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GEOLOGICAL AND GEOCHEMICAL INVESTIGATIONS SOUTHWEST OF FAREWELL, ALASKA

By

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GEOLOGICAL AND GEOCHEMICAL INVESTIGATIONS SOUTHWEST OF FAREWELL, ALASKA

by Gordon Herreid

ABSTRACT

The map area lies along the northern edge of the Alaska Range southwest of Farewell, in the headwaters of the Kuskokwim River. Bedrock is mainly strongly deformed, locally cross-bedded, medium gray slate-limestone of early Paleozoic age. Also present are smaller areas of light gray massive limestone of middle(?) Paleozoic age; granitoid stocks; numerous dikes of andesite, keratophyre and rhyolite; and rhyolite flows(?). About 100 square miles were mapped and 158 stream sediment samples were taken. The area was previously unmapped.

The mapping covers part of an upland block bounded along the north edge by the Farewell fault. Recurrent movements along this great break probably have had a strong influence on the emplacement of igneous rocks in the area. A swarm of steep, west-trending, mafic to acidic dikes extends eastward for a distance exceeding five miles from the large granitoid stock at the head of the Middle Fork of the Kuskokwim. The swarm underlies 2% to 50% of the bedrock over a width of at least four miles. The emplacement of these dikes was probably related to movements along the Farewell fault.

Stream sediments contain scattered nickel, copper, molybdenum, and zinc anomalies in the upper Middle Fork drainage. These are associated with diabase dikes and/or black slate within and marginal to the silicified aureole around the large granitoid stock at the head of the Middle Fork. One small nickel-bearing pyrrhotite deposit is associated with diabase in this area.

INTRODUCTION

The map area lies along the northern margin of the Alaska Range just south of the major Farewell fault. Dikes of varied composition and granitoid stocks are present. The geology had not been mapped previous to this investigation.

The only known mineral deposit in the map area is the Chip-Loy nickel prospect on the Middle Fork of the Kuskokwim. Twenty miles west, the small high-grade White Mountain cinnabar deposit is presently being mined. Much further west along the Farewell fault, the 47 Creek gold placer and the Cinnabar Creek mercury deposit have been mined at various times since the Second World War. To the east along the Farewell fault are located the "J and K", and Mespelt lead-silver prospects, the Slippery Creek copper, silver, lead, zinc, and mercury prospects, and the Mt. Eielson silver-lead-zinc deposits. The latter two are in Mt. McKinley National Park.

The present report is based on 28 days in the field between June 12 and July 13, 1966. 158 stream sediment samples were collected and approximately 100 square miles were mapped. Richard Reger most capably acted as assistant during this period.

PHYSIOGRAPHY AND GEOGRAPHY

The map area lies in an upland block bordered on the north by the Farewell fault. Material eroded from this block forms glacial and river-borne fans, aprons, cones, moraines, and drift of Quaternary age mantling the lowland north of the fault (Fernald, 1960). Ridge summits and mountains of the upland block define an old land surface of moderate, rounded relief (the Sleetmute upland surface of Cady and others, 1955) which has been much dissected as a result of intense frost action and erosion by streams and glaciers.

The ridges, steeper slopes, and smaller creek valleys above 3000 feet elevation contain many bedrock outcrops, but are mainly mantled by frost-rived bedrock rubble (rubbly colluvium of Fernald, 1960). On gentler slopes the rubbly colluvium contains more fines, partly windblown silt, and has a cover of tundra. At still lower elevations willow and other brush grows along the valleys. On the Middle Fork scattered willows extend as far up as the Chip-Loy prospect. Along the Windy Fork spruce stands suitable for small cabin logs are present.

There are no regular inhabitants in the map area. Surface travel during the investigations was by light river boat down the Windy Fork and on foot elsewhere. Landing areas for light short-take-off aircraft are available on the river bars of the Windy and Middle Forks. Flying was done from McGrath by Hub Air Service.

GENERAL GEOLOGY

The rocks of the map area include a great thickness of intricately folded early Paleozoic limy sediments, a great swarm of mafic to acidic dikes, two Mesozoic(?) granitic intrusives, an area of rhyolite flows, and patches of Tertiary conglomerate. The structure is dominated by the Farewell fault, a major fault that traverses the northern border of the map area.

The Paleozoic sediments are a thick sequence of medium dark gray thin-bedded limestone and calcareous slate with a few prominently outcropping massive limestone horizons up to 300 feet thick. A few exposures of clastic cross-bedded limestone indicate these sediments were deposited in shallow water. This sequence of limy rocks is correlated on the basis of lithology with the Ordivician and Devonian(?) sediments that have been mapped east and west of the area.

At White Mountain, 20 miles west, Sainsbury (1965) has described 4500-5000 feet of unmetamorphosed Middle(?) Ordovician marine miogeosynclinal dark gray thin-bedded limestone with fairly common shale partings and shale beds, overlain by 1500 feet of Devonian(?) limestone and dolomite.

Twenty-five miles east of the map area Brooks (1911) has described the Tatina group as thin-bedded siliceous limestone and limy slate of Ordovician(?) age overlain by 200 feet of Devonian(?) siliceous limestone.

Complex folding is present in all of these areas.

EARLY PALEOZOIC ROCKS

The Ordovician and Devonian(?) limy sediments have been mapped for a distance of 95 miles along the north flank of the Alaska Range and may extend further. On Windy Fork the bedrock is thin-bedded, medium gray, fine-grained limestone with slate partings interbedded with medium gray slate which is slightly to highly calcareous. Black slate is present in some areas up to a thickness of about 500 feet. It is generally noncalcareous. The thin slate horizons have good slaty cleavage, but some of the thick black slate bodies are massive. The limestone and slate are commonly interbedded or color-banded on a scale of a few millimeters. They have slightly crenulated lustrous bedding planes and undulating foliation which may be parallel to or crosscut bedding planes. The limestone is commonly foliated and in such localities rubble below outcrops is platy scree, often paper thin.

Massive medium gray to black, fine-grained, limestone beds six inches to ten feet thick are sporadically present throughout the area. These massive beds produce blocky medium gray weathering talus with rough hackly surfaces which differ distinctly from the prevalant smooth platy rubble of the color-banded or foliated slatey limestone. Massive limestone generally has from 1% to 5% crosscutting white calcite veinlets to 1-2 inches thick. Due to greater resistance to comminution, such material forms a disproportionately large percentage of the creek gravels. The thicker (100-300 feet thic massive siliceous limestone units shown on the geologic map may be of Devonian age, based on the conclusions of previous workers in adjacent areas.

From Fluorite Creek* to the major eastern tributary to the Windy Fork seven miles north (and possibly beyond), up to 1% tiny graphite flakes are commonly disseminated throughout the limestone.

A prominent light medium gray outcrop of massive limestone caps a ridge top 1 1/2 miles northwest of the confluence of the Windy Fork and its major tributary in the east central part of the map area. The limestone is estimated to be 200-300 feet thick and rests in probable conformity on noncalcareous black slate. The limestone is medium gray, fine-grained, with ± 1/8 inch composition banding above the basal 100 feet. The basal 100 feet shows a fragmental ± 1/4 inch pattern of dark chert on weathered surfaces. Irregular patches of black chert up to 1-2 feet in diameter are present. No fossils were found. Due to precipitous slopes only the lower 150 feet was examined.

Other massive to bedded limestone horizons are present in this area, but because of poor exposures and faulting the section was not determined.

The sediments in the Middle Fork drainage are similar to those on the Windy Fork described above except that foliated limestone which weathers to paper-thin rubble is absent and thick black slate horizons are more common. There is less white calcite veining of competent limestone beds and disseminated graphite is less commonly present.

About 1 1/4 miles up the major eastern tributary to the Middle Fork, a dark gray limestone 100-150 feet thick with 1-2 foot beds shows good current cross-bedding of the trough, cross-stratification type (McKee and Wier, 1953). The bed is overturned.

On the eastern tributary of the Middle Fork about 1 1/3 miles north of the granite contact, load casts of sandy limestone protruding into the underlying limy black slate are present. This is thought to represent tongues of unconsolidated calcite sand which have sunk into an underlying layer of liquified mud, and further indicates the clastic nature of the limestone beds.

SILICIFIED LIMESTONE AND SLATE

The Middle Fork granite is surrounded by an aureole of banded silicified limestone and slate. At the outer contact of this rock the thin-banded limestone-slate gradually becomes more silicified; the limy layers change from medium dark gray to a creamy white slightly limy cherty-looking rock and then to creamy noncalcareous cherty-looking silicified limestone within a distance of 100-200 feet. Over the same interval the slate layers change from medium dark gray to dark, sometimes purplish, gray silicified slate.

On the Windy Fork two miles south of Breccia Creek* a series of rather flat-lying cliff-forming beds form prominent outcrops. The rock grades from slightly limy thin-banded silicified limestone at the base to thin-banded, light greenish gray, partly

*Informal name used in this report

silicified limestone at the top over a stratigraphic distance of about 150 feet. Banded silicified limestone-slate is also exposed in the creek that parallels the cross fault in this area. Such rock is uncommon away from the granite contact, and these two exposures are thought to represent silicification along cross and thrust faults.

DIKES

A conspicuous swarm of west-trending steeply dipping dikes extends from the northern slopes of Fluorite Creek south beyond the mapped area for a distance of at least 4 miles. Dikes range from mafic types to trachyte and rhyolite. They are generally 3 to 30 feet wide and have sharp, usually planar contacts with the country rock. Dikes make up 10% to 50% of the rock over wide areas on Breccia Creek* and gradually diminish in frequency northward to a "background" dike frequency estimated to be less than 1% north of Fluorite Creek. The southward extent of the dike swarm is unknown.

The rhyolite dikes are yellowish-white aphanitic rocks speckled with about 5% corroded quartz phenocrysts (1 mm diameter). The ground mass is a fine-grained aggregate of K-feldspar, sericite and quartz. This is the oldest and least abundant dike type.

The mafic dikes are most abundant. They are mostly fine-grained to aphanitic, greenish gray to dark greenish gray rocks with plagioclase feldspar and/or mafic phenocrysts. Under the microscope the rock is a felty mass of fresh albite microlites with interstitial mafic and other minerals. The principal mafic mineral is augite, and in some specimens, hornblende and biotite as well. Other interstitial minerals are chlorite, carbonate, and minor quartz. Apatite needles are abundant in the feldspars. Phenocrysts are either lacking or are the same minerals as in the groundmass.

All the mafic dikes examined to date are andesites, but more complete petrographic data would probably show many of the darker mafic dikes to be basalt.

The keratophyre dikes are common and of distinct appearance. They are generally fine-grained grayish orange, pink, light brown, or light olive gray, free of quartz phenocrysts, and have prominent, stout K-feldspar, and occasionally, clinopyroxene (2V $\pm$ 60^{o}) phenocrysts. The groundmass is a felty mass of cloudy microlites with fluidal to random texture. The microlites ($\pm$ 0.1 mm long) are albite and (minor) magnetite. Some specimens also contain bluish soda-amphibile, clinopyroxene (2V $\pm$ 60^{o}), or basaltic hornblende microlites. Interstitial minerals include chlorite, quartz (up to 5%), carbonate, and limonite. Apatite needles are ubiquitous in the feldspar. The rock is much altered-feldspar to clay and chlorite and clinopyroxene to carbonate.

A composite dike with a light brownish gray keratophyre core exposed for a width of 5 feet and bounded by a 1-2 foot selvage of dark greenish gray andesite indicated the probability that the keratophyre is an alteration product of andesite. The selvage is fresh microdiabase with unaltered sodic andesine microlites and about 10% carbonate grains. The core has cloudy albite microlites with a slightly more radiating texture than the microdiabasic selvage. Carbonate (1%) is much less abundant in the core than in the selvage.

GRANITOID ROCKS

A considerable variation in composition of the granitoid rocks is indicated by the thin section data. The intrusive in the southwest portion of the map area is perthite leuco-granite at the head of Breccia Creek* and syenite at the head of Straight Creek*. The intrusive west of the air strip on the Middle Fork is quartz monzonite.

RHYOLITE

Rhyolite was seen as abundant float at the mouth of a small creek draining into the Windy Fork from the west. This float probably represents a large area of light colored rock visible in the hills west of the Windy Fork and south of the Farewell fault.

The float is a very light greenish-gray aphanitic rock with orbicules 2-4 mm in diameter around which swirl the flow bands of an aphanitic matrix. The orbicules occur as separate light gray masses or as connected strings of beads. They have a rude concentric structure of microcrystalline quartz cored by chlorite, biotite, and/or feldspar grains. The matrix between orbicules is glass and fine grained cryptocrystall K-feldspar. Flow lines in the matrix are green chlorite.

The rock flowed after the orbicules formed and probably originated as lava.

NENANA(?) GRAVEL

This formation was examined only in the prominent cutbank on the west side of the Windy Fork immediately north of the Farewell fault. The rock is a light gray, cliff-forming conglomerate. It is made up mainly of rounded pebbles less than 2 inches in diameter with scattered subangular 6 inch boulders. Bedding in the outcrop is indicate by a few 1-2 foot sandstone beds and a 2-6 inch brown weathering mudstone bed underlair by black bituminous layer containing a little lignite. The rock fractures around grair rather than through them, but is fairly well indurated. Clasts are quartzite, 78%; silicified black slate, 10%; chert, 5%; limestone, 5%; and quartzite schist, 2%. The quartzite is made up of rounded, strained quartz grains with sutured borders. The matr is composed of silt-sand sized quartz grains with scattered shreds of white mica plus minor clay. Grains are angular and some have secondary quartz overgrowths.

Grantz (1967) gives the age of the Nenana gravel as mid-Pliocene or possibly Miocene.

PEBBLE CONGLOMERATE

A massively-bedded gray brown pebble conglomerate is located on the slopes west of the Windy Fork near the south edge of the map. Clasts are pebble-size to 3 inches and consist of limestone, slate, and dike-rocks of the types seen in the district cemented by limy graywacke. The formation is light brown with spheroidal weathering. It was only seen in the one locality (Reger notes).

The restricted occurrence in a valley wall and the presence of clasts representinc all the bedrock types except granite indicate a probable Tertiary age for this unit.

PLEISTOCENE GEOLOGY

Glacial moraines are present in many of the larger valleys. These have not been vestigated in detail and are not shown on the geologic map. Figure 2 shows a Pleistoce section examined on the cutbank along the east side of the Windy Fork, opposite the mouth of Fluorite Creek by Reger. He concluded the following:

*Informal name used in this report

1. There have been two glaciations represented by separate tills (units A and C, figure 2).

2. The middle unit (B) represents valley train deposits which were cemented tightly by ground-water-bearing calcium carbonate.

3. Because of the freshness of the fills the ages of the glaciations are probably Early and Late Wisconsin.

4. Lakes were developed locally in front of the glacier which occupied the Windy Fork (C1, unit C). These lakes were over-ridden by later advances and may indicate several Early Wisconsin advances and retreats.

5. The tills were not cemented extensively, probably because of their low permeability.

STRUCTURE

Folds

The location and shape of any major folds in the area are not readily apparent from visual observation, air photo interpretation, or outcrop observations. This is due mainly to the dearth of outcrops and prominent stratigraphic marker horizons, and the lack of sufficient detailed mapping in critical areas.

The structural features present in individual outcrops are of similar style throughout the area. In most outcrops the bedding is roughly planar, but with minor B-lineation type structures (e.g.),crenulations, hand specimen-sized folds, and bedding-foliation intersections) such as are usually associated with major folding. The prevailing thin-bedded slate to slaty-limestone bedrock has slightly crenulated lustrous bedding planes and undulating foliation. The slate usually has good cleavage. White calcite veinlets which cross the foliation at small angles are often boudined (sheared). Foliation often cuts bedding at 20°-30° angles or greater. Occasionally bedding is offset as much as a few millimeters by movement along foliation planes. Kink-band folds are fairly common in the graphitic limestone-slate along the Windy Fork. In a few localities massive light gray limestone beds a foot or more thick interbedded with sheared slate show contorted plastic flow folds.

A significant number of exposures show fold hinges with radii up to several feet.

The bedding, foliation, and minor fold axis determinations taken along the Windy Fork have been plotted on figure 3. These stereo net plots show that bedding dips are generally gentle to moderate and that folds and other B-lineation features plunge gently, with a rude preferred orientation trending south and east-southeast. The similarity of the plot from the Middle Fork drainage in the vicinity of the granite intrusives to the plots from the Windy Fork suggests a permissive emplacement of granite without much bending of the wall rocks.

Gently-dipping mostly-planar beds together with the small structural features indicating folding and the shallow plunges of B-lineations indicate that major recumbent folds are probably present throughout the area. The two rather diffuse trends of B-lineations and the presence of two such lineations in a few exposures indicate that two periods of folding have probably taken place about southerly-trending and east-northeast-trending axes.

Faults

The Farewell fault trends N65°E across the Windy Fork. Its dip is unknown. This fault has roughly 100 kilometers of apparent right-lateral separation of Cretaceous rocks west of the map area and movement has continued until recent time (Grantz 1967). Long continued movements of such magnitude must have strongly influenced faulting in adjacent blocks such as the map area.

The two faults mapped between Breccia and Fluorite Creeks are nearly parallel to the Farewell fault, and similarly, have apparent right lateral offset movement. They are marked by silicified, bleached, and limonitized areas in the limestone-slate.

The Straight Creek fault is at a high angle to the Farewell fault. It is marked by limonite-depositing springs, copper, zinc, molybdenum, and nickel anomalies, and an offset of the silicified aureole around the upper Middle Fork granite pluton.

Several small left lateral faults offset the outer edge of the silicified aureole on Breccia and Fluorite Creeks*. These may be associated with emplacement of the intrusive. No mineralization is known to be associated with these offsets.

GEOCHEMISTRY

Throughout the map area stream sediment samples of mud or fine gravel were taken from creek beds, below water level wherever possible. These were analyzed in the field for readily extractable heavy metals by the Hawkes (1963) ammonium citrate field method The dried minus 80-mesh fraction was analyzed for total copper, lead, zinc, molybdenum, and nickel by the Rocky Mountain Geochemical Laboratories of Salt Lake City, Utah. Results have been tabulated (table 1) and frequency vs. concentration plotted for the various metals (figures 4,5).

Threshold values for anomalies were determined by inspection from the frequency concentration plots as follows: Copper, 100 ppm; zinc, 200 ppm; molybdenum, 6 ppm; nickel, 90 ppm.

Anomalies are conspicuously concentrated in the western part of the area. Several of these appear to be directly derived from erosion of the Chip-Loy deposit, but a number of others must come from other deposits or disseminated bedrock sources in the vicinity.

Field-test anomalies vs. total metal anomalies

There is a rather imperfect correspondence between the dithizone field-tests and the total contents of the various analyzed metals. Many samples containing anomalous amounts of one or more metals give only background dithizone field-tests. A few samples with anomalous field-tests have only background metal contents.

Despite the lack of detailed correspondence of field-test results with metal contents, most of the field anomalies are clustered in the western part of the map area where mineralization occurs. The samples with only readily extractable heavy metal anomalies may reflect anomalies associated with somewhat distant metal concentrations. This is shown by Sample #41 at the mouth of Straight Creek*, which gives a low field-test anomaly but does not contain anomalous amounts of an analyzed metal. Several

*Informal name used in this report

similar field-test anomalies in the map area warrant sampling further up their drainages.

ORE DEPOSITS

Chip-Loy prospect

This nickel-bearing ore deposit is an irregular steep-dipping layer of massive to disseminated pyrrhotite along the northwest side of a diabase pipe(?) located on the steep slope south of Straight Creek (figure 6). The country rock is banded silicified limestone-slate with recumbent folds whose axes plunge about 20° in a $S60^{\circ}E$ direction.

The diabase body has many offshoots that nearly parallel the bedding of the surrounding rock, but elsewhere it cuts the bedding sharply. Most of it is quite barren of sulfides. Steep dipping massive pyrrhotite up to 11 feet wide and disseminated ore up to 100 feet wide are present. Strike length of the mineralized zone is more than 1100 feet.

Samples taken at the deposit were lost. The nickel grade is not high for any amount of ore.

The intrusive has diabasic texture. Unaltered labradorite laths to 0.5 mm long make up about 50% of the rock. Interstitial minerals are clinopyroxene ($2V_z$=54°), 25% of the rock; tremolite, 20%;biotite, 1%; magnetite, 3%; apatite (needles in feldspar), 1%.

Reger pyrrhotite showing

This mineralized area is located in the silicified limestone-slate aureole 2500 feet north of the granite contact on the west side of Straight Creek . Here at an elevation of 3460 feet a steep west-trending mafic dike is covered by a thin coat of limonite stain and contains disseminated pyrrhotite. At an elevation of 3750 feet the same dike contains pods of pyrrhotite which make up 1% of the rock.

Geochemical station #21 showing

This is a narrow gossan-capped vein of pyrrhotite(?) and chalcopyrite in silicified limestone-slate bedrock. Mineralization also includes malachite and azurite.

Limonite-depositing springs

A line of more than a dozen springs, marked by conspicuous orange surface deposits of limonite, is present along Straight Creek just downstream from the Chip-Loy prospect. There is much limonite stain in the bed of Straight Creek below these springs. These springs may mark the fault paralleling the creek, or their position and iron content may be due to ground water flowing from the black slate located up the hill to the west. Geochemical sediment sample #23, from a small creek fed by one of these springs, is anomalous in zinc and molybdenum.

A limonite-depositing spring is also present in pyrite-bearing black slate up the hill, about 600 feet west of geochemical sample #18, in the same drainage. Sample #18 is anomalous in copper, molybdenum, and nickel.

The sporadic distribution of geochemical anomalies in the tirbutaries of Straight Creek supports the conclusion that the anomalies are related to scattered sulfide veins rather than a general high metal content in the black slate.

Fluorite Creek float

A single 5-inch cobble of green fluorite was found in the gravel of Fluorite Creek near geochemical station 126. No other fluorite float was found along the creek or elsewhere in the map area.

Gossan float was also found in the Fluorite Creek gravel, ranging in amount from very sparse and difficult to find at the mouth to common, but much less than 1 percent, in the moraine at the head of the creek. A small but prominent gossan zone seen on a cliff 0.3 miles southwest of geochemical sample site 129 may represent at least a partial source of the gossan float. Apparently representative gossan float contains gold 0.06 ounces per ton*, silver 0.16 ounces per ton*, copper 0.75% to 1%**, lead 0.01% to 0.1%**, zinc 0.1% to 0.2%**, molybdenum not detected**, nickel not detected**. It is not probable that a large amount of material of this grade is present in the drainage.

CONCLUSIONS

The mineral showings and geochemical anomalies in the Straight Creek area are spatially associated with a fault which offsets the contact aureole around the granitoid intrusive at the head of Straight Creek. This sequence of igneous intrusion, faulting, and introduction of ore may be present elsewhere around the intrusive. Further prospecting for lode deposits is warranted on Straight Creek and elsewhere around this intrusive and other intrusives in the region, particularly where faulting is present.

The diabase dike on Straight Creek shows commercial possibilities. No signs of economic mineralization were seen in the other dikes in the map area.

Analysis of stream sediments for specific metals or for readily extractable heavy metals is effective in indicating the presence of mineral deposits in the area. The maximum interval for effective sampling along the creeks is not clearly indicated by the data, but appears to be at least one mile.

* Fire assay by Don Stein, Division of Mines and Minerals

** Semi-quantitative spectroscopic analysis by Don Stein, Division of Mines and Minerals

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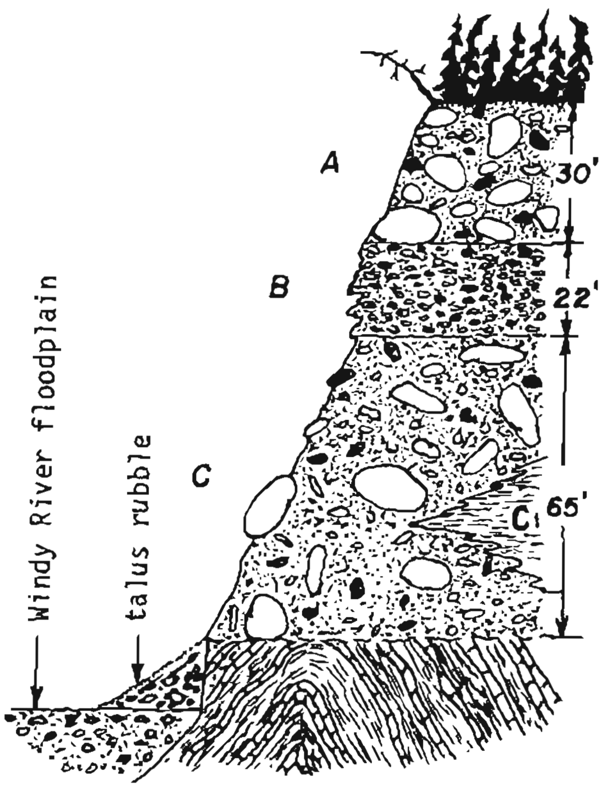
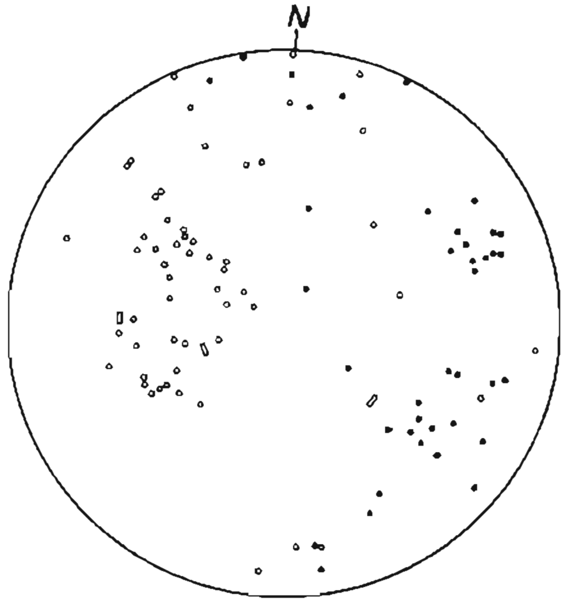


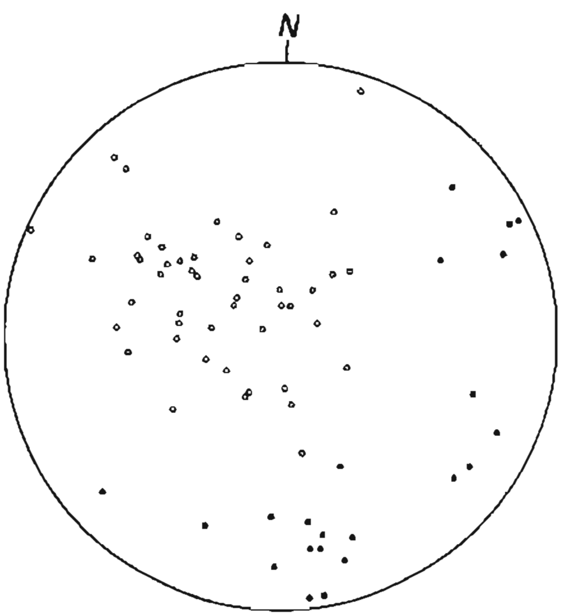
Figure 2. Diagramatic cross-section of Pleistocene deposits, Windy Fork of the Kuskokwim River

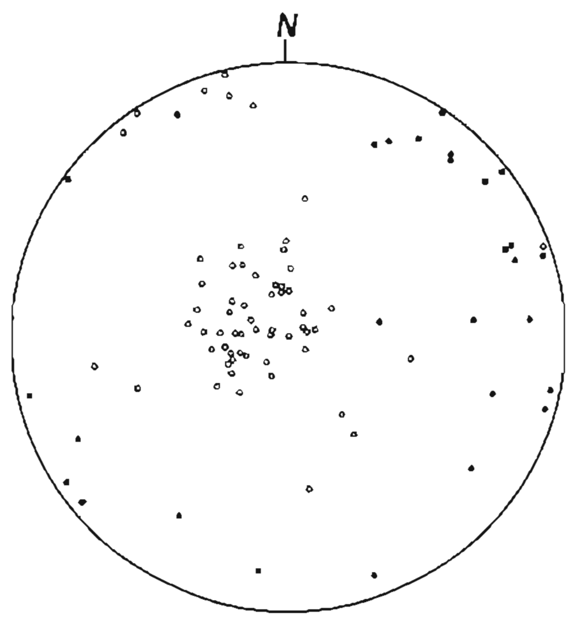
A. Sandy till, unconsolidated, medium gray to grayish brown, blocks to 12 feet in diameter, some limy cement, frost disintegration of granite and basalt boulders to 10 inches in diameter

B. Glacial outwash gravel, well cemented (with calcium carbonate) to unconsolidated, light reddish to yellowish brown, crude bedding dips gently downstream, weathering rinds to 1/8 inch thick on basalt cobbles

C. Sandy till, unconsolidated, medium grayish brown, with local lake silts, blocks to 20 feet in diameter, most clasts unweathered







Windy Fork drainage,
north of Fluorite Creek

Windy Fork drainage,
Fluorite Creek south

Figure 3. Lower hemisphere equal area projections of poles of bedding (open circles), axes of minor folds (dots), and axial planes of minor folds (rectangles) in the Windy Fork - Middle Fork drainages

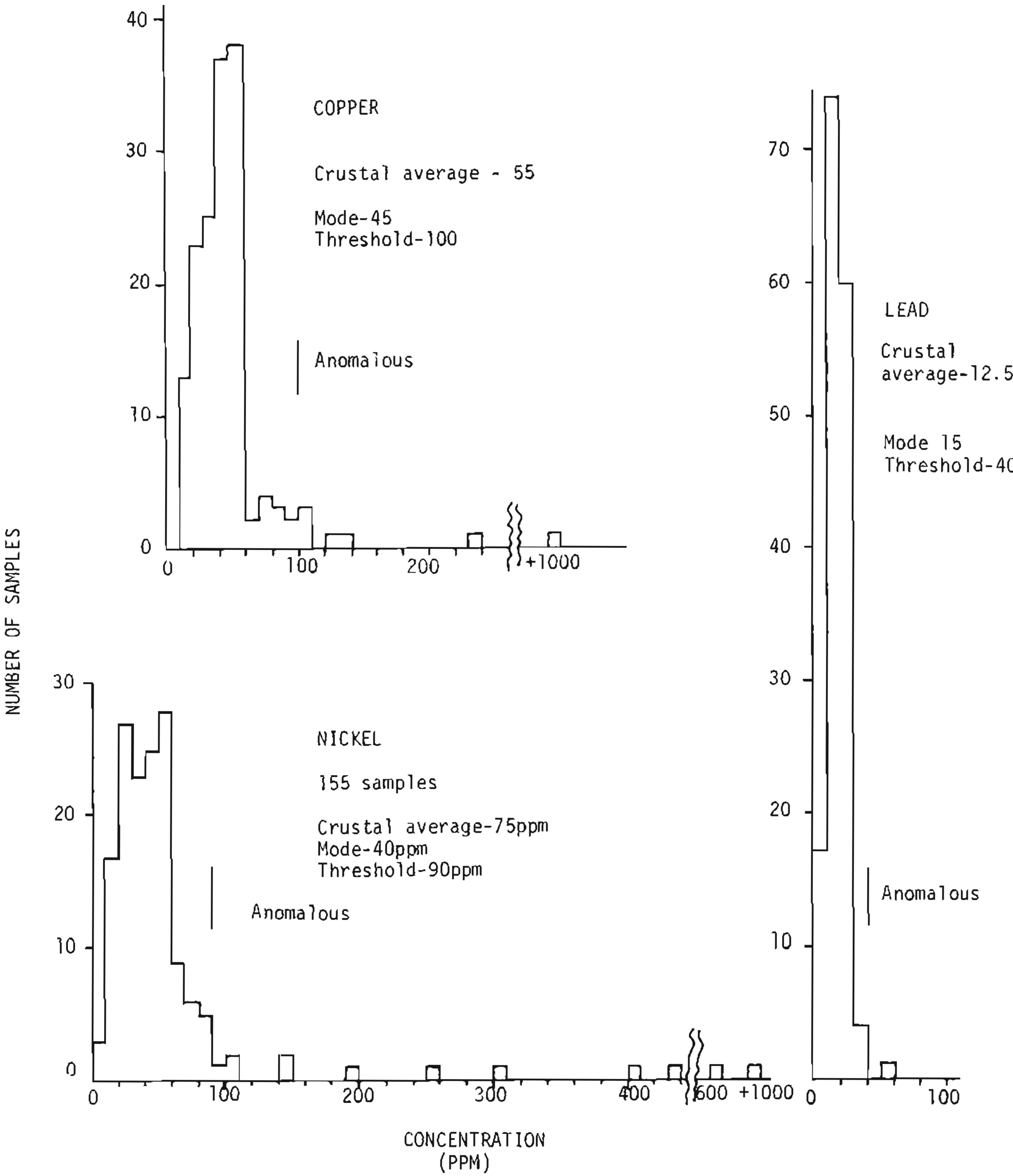


Figure 4. Frequency-concentration graphs of copper, lead, and nickel in stream sediment from the Windy Fork-Middle Fork drainages

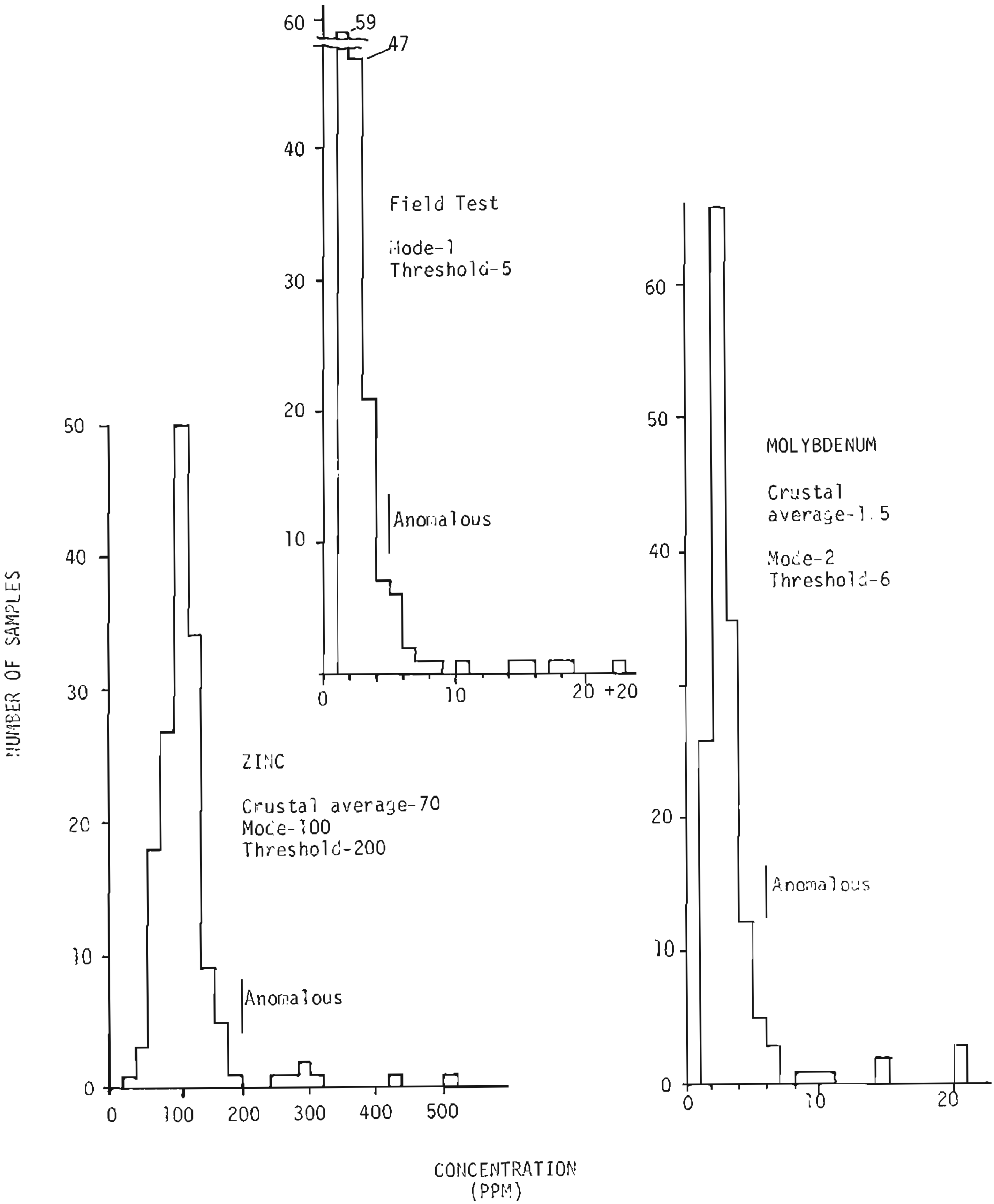


Figure 5. Frequency-concentration graphs of zinc, molybdenum and readily extractable heavy metals (field test) in stream sediments from the Windy Fork-Middle Fork drainages

TABLE I

Copper, zinc, lead, molybdenum, and nickel contents of stream sediments in the Windy Fork-Middle Fork Region

Map No.	Sample No.	Concentration (ppm)* Cu	Zn	Pb	Mo	Ni	Field** Test	Stream Width	Float at sample site***	Bedrock	Mineral-ization	Remarks
1	6L 326	20	50	5	1	30	2	5'	c-1, g-99	g		
2	6L 327	15	50	5	1	10	2	7'	c-1, g-97, an-2	g		
3	6L 325	20	155	10	2	15	1	2'	g-75, an-25	g		
4	6L 328	20	60	5	1	10	2	2'	c-2, contact breccia-2, g-93, an-3	g		
5	6L 329	15	65	5	1	20	1	3'	c-1, contact breccia-1, g-97, an-1	g		
6	6L 319	10	60	5	2	20	1	12'	c-1, g-97, an-4			
7	6L 320	25	110	5	2	50	1	5'	c-10, g-84, an-6	g		
8	6L 317	40	135	10	2	30	2	3'	c-29, ls-1 contact breccia (gy. c veined w/granite) g-40, an-5	g(?)	Py & Po (?)float	
9	6L 321	15	65	5	4	15	1	9'	c-15, g-85	c		
10	6L 316	30	75	10	4	40	1	2'	c-93, ls-5, g-1, an-1	c	M gy ls	
11	6L 314	25	60	10	1	45	1	3'	c-71, ls-28, g-1	c w/ marble		ls: massive gray-25, brown weath-3
12	6L 312	40	85	15	2	55	2	3'	c-75, ls-20, g-1, d-1, an-2, b-1	c		M gy ls
13	6L 331	20	70	5	3	25	1	20'	c-20, g-77, an-2, b-1	c		
14	6L 311	15	65	5	2	10	1	10'	c-10, dolo-1, g-86, d-1, an-2			
15	6C 480	10	65	10	2	30	1	8'		di-c		
16	6L 280	10	35	5	1	10		4'	c-10, g-81, r-1, d-2, an-5, b-1			

Map No.	Sample No.	Concentration (ppm)* Cu	Zn	Pb	Mo	Ni	Field** Test	Stream Width	Float at sample site***	Bedrock	Mineral-ization	Remarks
18	6L 278	125	130	30	5	400	1	3'	c-46, ls-5, s-8, g-20, an-4, b-2	c	Po & lim gos-15	Creek fed by limonite depositing springs
19	6L 277	90	280	25	20	140	15	4'	c-40, ls-10, s-35, g-10, an-5	c-ls-s		an dikes
20	6L 275	15	60	5	5	25	1	10'	g-50, an-5, c-24, ls-1		gos-20	strong lim coating of cr. 12" cr.gravel
21	6L 274	230	110	25	2	600	5	dry	c-65, ls-5, g-15	c-ls	gos-15	vein with Po & Cp capped by gos w/lim, malachite, & azurite.
22	6C 445	7500	80	30	8	1500						creek below Chip-Loy prospect
23	6L 273	25	270	25	10	70	5	3'	c-30, ls-35, s-25, g-10			stream from lim-depositing spring
24	6L 272	15	60	5	1	35	10	10'	c-25, ls-20, g-35		gos-20	lim stain restricted to w/in 24" of present cr. level
25	6C 437	35	105	20	3	80	3	4'	ls-50, s-49, an-1	ls-s	minor bl. slate gos	ls:slaty-30, M gy 20
26	6L 271	20	75	5	2	40	8	8'	c-30, ls-25, dolo-5, g-18, an-2		gos-20	lim stain restricted to within 8" of present cr. level
27	6L 270	50	130	15	5	80	14	3'	c-66, ls-15, dolo-8, g-5, an-4	c-ls	gos-2	an dikes
28	6L 269	55	165	25	1	50	4	dry	ls-91, s-5, dolo-1, an-2	ls	gos-1	slaty ls w/an dikes
29	6L 268	25	80	10	2	50	2	8'	c-15, ls-56, g-25, an-2	ls-s	gos-2	an dikes
30	6L 267	45	75	15	2	65	1	3'	c-20, ls-49, dolo-1, g-25, an-3	ls	gos-2	
31	6L 298	80	245	25	14	140	4	dry	ls-20, blk s-65, dolo-15	ls		
32	6L 299	30	125	10	3	60	6	10'	c-10, ls-58, s-25, g-5, an-2	slaty ls		
33	6L 300	105	505	25	20	435	18	2'	ls-35, blk s-64, dolo-1			stain on gravel to 8" above st. cr.

Map No.	Sample No.	Concentration (ppm)* Cu	Zn	Pb	Mo	Ni	Field** Test	Stream Width	Float at sample site***	Bedrock	Mineral-ization	Remarks
34	6L 266	40	100	15	3	55	2	2	ls-92, dolo-1, g-1, an-5, Cc-1	ls		
35	6L 265	130	430	30	20	300	+20	2'	ls-5, s-93, an-2		fe stain	bright reddish-orange iron stain. Straight Cr.
36	6L 301	70	195	15	5	65	2	3"	ls-67, s-20, dolo-1, g-5, an-5, Cc-2	slaty ls		
37	6L 264	50	165	15	6	80	3	14'	c-20, ls-50, s-10	gos-2		
38	6L 263	75	135	20	2	50	1	dry	ls-97, dolo-1, an-1	ls	gos-1	dikes
39	6L 302	50	135	15	2	55	4	dry	ls-68, s-30, dolo-1,Cc-1	slaty ls		
40	6L 262	50	150	15	6	80	3	8'	c-15, ls-57, s-15, g-10, an-2	ls	gos-1	an dikes
41	6L 303	40	95	10	2	45	5	15'	c-4, ls-57, s-15, dolo-15, g-5, an-1, b-1, Cc-2	slaty ls		
42	6L 428	45	125	15	2	85	6	2'	ls-s-70, g-30		no gos	
43	6L 304	30	80	10	3	15	1	30'	ls-57, s-20, dolo-4, g-7, an-10, Cc-2			
44	6L 305	25	85	10	3	20	1	20'	g-2, an-2, ls-72, s-20, dolo-3, Cc-1			
45	6C 427	20	145	20	2	5	3	dry	g-100, minor iron stain		minor gos	
46	6C 426	45	300	20	4	35	7	dry	c-10, g-89, limonitized hornfels-1		minor gos	f. gr. granite w/iron stain
47	6C 423	100	140	15	5	255	3	5'	ls, g-5, an-1, b-5	slaty ls		mafic (gossan) boulders to 10ft. dia.
48	6L 251	35	85	15	3	45	3			ls		
49	6L 256	50	115	20	4	55	3	4'	ls-76, s-15, g-4	ls		an dike 12' wide
50	6L 261	50	100	20	4	55	2	3'	ls-84, s-15, an-1	ls		an dikes
51	6L 361	35	90	15	3	20	1	18'	g-10, an-1, s-5, Cc-3			ls: slaty 36, M dy

Map No.	Sample No.	Concentration (ppm)* Cu	Zn	Pb	Mo	Ni	Field** Test	Stream Width	Float at sample site***	Bedrock	Mineral-ization	Remarks
52	6L 336	35	75	10	3	25	3	25'	c-3, ls-72, s-5, g-3 Cc-15			
53	6C 456	80	280	20	14	195	5	dry	ls-1, blk slate-98+		vein qtz w/dissem. Py-1	graptolites in slate float
54	6L 306	55	115	20	3	65	1	dry	ls-59, s-30, dolo-8, d-1, Cc-2	slaty ls		
55	6L 335	35	80	10	2	35	1	30'	c-2, ls-85, s-1, dolo-8, g-4			ls: slaty-65, brown-20
56	6L 307	55	125	20	3	35	1	dry	ls-70, s-25, dolo-3, d-1, an-1	slaty ls		
57	6C 357	45	100	20	2	15	1		ls-60, vein Cc-5, g, di, breccia, an			ls: slaty-45, M W/Cc veins-15
58	6L 334	20	65	5	3	25	3	25'	c-4, ls-85, dolo-4, g-5, an-1, Cc-1			
59	6L 308	50	125	25	4	35	4	dry	ls-85, s-10, g-1, an-2, b-1, Cc-1	slaty ls		
60	6L 333	40	100	15	2	25	2	30'	c-30, ls-63, g-5 and 1, Cc-1			
61	6L 309	50	100	10	1	30	2	3'	c-20, ls-60, s-10, dolo-1, r-1, d-1, an-5, b-2	ls & c		
62	6C 458	40	105	20	2	45	1	8'		ls-s		
63	6L 332	15	70	10	3	25	1		c-25, ls-2, G-72, an-1	slaty ls		
64	6L 310	40	90	10	2	40	3	2'	c-81, ls-10, s-1, dolo-3, an-5	c		
65	6L 337	70	150	20	6	100	2	2'	ls-60, s 35, dolo 5	s		
66	6L 338	80	130	20	9	95	3	2'	ls-87, s-11, dolo-2	s		ls-slaty marble
67	6L 339	40	110	15	2	50	2	3'	ls-83, s-15, dolo-2	slaty ls		ls: slaty 58, M gy-25
68	6L 360	35	90	15	4	50	1	20'	ls-94, Cc-3, an-3			ls: slaty-44, M dy gy 10 M bn weath-40
69	6L 340	55	105	20	3	70	3	4'	ls-91, s-5, dolo-3, an-1			ls: slaty-76 M gy-15

Map No.	Sample No.	Concentration (ppm)* Cu	Zn	Pb	Mo	Ni	Field** Test	Stream Width	Float at sample site***	Bedrock	Mineral-ization	Remarks
70	6L 359	40	95	15	3	20	1	15'	ls-95, Cc-3, an-2	slaty ls		ls; slaty 58, M dk gy-12 M bn 25
71	6L 341	45	90	20	1	55	1	1'	ls-88, dolo-8, Cc-4			ls: slaty-83, M gy-5
72	6L 342	60	110	20	3	45	1	3'	ls-93, s-5, an-1, Cc-1			ls: slaty-87, M gy-6
73	6L 358	40	95	15	3	25	1	18'	ls-98, Cc-2	slaty ls		ls: slaty-18 s M gy blk 20, M gy bn 60
74	6L 343	50	90	15	2	55	2	3'	ls-94, s-2, an-2, Cc-2			ls: slaty-84, M gy-10
75	6L 344	55	85	20	2	60	1	2'	ls-84, dolo-15, M Cc-1			ls; slaty-81, M gy-3
76	6L 345	45	100	15	2	60	1	3'	ls-78, Cc-20, an-2			ls: slaty-70, M gy blk 8
77	6L 346	55	75	20	2	35	1	2'	ls-92, s-5, dolo-2, Mc-1			slaty ls
78	6L 357	50	115	20	2	30	1	14'	ls-95, Cc-5	slaty ls		ls: slaty-30, M gy blk-15, M bn weath-50
79	6L 347	45	115	15	3	70	1	6'	ls-60, Cc-35, an-5			ls: slaty 25, M gy blk-35
80	6L 348	45	100	20	3	30	4	2'	slaty ls-100			red gossan on hill side at head of Cr.
81	6L 356	50	100	15	2	50	1	13'	ls-96, an-2, Cc-2			ls: slaty-10, M dk gy-15, M bn weath-71
82	6L 349	40	65	15	2	20	2	3'	ls-30, dolo-69, Cc-1			ls: slaty-10, M gy-20
83	6L 350	55	140	20	2	60	1	1'	ls-60, Cc-40			ls: slaty-20, M gy-40
84	6L 355	45	100	15	1	65	1	6'	ls-87, s-5, an-3, Cc-5	ls-s		ls: slaty-47, M blk-20 beds to 3' thick, M bn gy-20
85	6L 351	55	130	20	2	45	1	3'	ls-96, Cc-2, an-2			ls: slaty bn weath-71, M gy to gy bn-25
86	6L 354	40	80	20	4	105	1	8'	ls-97, Cc-1, an-2	blk s		ls: slaty-42, M gy-20 M gy bn-35
												ls: slaty-5, M gy bn-73

Map No.	Sample No.	Concentration (ppm)* Cu	Zn	Pb	Mo	Ni	Field** Test	Stream Width	Float at sample site***	Bedrock	Mineral-ization	Remarks
88	6L 352	50	85	15	4	40	1	4'	ls-99, d-1			ls slaty-15, M gy bn weath-54, M dk gy-30
89	6L 156	25	70	5	2	20	4	8'	ls-10, sl-60, g-20, an-10	s-ls		dikes & sills
90	6L 155	35	85	5	3	55	3	10'	ls-30, sl-40, g-15, d-7, an-8	s-ls		dikes: d & an
91	6L 154	45	120	15	2	40	3	6'	ls-45, s-50, d-2, an-3	s-ls		
92	6L 153	45	100	15	2	25	2	3	ls-10, s-49, cg-5, g-1, d-20, an-15	ls-s		dikes & sills
93	6L 152	50	105	15	4	35	1	6'	ls-10, sl-40, r-2, d-25, an-21, b-2	s-ls		dikes & sills
94	6L 159	30	130	20	2	20	2	3'	ls-1, s-15, g-4, d-50, an-30	s-w/ls		dikes & sills, g fm. till
95	6L 158	50	115	20	3	50	3	6'	ls-s, g, r, d, a	s w/ls		dikes & sills, g fm. overlying till.
96	6L 163	50	110	20	1	45	2	5'	ls-5, s-15, cg-40, d-15	cg		dikes: d & an
97	6L 168	30	85	10	1	35	3	14'	ls-70, sl-2, g-10, r-2, d-5, an-8, b-3	ls-s		
98	6L 169	55	150	20	1	35	1	20'	ls-50, s-20, g-15, d-4, an-10, b-1			
99	6L 135	90	130	20	3	30	1	10'	ls-5, s-2, c-2, g-10, r-35, d-40, a-2, b-4	ls-s		
100	6L 136	<u>105</u>	125	20	2	35	3	2'	ls-10, s-8, r-7, d-35, a-25, b-15	ls-s		
101	6L 137	30	105	15	2	15	2	10'	ls-3, s-2, c-5, g-45, di-10, r-5, d-20	ls-s		dikes & sills: r, d, an, b
102	6L 138	35	120	25	3	15	2	6'	c-35, g-40, r-5, b-5, d-15, b-5			dikes: r&d, moraine spring from breccia zone in chert
103	6L 140	30	110	15	1	25	1	7'	c-35, g-20, gdi-15, r-2, d-10, an-5, b-3	c		dikes & sills spring from fault zone

Map No.	Sample No.	Concentration (ppm)* Cu	Zn	Pb	Mo	Ni	Field** Test	Stream Width	Float at sample site***	Bedrock	Mineral-ization	Remarks
104	6L 139	50	130	20	2	35	2	3'	c-45, g-2, r-8, d-20, an-15	c		dikes & sills: r, da, an, b
105	6L 141	50	150	15	3	35	3	3'	c-15, g-10, r-2, d-30, an-25, b-10	c		dikes & sills
106	6L 143	50	115	15	1	50	2	8'	c-20, ls-2, g-20, gdi-15, r-3, d-20, an-15, b-5			
107	6L 142	20	90	15	4	15	2	4'	c-20, ls-2, g-15, r-3, d-25, an-25, b-10	ls & c		dikes & sills
108	6L 145	15	85	10	1	15	1	8'	c-30, ls-5, g-40, r-1, d-10, an-10, b-4	banded c		dikes & sills
109	6L 144	20	115	25	2	15	2	4'	c-20, ls-4, g-45, r-1, d-10, an-10, b-10	banded		base of ablation moraine dikes & sills
110	6C 337	30	130	20	2	40	2	4'	mud only	ls-s		dikes: an-b
111	6L 184	25	120	15	2	25	1	25'	c-5, ls-2, g-85, d-4, an-4			
112	6L 185	45	110	15	2	40	2	8'	ls-55, s-30, d-5, an-9, b-1			
113	6L 183							5'	c-3, ls-85, s-5, g-3, an-4	ls-s		
114	6L 186	25	115	10	2	25	2	3'	ls-40, s-9, d-15, an-35, b-1			base of fan
115	6L 182	25	110	15	2	45	1	10'	ls-40, s-6, g-43, d-3, an-7, b-1	ls-s		dikes: an & d
116	6L 181	30	105	15	2	35	2	30'	c-5, ls-30, s-35, g-10, d-10, an-8, b-2	ls-s		dikes & sills
117	6L 187	35	170	50	1	15	3	4'	ls-5, s-2, d-30, an-60, diorite 3	ls & s		dikes & sills
118	6L 188	25	125	20	2	25	2	25'	c-15, ls-5, s-10, g-10, r-2, d-10, an-35, b-3			
119	6C 354	30	125	20	3	70	2	8'	c-30, ls-10, r-15, d-5, an-20, b-20	banded rhy		Py in b-dikes
120	6L 189	30	120	15	3	20	2	2'	ls-30, s-10, g-10, d-18, an-30, b-2	s-ls		dikes: an, d, b

Map No.	Sample No.	Concentration (ppm)* Cu	Zn	Pb	Mo	Ni	Field** Test	Stream Width	Float at sample site***	Bedrock	Mineral-ization	Remarks
121	6L 190	40	100	15	2	35	1	dry	c-3, ls-45, s-20, d-10, an-20	s-ls-c		dikes
122	6L 191	35	125	15	2	45	1	dry	c-10, ls-10, s-8, r-15, d-20, an-32, b-5	s-ls-c		dikes & sills, alluvial fan
123	6C 356	30	115	20	3	20	2	12'	ls-33, r-7, d-22, an-22, b-16	ls w/c veinlets		ls: blk w/ Cc veins-22 slaty-11
124	6C 358	35	100	15	2	5	1	10'	c-10, ls-19, g-30, r-2, d-4, an-30, b-5	ls		
125	6C 366	45	110	15	3	30	2	5'	ls-80, g-5, an-5 Mc-10	ls		ls: slaty blk 75 M blk-5
126	6C 368	40	105	15	3	25	2	15'	c-20, ls-17, g-10, di-3, r-1, d-3, an-40, b-6	ls	1 piece fluorite 5" dia.	
127	6C 371	50	125	15	3	20	1	10'	ls-9	s-ls		
128	6C 372	30	95	15	2	30	1	10'	c-24, g-20, r-8, d-16, an-24, b		Py in r & d	dikes
129	6C 378	15	85	20	2	20	2	6'	g, di, an, b			
130	6L 193	50	120	15	1	55	2	8'	c-15, ls-30, s-45, g-2, an-3	ls-c-s	5% vein quartz	
131	6L 198	50	110	20	2	40	1	3'	c-20, ls-35, g-5, an-5	ls-c-s		dikes: an & d
132	6L 207	50	115	20	2	55		5'	g-2, an-1, b-2, ls-66, s-30	ls-s		most ls has (up to 90%) Cc veins (1/8-2")
133	6C 389	50	105	20	2	40	5	6'	ls-95, g-5, di-1	ls schist w/graphite specks		ls: schistose; M med-gy w/Cc veins; M tan weath
134	6C 394	70	110	20	2	45	5	4'	ls w/ c veins, an-5, b-5	ls schist		
135	6L 208	50	105	15	1	55		4'	ls-68, s-20, g-8, d-1, an-2	ls-s		85% of marble has Cc veins to 4" wide
136	6L 214	60	120	20	2	50	2	2'	m-91, s-8, an-1	m-s		
137	6L 215	35	110	15	2	45	1	8'	ls-50, s-2, g-1, r-2, d-5	ls-s		

Map No.	Sample No.	Concentration (ppm)* Cu	Zn	Pb	Mo	Ni	Field** Test	Stream Width	Float at sample site***	Bedrock	Mineral-ization	Remarks
138	6L 216	50	126	20	3	50	2	2'	ls-14, s-1, g-85	ls-s		g concentrated from till
139	6L 217	45	110	20	2	50	2	3'	ls-27, s-2, g-85, an-4, b-2	ls-s		g concentrated from till
140	6L 218	45	115	20	4	50	2	4'	ls-42, s-2, g-50, an-5, b-1			
141	6L 219	50	110	20	1	45	2	2'	ls, s, g, an-3, b-1	ls		
142	6L 220	45	130	25	2	45	1	3'	ls-87, s-3, g-4, an-5, b-1	ls-s		
143	6C 397	45	135	20	3	15	1	10'	ls-55, cg-1, g-35, di-5, an-5			ls: foliated med. gy; M blk w/Cc veins
144	6C 403	45	150	20	3	70	2	6'	ls-99, dolo-1			ls slaty tan weath-79, M blk-20 w/2% Cc veins
145	6L 238	30	95	15	1	60	2	40'	c-3, ls-30, s-15, g-2, r-1, d-4, an-25, b-10	ls-s		dikes
146	6L 239	25	100	15	3	20	2	30'	c-3, ls-55, s-1, g-10, r-1, d-10, an-20			
147	6L 240	50	130	35	1	40	1	25'	c-1, ls-55, s-2, g-8, r-2, d-5, an-25, b-2	ls-s	gos float	volcanics w/Py & Po(?)
148	6L 241	45	120	25	2	50	1	3'	ls-83, s-2, g-8, d-2, an-4, b-1			
149	6L 242	40	160	20	1	40	2	2'	ls-93, s-2, g-2, d-1, an-2	ls-s		
150	6L 243	50	125	20	2	55	2	3'	c-1, ls-55, d-2, an-41, b-2	ls		dikes and sills
151	6C 418	45	120	15	2	70	6	3'	ls-88, r-7, d-3, an-2			ls: foliated 68, M dk gy 20
152	6L 245	25	100	15	2	25	1	30'	c-1, ls-84, g-3, d-4, an-7, b-1			
153	6L 244	40	100	15	2	55	3	4'	ls-88, g-1, d-5, an-4,	ls		dikes

Map No.	Sample No.	Concentration (ppm)* Cu	Zn	Pb	Mo	Ni	Field** Test	Stream Width	Float at sample site***	Bedrock	Mineral-ization	Remarks
154	6L 246	50	170	15	3	55	2	5'	c-4, ls-80, g-2, d-3, an-10, b-1	ls		dikes & sills
155	6L 247	25	120	20	1	15	4	4'	r-70, an-30			rhyolite tuff
156	6L 248								g-1, 5-29, d-10, an-60	slate		
157	6L 249	20	100	10	2	15	17	2'	c-8, g-43, d-15, an-24	ls & Nenana gravel		Small Cr. draining Farewell fault

* Total metal contents analyzed by Rocky Mountain Geochemical Laboratories, Salt Lake City, Utah Reported in parts per million

** Milliliters dithizone, cold extractable heavy metals test (Hawkes, 1963).

*** Rock types in the stream beds or sediments at sample sites.

Symbols for rock types or characteristics are as follows:

an - andesite	Cc - calcite	dolo - dolomite	ls - limestone	r - rhyolite
b - basalt	cg - conglomerate	g - granite	M - massive	s - slate
blk - black	d - trachyte	gos - gossan	med - medium	w - with
bn - brown	di - diorite	gy - gray	Po - Pyrrhotite	weath - weathered
c - chert	dk - dark	lim - limonite	Py - pyrite	

Percentages of rock types at each sample point shown in figures after the symbols.