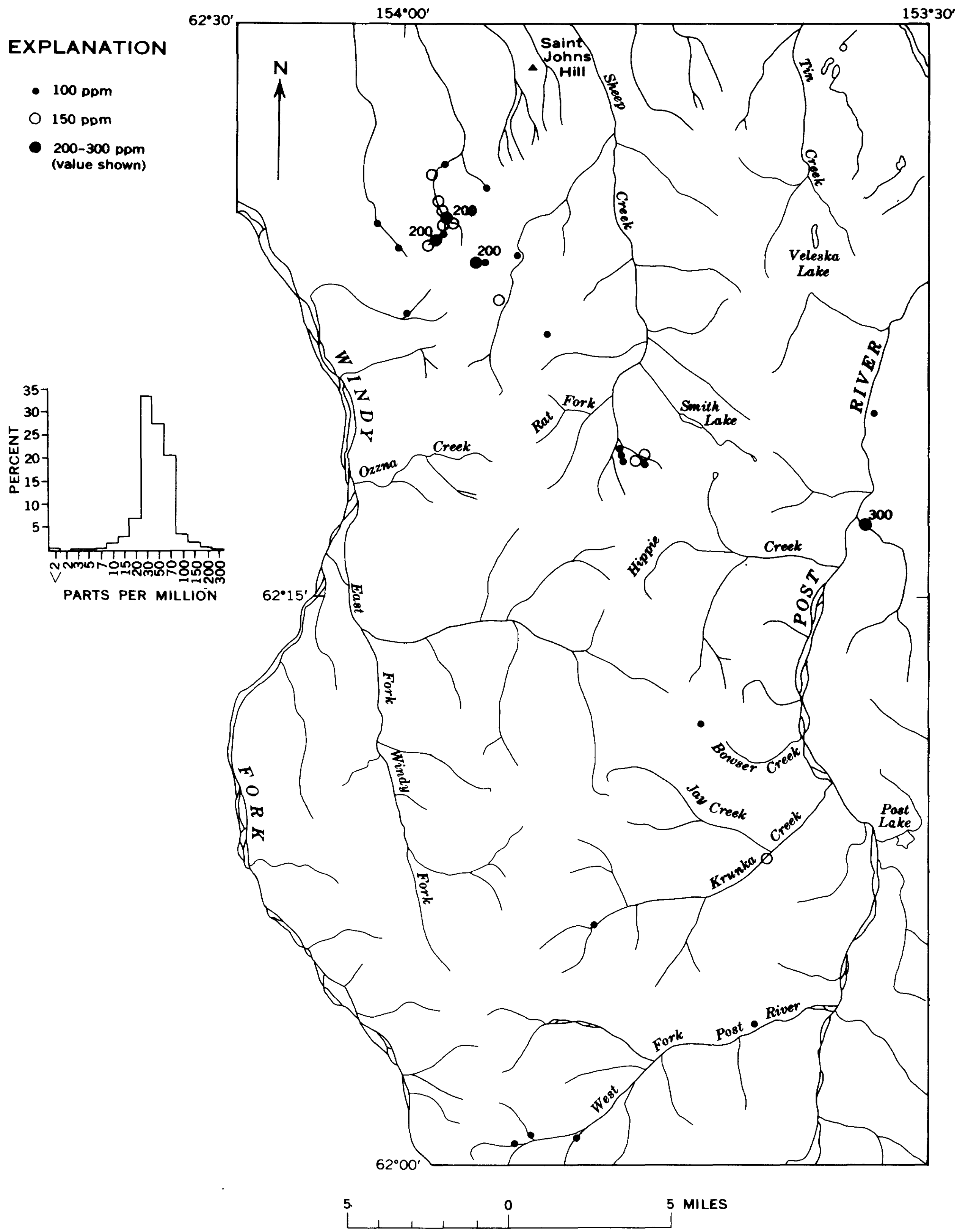

Figure 7.—Nickel distribution showing location of samples with 100 ppm or greater. Histogram shows percentage frequency distribution of nickel in 556 stream-sediment samples collected in map area.

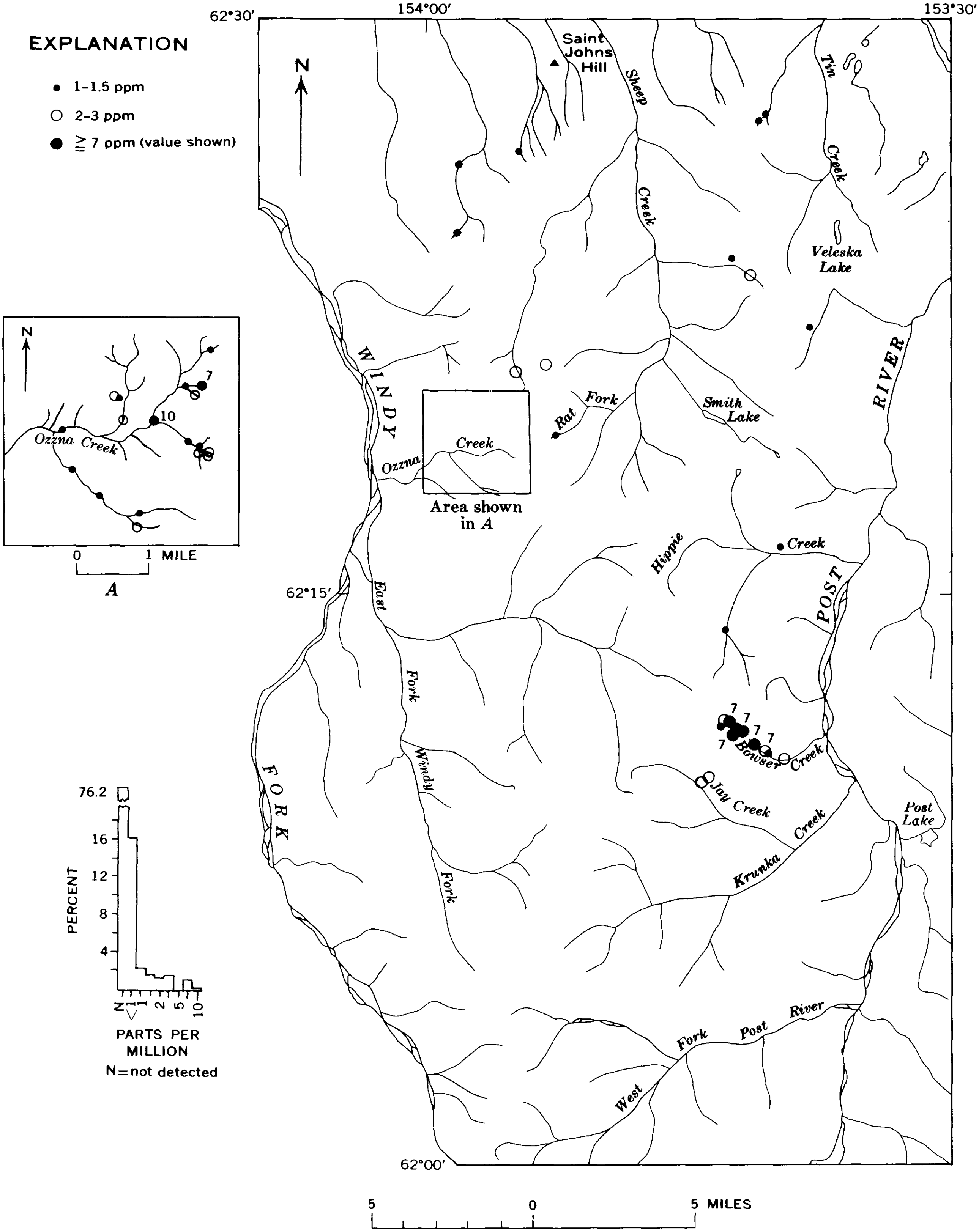

Figure 8.—Silver distribution showing location of samples with 1 ppm or greater. Histogram shows percentage frequency distribution of silver in 556 stream-sediment samples collected in map area.

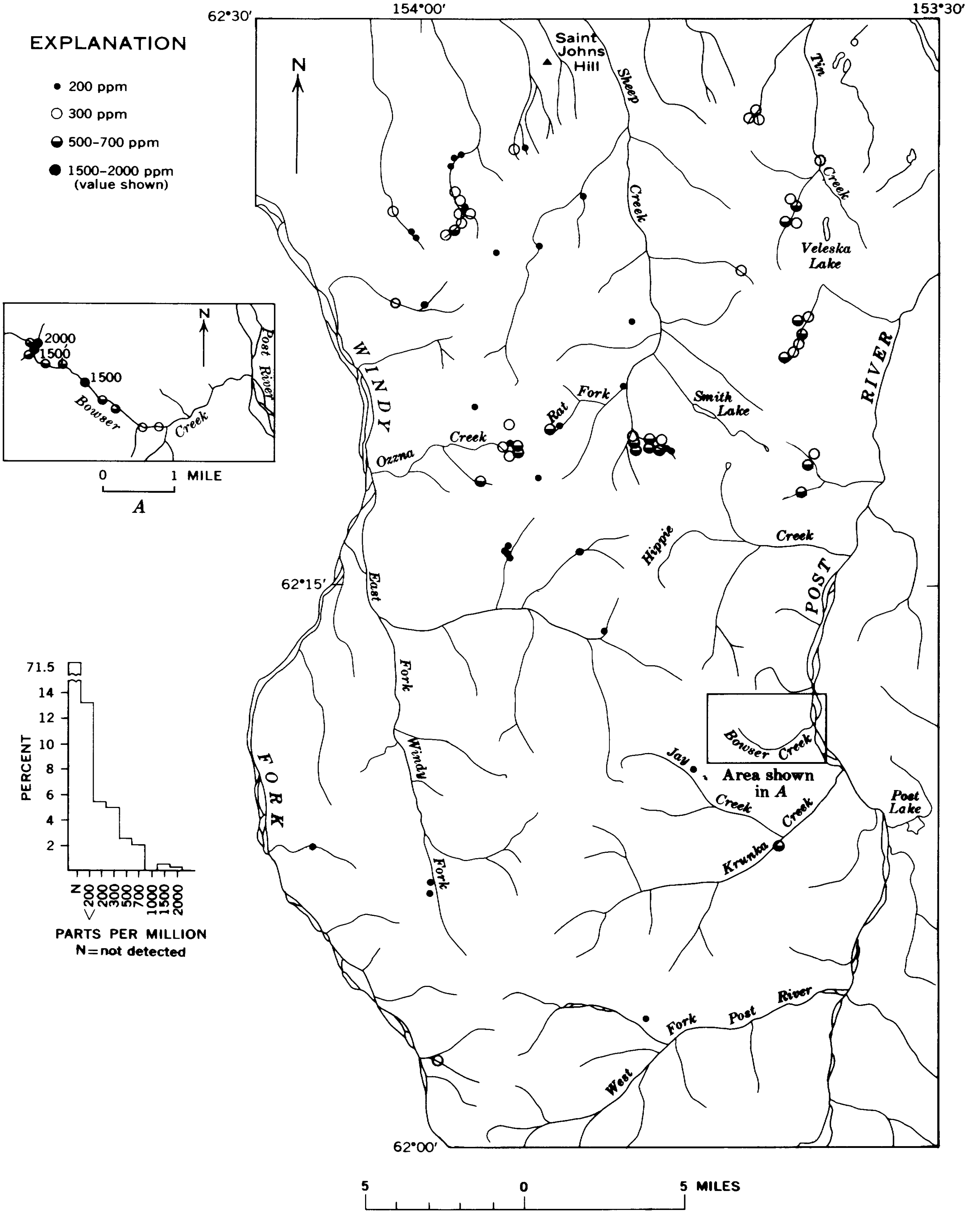

Figure 9.—Zinc distribution showing location of samples with 200 ppm or greater. Histogram shows percentage frequency distribution of zinc in 556 stream-sediment samples collected in map area.

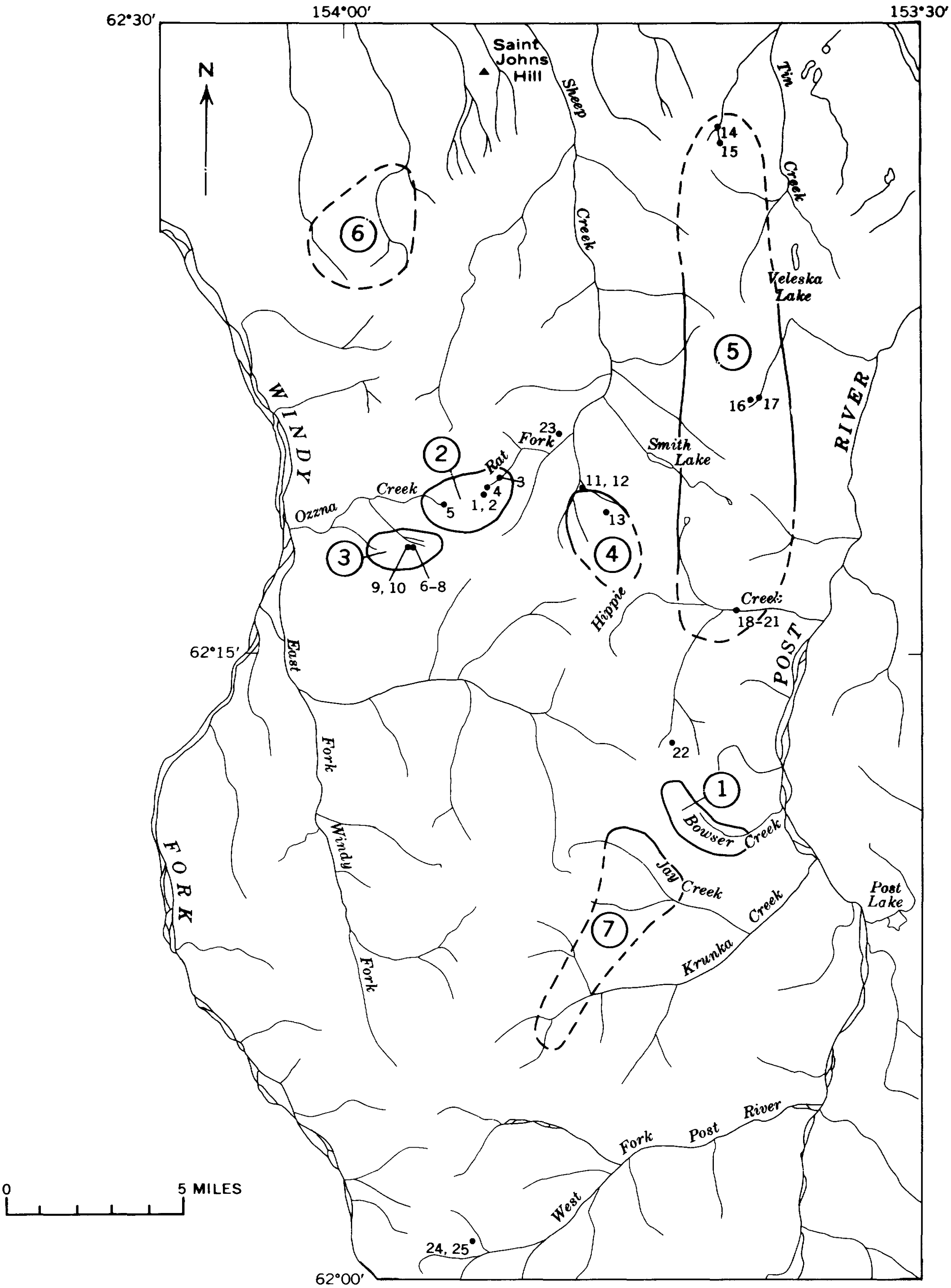

Figure 10.—Map showing areas with anomalous metal concentrations in stream-sediment samples. Circled numbers identify areas discussed in text. Small numbers show location of bedrock samples; analyses of these samples are given in tables 1 and 2.

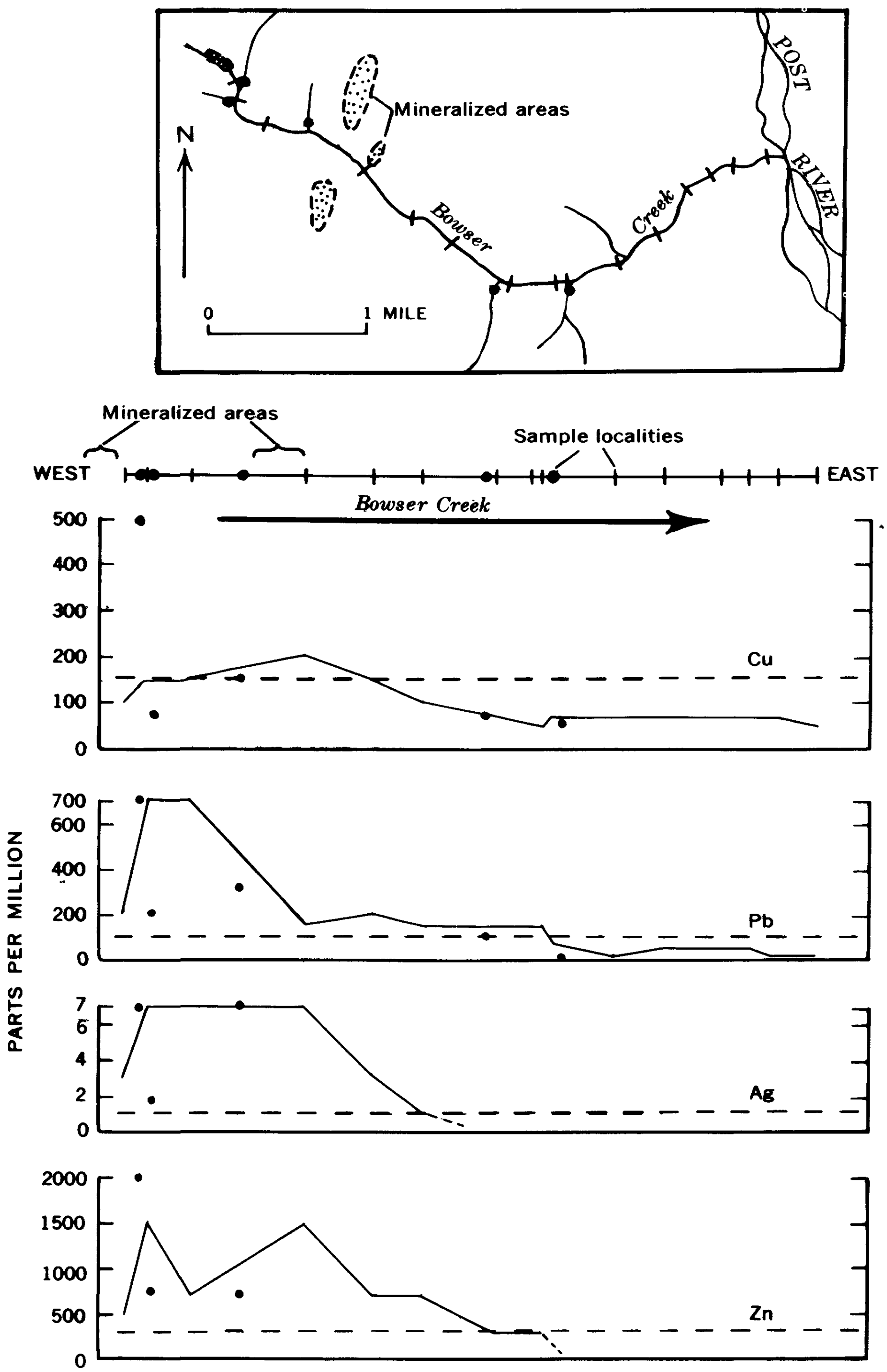

Figure 11.—Map of Bowser Creek showing location of stream-sediment samples and sulfide mineral deposits. Sample profiles showing distribution of copper, lead, silver, and zinc in stream-sediment samples. The closed circles on the map and profiles represent sediment samples from tributaries to Bowser Creek. The dashed line on the sample profiles represents values that are considered anomalous for the area discussed in this report. Stream flows to right (east).