COBALT AND COPPER INVESTIGATION OF THE HULAHULA RIVER REGION

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Critical and Strategic Minerals in Alaska -

Eastern Brooks Range Project

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U. S. DEPARTMENT OF THE INTERIOR

James G. Watt, Secretary

BUREAU OF MINES

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INTRODUCTION

A brief mineral investigation of the copper occurrences in the upper Hulahula River region (fig. 1) of northeastern Alaska was made by the Alaska Field Operations Center, U. S. Bureau of Mines. The work was part of an Alaska-wide assessment of 'critical and strategic' minerals, and follows-up on the brief reports of observed mineralization by the U. S. Geological Survey. The following manuscript is a summary of field work in 1981, and will be updated as additional work is completed.

Specific objectives of this investigation were to re-examine the previous reports of copper mineralization, and to evaluate the potential for economic copper $\pm$ cobalt deposition in the area. Since the area has been virtually unexplored at the present time, the likelihood of discovering ore deposits with this level of investigation is nil. It is not the present intention of the Bureau to commit the necessary time and expenditures to discover and to determine grade and tonnage of mineral deposits in the region.

While only copper has been noted in the Hulahula River area, it was felt that the geological setting may be favorable for associated cobalt mineralization. There has been no attempt in the past to evaluate cobalt in the eastern Brooks Range. Presumably an investigation of the geology and the mineralization in the rock units of the Hulahula area would further serve as an exploration guide to a more widespread geologic terrane in the eastern Brooks Range.

The area examined covers approximately 40 sq mi of rugged mountainous terrain in the eastern Brooks Range.

Ak map insert

Figure 1. - Location Map

Remove political boundaries except for Arctic Wildlife range & Venetie Reservation

HISTORY AND PREVIOUS INVESTIGATION

There are no reports of mineral exploration in the Hulahula River region. Undoubtedly some gold prospectors visited the region after the early Alaskan gold strikes of this century, however, there were no reports of gold discoveries. At that time, minerals other than precious metals were of no economic interest in such a remote area as northeastern Alaska.

Early work by the U. S. Geological Survey included regional reconnaissance by Leffingwell in 1919 (8)[1], who described and named the Neruokpuk rocks in the Hulahula valley. In 1948, Whittington and Sable (13) reported on the nearby Sadlerochit River area; in 1968, Reed (9) described the Lake Peters area to the northwest; and Sable reported detailed work to the northeast in the Romanzof Mountains in 1959, 1977 (11, 12). Regional reports of interest include Brosge & others, 1962 (2), Dutro, 1970, 1972, 1978 (5, 7, 6), Churkin, 1973 (4), Wood, 1975 (14). Geological reconnaissance mapping at 1:250,000 scale was compiled by Reiser and others, 1971 (10). Other Geological Survey investigators, too numerous to list here, have compiled regional studies pertaining to various aspects of geology, geomorphology and geophysics of the eastern Brooks Range.

A report entitled "Mineral Resources of the Arctic Wildlife Range" by Brosge and Reiser (3) in 1976 suggested the vicinity of the upper Hulahula River to be favorable for deposition of copper. This theory was based on the presence of mafic volcanic rocks containing a "high intrin-

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[1] Underlined numbers in parentheses refer to items in the list of references at the end of this report.

sic copper content", and on the occurrence of copper mineralization at four localities in the vicinity. One of these occurrences was in sheared volcanics, the other three were in the adjacent clastic sedimentary rocks. There was no mention of or analyses for cobalt.

OWNERSHIP

The entire area of this investigation is included within the Arctic National Wildlife Range which was established by Public Land Order 2214 on December 6, 1960. As part of the Alaska Lands legislation of December 2, 1980, (PL 96-487) this area was also given a "Wilderness" classification. The area is administered by the U. S. Fish and Wildlife Service from their field office in Fairbanks.

PHYSIOGRAPHY AND CLIMATE

The report area is in an alpine region known as the Romanzof Mountains of the northeastern Brooks Range and lies immediately north of the continental divide. The Romanzof Mountains, the highest mountain mass of the Brooks Range, reach elevations over 9,000 ft. The valley floor in the report area (fig. 2) has an elevation of approximately 2,500 ft.

The valleys in the region have been glaciated and are typically U-shaped. Moraines are common. Flood plain alluvial sediments consist of reworked glacial till and material reduced by mechanical fracturing and abrasion. Primary river channels such as the Hulahula are generally braided, while secondary creek drainages tend to be steep to cascading and contain little fine sediment. All drainage is northward to the Arctic Ocean. Glaciers occupying small upper valleys and cirques are still active in the Romanzof Mountains, and permanent ice occurs in sheltered areas above 5,000 ft.

Climate is arctic alpine, with low precipitation levels. However, extended periods of wind, fog and light rain or mist are typical in the summer. Visibility can be frequently reduced to less than several hundred feet. The snow free period generally extends from mid-June to early September, although snow can occur in any month of the year.

Vegetation is sparse, consisting of tundra on the valley floors and on moderately inclined slopes. Stunted growths of willow and alder brush are found in protected ravines at lower elevations. Rock exposure as bedrock or rubble is extensive. Due to the arctic climate and active erosion there is very little soil development by normal chemical processes.

Figure 2. - View to the south towards the headwaters of the Hulahula River.

ACCESS

Access to the report area is limited to air during the summer. Small wheeled aircraft can land on an unimproved gravel bar strip (fig. 3). Operation of helicopters, though practical in this terrain, is prohibited due to the present federal land classification. The village of Kaktovik at Barter Island, approximately 80 mi to the northeast is the most practical logistical center. Communications, lodging, supplies and charter aircraft are available there. Bush plane operation on VFR is most reliable from Kaktovik to the north since the continental divide to the south is frequently obscured, thus blocking access from more southern bush villages.

$\times^{41}$ Report of copper mineralization by the USGS.

$+_A$ " " " " found during this investigation

Scale 1 inch = 4 miles

FIGURE 3. – Map of the upper Hulahula River valley.

REGIONAL GEOLOGY

The oldest sedimentary rocks in the Hulahula River region are slightly to moderately metamorphosed Precambrian rocks primarily composed of quartzite and semischist. These are referred to as the Neruokpuk Formation.

Overlying the Precambrian rocks is a poorly defined, diverse group of rocks of lower to mid-Paleozoic age (Reiser, 10). A fossil locality in limestone has been identified as Cambrian age by Dutro and others (7).

Some geologic investigators combined all or some of these units into a broader, pre-Mississippian age Neruokpuk. Reference to Neruokpuk classification was made by authors mentioned previously, particularly the work by Brosge and others, 1962 (2) and Dutro and others, 1972 (7).

Brosge and others in 1962 (2, pp. 2185-2192), divided the pre-Mississippian rocks of the northeastern Brooks Range into four Neruokpuk members:

(1) The older lowermost member is a massive gray-green, quartzite-schist unit containing interbedded phyllites and slates. It is found to be locally ferruginous. The total thickness is estimated at 3,500 to 4,000 ft.

(2) The next lower member is a medium gray to gray-black limestone which is medium to massively bedded. The limestone is estimated to be 1,000+ ft thick.

(3) The third member is an interbedded light gray to orange weathering limestone-phyllite succession containing some sandstone, shale, and calcareous grit strata. Limestone locally grades to arenaceous limestone or calcareous grit. The third member is approximately 1,000 ft thick.

(4) A fourth member composed of phyllite-chert then overlies the lower units with a regional unconformity and has a thickness of approximately 3,300 ft. It is composed of varicolored phyllite, locally calcareous and pyritic schist, quartzitic sandstone, and thinly bedded chert.

The entire Neruokpuk assemblage is overlain by the Upper Devonian to Mississippian Kekiktuk Conglomerate with an angular unconformity.

The interpretation of the Neruokpuk was further refined by Dutro and others, (7), to account for structural complexities and somewhat revised stratigraphic correlations. The rock units of the upper Hulahula River appear to correlate to Sequences A & B as described by Dutro and applicable to region between the Canning and Jago Rivers (fig. 4).

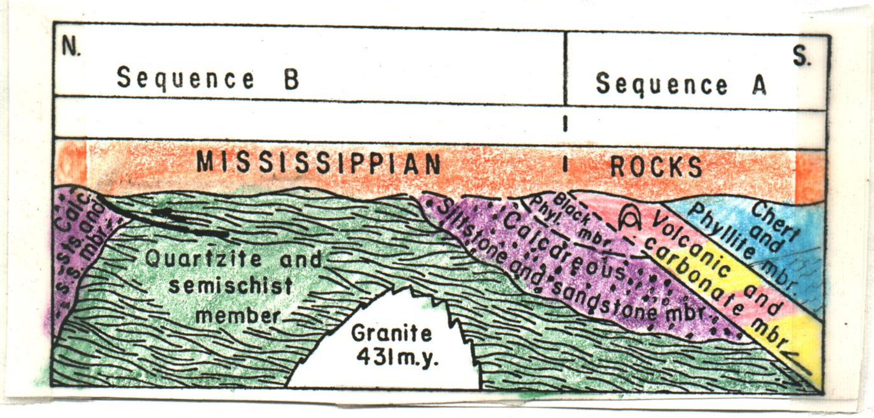

Figure 4. - Suggested stratigraphic and structural relations of members of the Neruokpuk Formation from the region of the Canning and Jugo Rivers. Lower Cambrian trilobites occur in the volcanic and carbonate member. Taken from Dutro, Brosge, and Reiser, 1972, (7).

From oldest to youngest these are:

Sequence B-includes the older quartzite-semischist member which is unconformable overlain by a calcareous siltstone and sandstone member and by a black phyllite/slate member.

Sequence A-includes a member of orange weathering carbonates and volcanics. This member includes mafic sills, flows, tuffs and intrusions with slates, cherts, partially oolitic and laminated dolomites, and bioclastic and thinly bedded limestones which gradationally underlie the younger chert-phyllite member. The chert-phyllite member is marked with a basal oolitic dolomite. The contact with the underlying Sequence B is believed to be a regional thrust fault, figure 5.

Figure 5. - Bedrock exposures of Neruokpuk rocks along the east side side of the upper Hulahula. Note: Phy-Cht is the chert and phyllite member (probably overturned), L.S. is limestone of the volcanic (V) and carbonate member, B.S. is the brown calcareous siltstone and sandstone member. B.P. is the overlying black phyllite member.

The Neruokpuk formation (including all the pre-Mississippian units) was reported by Sable, 1977, to contain at least one and possibly several major unconformities, other uncertain limited unconformities, and indications of rapid and as yet unpredictable facies changes (12, p. 5). The formation is 6,000+ ft thick at Lake Peters, where it was measured by Reed (9, p. 99-117). However the base of the Neruokpuk is not exposed and nowhere is it present in the eastern Brooks Range. Thickness estimates are therefore only minimum approximations.

The outcrop map and rock descriptions from the present investigation (see fig. 6), suggest a close correlation to the Neruokpuk classifications of Brosge and others (2) and Dutro and others (7).

The youngest sedimentary rocks in the upper Hulahula area are erosional remnants of middle to late Paleozoic age which unconformably overlie the pre-Mississippian Neruokpuk as south-southeast dipping, imbricate thrust sheets. From oldest to youngest, these units include the Kekiktuk Conglomerate, the Kayak Shale and the Lisburne Group (10).

The geological setting of the upper Hulahula River is dominated by the regional uplift of the Romanzof Mountains which exposes a broad anticlinorium of the Neruokpuk basement rock.

The Romanzof uplift has been intruded by granitic stocks of the Okpilak batholith and the Jago stock which are both exposed approximately 10 mi northeast of the report area. Lead-alpha determinations [Sable, 1977 (12, p. 57)] for two samples of granitic rocks from the Romanzof Mountains give ages of 310 ± 35 m.y. and 405 ± 45 m.y. Hornblende from the Jago stock was dated as 431 ± 13 m.y.

Sable described the intrusive effects of the granitics in the Neruokpuk rocks of the immediate Okpilak-Jago area, and there is uncertain evi-

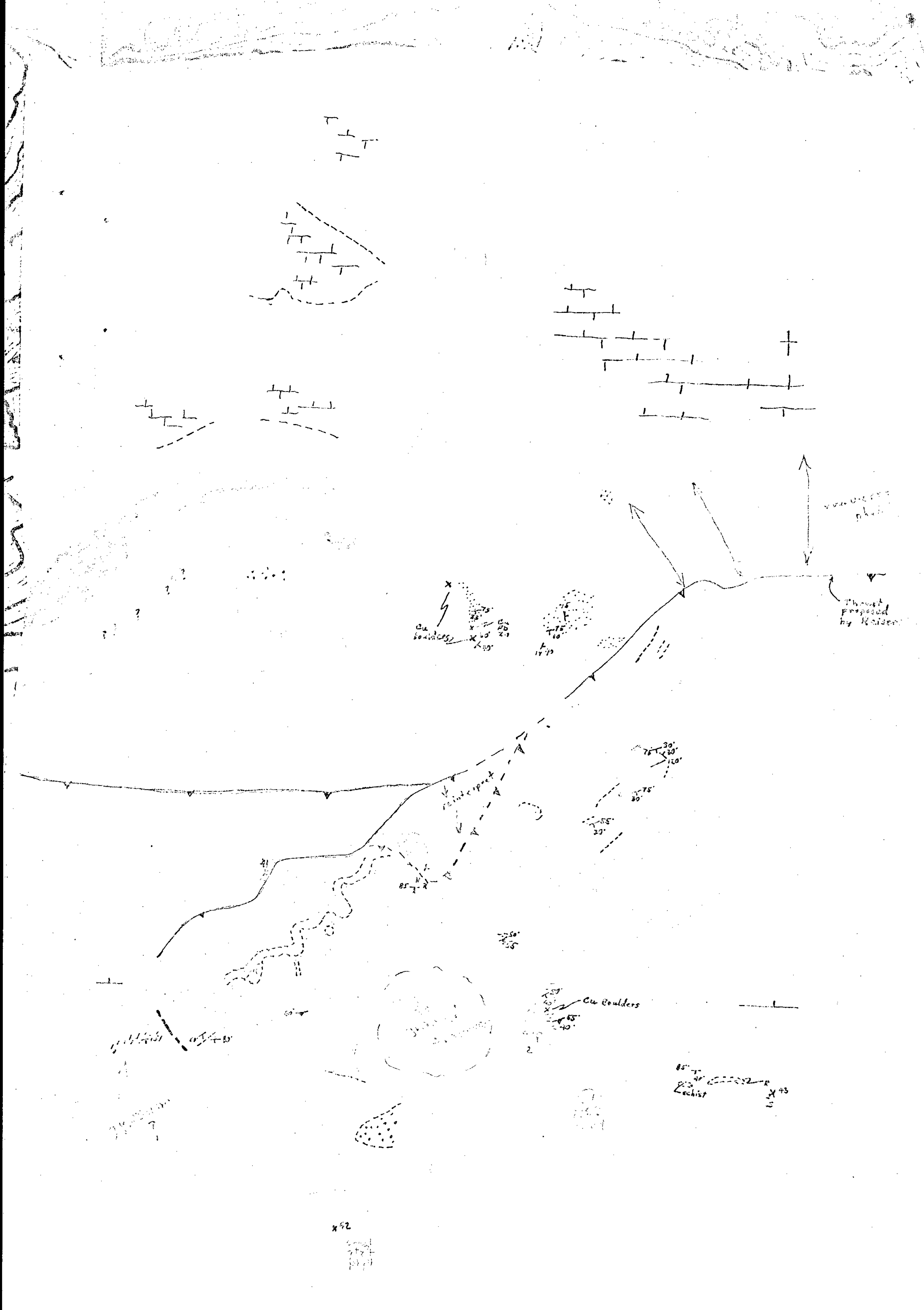

Figure 6. - Outcrop geology and mineral occurrences

Figure 6 - Explanation

Massive, white weathering Lisburne Limestone

Kayak Shale / Kekiktuk Conglomerate
includes anthracite beds

Sequence A (Datro-72)

Maroon and green phyllite

Chert, massive gray, green and black to locally thinly bedded, grades to argillite and phyllite, Pattern indicates argillaceous chert to limestone.

Thinly bedded dolomite

Mafic sills, dikes, volcanics, andesite frequently with quartz-carbonate veins with epidote and chlorite. Local areas of agglomerate.

Limestone - Coarse crystalline, typically ferruginous, to medium grain silty tan

Sequence B (Datro-72)

Phyllite to black shale, calcareous; calc-siltstone and sandstone, locally micaceous. Pebble conglomerate reported on East Patuk Creek. Dot pattern indicates sandstone.

Schist and Quartzite, minor slate.

R Iron staining

x strike & dip of bedding

x Cu Mineral Occurrence

---- inferred contact

— — Fault

dence of thermal alteration extending into the Mississippian-age Kekiktuk conglomerate (12, pp. 40-43).

Mafic dikes commonly intrude the Okpilak batholith and are correlated by Whittington and Sable, 1948 (13), and Sable, 1977 (12, p. 61) with the mafic rocks intruding the Neruokpuk of the Hulahula River. Dutro and others (7) described the mafic intrusive rocks and pyroclastics on the upper Hulahula in more detail. Since these dikes were not found to intrude the Kayak or Kekiktuk sediments, they are judged to be late Devonian due to the Devonian (?) age of the granites.

Further lithologic and petrologic descriptions of these rocks are given in the cited references and will not be repeated here.

WORK BY THE BUREAU

FIELD WORK

A brief investigation of a portion of the upper Hulahula River region was made in July, 1981. Work was conducted by a three-man team working on foot from a tent camp near an unimproved landing strip. A total of six days were spent working in the area which included, 1) mapping (fig. 6), 2) geochemical sampling (fig. 7), 3) examination of mineralized exposures and float rock, and 4) an unsuccessful attempt to relocate the copper occurrences reported by the USGS. Due to foul weather at the higher elevations none of these previously reported occurrences were found, although the presence of mineralization was indicated by the stream sediment sample data. Work throughout the area was hampered by extremely poor weather including snow.

overlay to base of fig. 6

Figure 7. — Sample location map

SAMPLING AND ANALYTICAL PROCEDURES

Stream sediments were collected with a steel shovel from the finer sandy portion of the active channel or from the deepest, most active part of a dry creek bed. Samples were put in water-resistant paper sample bags and air-dried before screening at -80 mesh. Float-rock and stream characteristics were noted and recorded at each sample station.

A pulverized fraction of each crushed rock sample and a pulverized -80 mesh portion of each stream sediment sample collected were analyzed by standard atomic absorption methods for Cu, Pb, Zn, Ag, Mo, Co, and Ni. These analyses were made by TSL Laboratories of Spokane, Washington. Results are noted in tables 1 and 2, and locations are shown on figure 7.

MINERAL INVESTIGATION

Prior to and during the field work, four basic models were considered as potential economic-scale deposits targets for copper-cobalt mineralization in the Hulahula region. The investigation was oriented to examined evidence for or against each of the models.

1. Replacement deposition within breccia or other tectonic zones in the cherts and limestones. No mineralization was found in the cherts other than occasional malachite. Evidence of large limestone breccia zones and quartz veining that could host mineralization was observed at sediment sample location AW19107 (see fig. 7). Traces of copper minerals were noted in rubble below a well defined iron-stained zone in the cliffs (location D, fig. 3). Minor traces of copper minerals related to the thermal alteration were found in the limestone along contacts with the mafic rocks such as at sample location AW19082 (table 1, fig. 7).

TABLE 1. - Analyses and description of rock samples

Map No.	USBM Sample No.	Atomic Absorption Anaylses[1] Ag	Co	Cu	Mo	Ni	Pb	Zn	Sample Description
	AW19045	1.6	37	390	<2	140	13	50	Andesite with minor epidote and traces of malachite. Finely disseminated pyrrhotite.
	AW19047	3.8	65	115	<2	76	22	130	Pyritic zone in bleached, and sheared andesite. Replacement silica and quartz veinlet stockworks with sulfides. Zone dips southward.
	AW19048	----	53	------	--	86	-----	------	From a 10 to 15 ft wide bleached zone parallel to the above zone. Contains traces of chalcopyrite.
	AW19059	8.9	20	405	<2	73	16	55	Mineralized zone with malachite and slickenside, and traces of bornite along contact between green metasediment (volcanic?) and brown shale.
	AW19060	17.6	41	1,700	<2	195	17	110	Gray calcareous shale with malachite from same location as AW19059.
	AW19061	0.3	16	63	<2	62	10	23	Quartz stockworks in meta-volcanic with abundant epidote.
	AW19082	37.6	16	22,500	<2	47	12	32	Malachite stained rubble in talus below contact of meta-volcanics and overlying limestone. Sample contains a gray sulfide.
	AW19086	4.5	45	150	<2	45	18	110	Pyritic, malachite stained zone approximately 5 ft wide within a sill of meta-volcanic.
	AW19087	2.1	32	81	2	78	32	10	Thermally altered, iron-stained limestone at contact with mafic meta-volcanic.
	AW19104	3.4	41	335	<2	185	10	13	Foliated, pyritic dolomite with finely disseminated metallics. This sample is typical of bedrock cliffs along valley.

See footnote at end of table.

Analyses and description of rock samples - Continued.

Map No.	USBM Sample No.	Atomic Absorption Analyses[1] Ag	Co	Cu	Mo	Ni	Pb	Zn	Sample Description
	AW19113	1.3	7	53	4	8	10	38	From a typical 30 ft thick section of carbonates and cherts with occasional mineral salts, pyrite, and gypsum.
	AW19114	9.7	5	1,350	<2	<1	8	7	From several similar silicified conglomerate boulders (30 in diameter) in river bed, partially stained with malachite, containing pyrite and chalcopyrite. Quartz stockworks throughout. Sulfides occur on fractures, in veins, and in conglomerate matrix.
	AW19115	28.6	6	18,600	<2	4	7	24	Silicified (conglomerate?) boulder containing several percent sulfides. Found on river bar.
	AW19116	1.4	11	83	8	30	26	200	Channel sample across pyritic fault zone and gouge forming contact between thinly bedded sandstone and and overlying chert. Zone contains gypsum and mineral salts.
	AW19117	0.6	30	53	<2	51	18	135	Chips from random boulders of fresh mafic sill, no alteration present.
	AW19118	4.1	48	590	<2	50	65	96	Chip sample across a sparsely mineralized strata within calcareous black shale outcrop. Copper mineral is chalcopyrite. Mineralized beds are between 0.5 and 1.5 in thick. Shale is folded and cut by several episodes of quartz veinlets, one of which contains traces of galena and sphalerite(?) (see AW19123).

Analyses and description of rock samples - Continued.

Map No.	USBM Sample No.	Atomic Absorption Analyses[1] Ag	Co	Cu	Mo	Ni	Pb	Zn	Sample Description
	AW19119	4.8	38	255	<2	42	495	225	Four foot channel sample across several intervals described above.
	AW19121	52.9	710	26,000	<2	1,370	13	1,700	Small boulder on river bar near black shale outcrop containing copper mineralization in a siliceous mass with attached bleached shale.
	AW19123	2.1	29	135	<2	20	7,900	52,500	Galena bearing 1/2 in thick quartz veinlet and host shale in outcrop of black shale (see AW19118). Sample is typical of the randomly oriented mineralized veinlets.
	AW19126	0.9	8	21	<2	10	17	93	Gouge zone, 16 in wide in black shale.
	AW19128	0.7	21	49	<2	26	16	43	From a 5 in thick quartz vein in black shale which contains pyrite and an unidentified black mineral.
	AW19129	1.0	14	22	<2	23	33	150	Chips from coal-bearing black Kayak shale from rubble.

[1] Analyses by TSL Laboratories, Spokane, Washington.

NOTE. - All values in parts per million.
---- not analyzed for.

TABLE 2. - Analyses of stream sediment samples

MAP No.	USBM Sample No.	Atomic Absorption Analyses[1]						
		Ag	Co	Cu	Mo	Ni	Pb	Zn
	AW19033	1.1	17	56	2	45	19	97
	AW19034	---	18	57	2	55	20	98
	AW19043	1.1	26	79	2	89	79	110
	AW19044	1.1	30	73	2	105	16	105
	AW19049	0.6	20	61	<2	29	20	54
	AW19057	1.4	25	56	2	46	18	93
	AW19058	1.2	34	81	<2	74	18	140
	AW19062	---	39	300	5	75	16	245
	AW19063	---	16	155	6	51	16	145
	AW19064	0.7	17	69	3	40	11	89
	AW19065	---	20	65	2	33	11	52
	AW19066	0.9	16	130	2	33	11	58
	AW19067	0.5	27	68	4	57	18	125
	AW19069	1.0	10	140	25	22	34	68
	AW19070	1.6	26	205	6	61	20	290
	AW19071	1.4	7	84	4	22	13	36
	AW19072	---	---	---	---	---	---	---
	AW19073	0.9	8	15	3	49	17	105
	AW19081	0.2	16	73	2	51	15	100
	AW19083	0.8	27	41	2	83	21	47
	AW19084	1.1	32	66	<2	110	20	94
	AW19085	---	30	105	4	79	20	150
	AW19088	1.4	17	38	<2	28	18	79
	AW19089	---	16	30	---	30	19	67
	AW19090	---	16	32	<2	29	16	79
	AW19091	---	16	33	<2	29	18	78
	AW19093	1.4	18	35	<2	34	12	72
	AW19094	1.1	18	44	<2	30	15	67
	AW19095	1.3	16	41	2	26	15	74
	AW19096	1.9	15	24	2	26	18	135
	AW19098	1.2	18	28	<2	31	17	54
	AW19099	1.3	22	45	<2	35	18	93
	AW19100	1.3	18	39	<2	29	24	135
	AW19101	1.4	18	28	2	29	19	66
	AW19102	1.1	21	76	<2	55	16	115
	AW19103	0.7	25	63	2	74	18	105
	AW19105	0.6	28	77	<2	56	15	97
	AW19107	1.9	31	115	3	79	17	240

See footnote at end of this report.

Analyses of stream sediment samples - continued

Map No.	USBM Sample No.	Atomic absorption analyses[1] Ag	Co	Cu	Mo	Ni	Pb	Zn
	AW19108	1.6	30	67	<2	100	14	115
	AW19109	0.8	27	74	6	33	18	81
	AW19110	0.7	25	61	2	45	16	175
	AW19111	0.7	28	93	4	53	19	190
	AW19112	1.1	29	145	9	75	24	290
	AW19124	2.1	47	210	8	80	54	360
	AW19127	1.4	21	49	<2	44	18	92
	AW19130	1.0	18	46	<2	40	15	84
	AW19131	1.1	22	46	<2	49	23	205
	AW19153	1.4	15	21	<2	27	17	155
	AW19154	1.5	16	58	<2	29	14	180
	AW19155	1.0	12	41	<2	23	10	47
	AW19156	0.9	13	15	<2	23	10	51
	AW19157	0.6	6	120	6	13	23	32
	AW19158	0.3	12	34	2	52	16	115
	AW19160	0.3	19	47	<2	37	19	84

[1] Analyses by TSL Laboratories Ltd., Spokane, Washington.

NOTE. - All values in parts per million.
--- not analyzed for.

2. <u>Massive sulfide and other deposits hosted by the volcanics.</u> The mafic volcanic rocks and intrusive sills have a high background of copper; malachite and occasional chalcopyrite pods can be found along discontinuous quartz-carbonate veins. Mineralization was never found to be extensive.

The copper minerals appeared totally restricted to these narrow hydrothermal veins and altered fractures that have "sweated out" copper from the mafic wall rock. The best showing is apparently at the USGS locality No. 41 on figure 3, where chalcopyrite reportedly occurs in sheared mafic volcanic.

At USBM rock sample location AW19086, one of several highly iron-stained zones with lenses of iron sulfides was sampled, but economic metal grades were low (table 1). Hydrothermally altered, shear zones up to 15 ft wide within the mafic rocks were also found at rock sample locations AW19047-48 where a pyritic bleached zone in the volcanics contained secondary silica and traces of copper minerals. The zone strikes toward the USGS location No. 41 about 1/2 mi to the west. Nearby, (AW19049) bleached pyritic zones and limonite in andesite are up to 40 ft across but no evidence of copper mineralization was observed or indicated by sample analyses.

3. <u>Stratabound mineralization within the Kekiktuk quartzite, conglomerates and sandstones.</u> There are abundant unmineralized quartz stockworks in the Kekiktuk. However, several mineralized conglomerate boulders with quartz stockwork (location C, fig. 3) were found in the river bed as shown on figure 8 (see sample AW19115 - table 1). No bedrock occurrences were found. The USGS reported minor traces of chal-

Figure 8. - Foliated conglomerate boulder with copper mineralization. Note: sample AS19115 of this rock contained 1.86% Cu.

copyrite occurring in brecciated quartzite, chert, and quartz pebble conglomerate at location No. 42. The outcrop is described as schistose by Brosge, 1982 (1), and contains interbedded black phyllite with the conglomerate (location 42, fig. 3).

4. Stratiform mineralization in the Sequence B members of the pre-Mississippian Neruokpuk Formation. These rocks include shale, micaceous sandstone, limestones, gypsum-bearing dolomites, argillite-phyllites and cherts (see fig. 6). It is evident from field observations of rapid facies change that each member may represent several or more depositional environments.

Traces of stratiform mineralization in black phyllites and shale were found at location A, figure 3 (see samples AW19118-28). Disseminated chalcopyrite occurred along select thin beds of the southdipping calcareous shale (fig. 9). The mineralized strata observed were no more than 1.5 in thick. At sample location AW19059-60 (location B) minor copper mineralization occurs at the contact of brown and green argillites. Thinly bedded dolomites outcropping at sample location AW19104 contained disseminated sulfides including traces of chalcopyrite. To the southeast at USGS locality No. 46, Brosge, 1982, (1) reported a quartzite and light-green sandstone succession to contain minor copper staining.

Potentially remobilized secondary mineralization (e.g. veins, shear zones etc.) could occur as stratabound deposits within Sequence B. The mineralized quartz veinlets at Location A may be an example of this.

Figure 9. - Outcrop at Location A. Black calcareous phyllite and shale with thin stratiform horizons containing chalcopyrite, and galena and quartz veinlets.

SUMMARY AND RECOMMENDATIONS

Examination of the upper Hulahula River region has indicated widespread copper occurrences in some cases with minor silver and zinc. Although no mineralized deposits of economic importance have yet been located, the area is considered potentially favorable based on the present data.

While the occurrence of and favorability for copper and minor silver is obvious in the region, the association of cobalt remains an open question. Significant concentrations of cobalt (0.07%) were detected in only one sample (AW19121) which was found as riverbar float. The increased background of cobalt detected in samples from the copper-bearing shale (location A - AW19118-28) may be considered encouraging if economic grade stratiform copper mineralization should be discovered.

Further investigation of stratabound or stratiform Cu, Ag, Co, and Zn mineralization associated with the lower Paleozoic to upper Precambrian age dolomite-shales-argillite-sandstone series described as Sequence B should be made. This type of mineralization is suggested by samples and observations at localities A, B, 42, 43, 46. Because of the implication of potential mineralization, particular attention should be paid to geologic features indicative of sabkha-type deposits. Future examination should focus on potential intertidal facies change occurring between the gypsum-bearing dolomite section and deeper water shales and siltstones.

Boulders of mineralized float are evidence of secondary mineralization such as by replacement deposition in the Kekiktuk Conglomerate (location 42, C). The area of higher elevation along lower Itilik Creek (fig. 6) should be further examined.

No evidence was found of significant mineralization occurring as replacement deposits within the chert or limestone units, or as massive sulfide bodies (other than iron) in the volcanics. The occurrences of pyrrhotite pyrite lenses on the ridge west of the Hulahula suggest that this type of deposit cannot yet be ruled out. Effects of the mafic intrusions on the limestones, such as location D, appear limited to narrow thermal contact zones. Significant concentrations of metals in these zones appears unlikely.

Any future work must include, as a primary consideration, detailed mapping and stratigraphic correlation. Few meaningful conclusions can be drawn until this is completed. Traverses across the stratigraphic section are suggested for: 1) the ridges 2-3 mi east of the airstrip, 2) the dolomite section in the southwest portion of the study area, 3) the Kekiktuk Conglomerate on the ridge between the upper forks of the Hulahula.

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